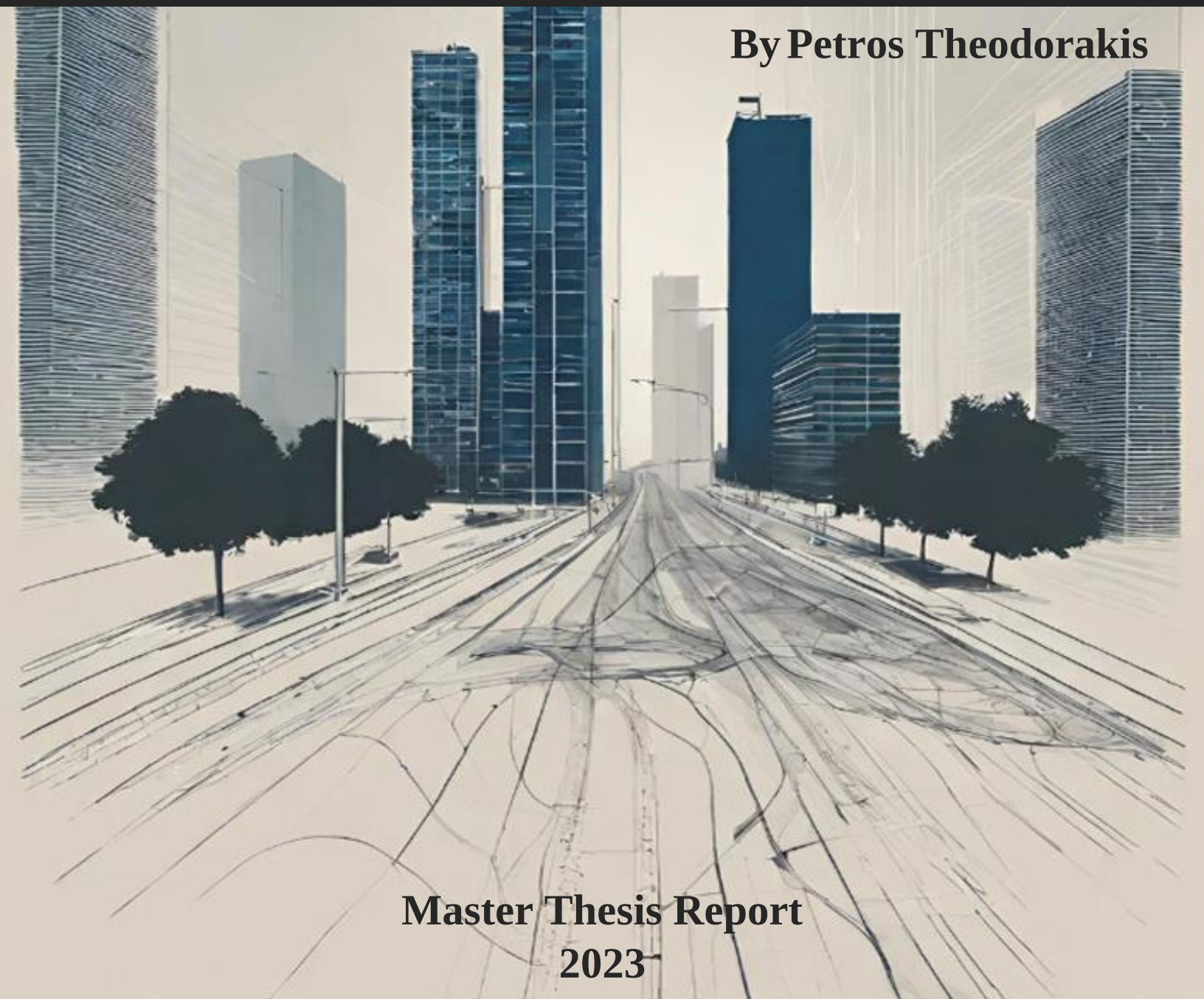
An Applied Transition from Traditional Arrangements (Cost-Driven) Towards Enterprise (Value-Driven), Enriching the Performance of Large Infrastructure Projects

By Petros Theodorakis



Master Thesis Report

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An Applied Transition from Traditional Arrangements (Cost-Driven) Towards Enterprise (Value-Driven), Enriching the Performance of Large Infrastructure Projects

MASTER THESIS REPORT

University: Delft University of Technology
Faculty: Department of Civil Engineering & Geosciences
Program: M.Sc. in Construction Management & Engineering

Name: Petros Panormitis Theodorakis

Student ID: 5050553

Chair: Prof.dr.ir. M.H. Hermans
Faculty of Architecture and the Built Environment

First Supervisor: MSc. Pedram Soltani
Faculty of Architecture and the Built Environment

Second Supervisor: Dr. Martijn Leijten
Faculty of Technology, Policy, and Management

Company Supervisor: Rob Rijnen
Witteveen+Bos

Preface

This research, conducted in collaboration with Witteveen+Bos, marks the end of my master's journey in Construction Management and Engineering at TU Delft and it would not be achieved without the invaluable support and contributions from many individuals.

Foremost, I extend my gratitude to my graduation committee: Ph.D. (C) Ir. Pedram Soltani, Dr. Martijn Leijten, and Prof.dr.ir. M.H. Hermans for their help, guidance and support. Despite the willingness to share their broad and deep knowledge with no limitations, they also equipped me with significant normative standards in mastering success; both personally and professionally.

A special appreciation goes to Rob Rijnen, my supervisor at Witteveen+Bos, for his support and invaluable suggestions on my research. His mentorship was exceptional, and the ease with which I could seek his guidance at any time was noteworthy. I am also grateful to all those who provided me with valuable insights towards enhancing the research's quality.

I would like to express my gratitude to my family for all the unwavering effort and continuous support over these years; all my efforts are mutually shared. Last but not least, I would like to thank my friends who have been an important pillar in better coping with this journey's social challenges.

On my way to Ithaca, I am deeply honored for the contribution of all those individuals. I hope that my research will potentially deliver meaningful impact in both academic knowledge and practical application. Enjoy reading!

Petros Theodorakis

Delft, 2023

Abstract

This research investigates how value engineering can be integrated with benefits management in the front-end of infrastructure projects, accompanied by the appropriate governance mechanisms, to consider value more holistically. This is achieved by developing holistic project governance process that combines value, costs, and impacts. The strategy comprises four sequential research methods: literature review, semi-structured interviews, cumulative cross-case analysis, and expert workshop validation.

The literature review aims to understand the benefits management and value engineering approaches and which governance mechanisms interplay in the front-end of infrastructure projects. Next, the semi-structured interviews aim to understand how actors currently conduct value engineering at the front end of built environment projects. After that, the cumulative cross-case analysis supplies a project governance process aimed at identifying and planning value, accompanied by the appropriate governance mechanisms, at the front-end of infrastructures. Once developed, the strategy leads to an expert workshop aiming to validate the suggested process in terms of feasibility and practicality.

Executive Summary

Introduction

A debate spanning the last two decades highlights the need to achieve other value types to meet the actors' expectations and broader organizational goals, such as strategic value, but it remains uncertain what value creation means in a multi-actor context. Consequently, a new management approach may be required to adequately cope with these types.

The value engineering approach, later adjusted under the term 'value management,' achieves desired functions at the lowest cost through a set of workshop activities. This approach's imitations mainly include limited exploration of value beyond functionalities, assumption of constant function over time, and comparison of alternative design solutions solely in terms of cost. Integrating value engineering with benefits management could expand what value means and identify additional impacts at an additional cost. However, benefits management has limited applicability to infrastructure projects due to inconsistent definitions and perceptions regarding governing value. Although the literature lacks an understanding of the governance mechanisms, they are crucial in ensuring alignment among the actors' value expectations. Consequently, such an approach requires more research on corresponding processes, and governance mechanisms for successful implementation.

Research objective

Extensive research was conducted in this study to answer the main research question:

'*How can value engineering be integrated with benefits management in the front-end of infrastructure projects, accompanied by the appropriate governance mechanisms, to consider value more holistically?*'

To answer the main research question, four sub-questions are formed, which are as follows.

SQ1: What are value engineering and benefits management in the front-end of infrastructure projects?'

SQ2: 'How can governance mechanisms be conceptualized in the context of infrastructure projects?'

SQ3: 'How is value engineering currently conducted in the front-end of built environment projects?'

SQ4: 'What steps should be carried out to expand value engineering with benefits management to assist practitioners in considering value more holistically in the front-end of infrastructure projects?'

Research strategy and methods

The research utilized a multiple-case study strategy, including data triangulation (i.e., interviews and documents), to investigate the value engineering multi-phase process, the actors' perspectives, and the governance mechanisms in infrastructure projects. The four methods used were a literature study, semi-structured interviews, cumulative cross-case analysis, and a workshop. The goal was to develop a project governance process that considers value more holistically at the front-end of infrastructure projects by merging both the theoretical and empirical results.

Results and Analysis

The cases' workshop activities were structured into seven phases: preparation, information, function analysis, creative, evaluation, development, and presentation. The governance mechanisms used included coordination, building-capability, goal-setting, monitoring, and roles & decision-making.

The suggested project governance process involves several workshop activities and governance mechanisms to help practitioners consider value more holistically by defining value in terms of impact and then working backwards through a multi-phase process, where all the end-results are documented into a benefits realization plan and a business case, and reported to the project clients, such as directors. This process is divided into eight phases: usefulness & necessity phase, preparation phase, information phase, outcome and impact analysis phase, creative phase, evaluation phase, development phase and presentation and reporting phases. These are illustrated in Figure 4.1 in the original document.

An expert workshop validation confirmed the suggested process' feasibility for implementation because all phases are clearly explained. To make the process more practical, experts' recommendations included linking these phases with work packages, conducting risk analysis

before the "creative phase" (workshop activity), and making it more visually appealing through a flowchart full of icons (or colours) to help technical actors better understand it.

Discussions

- The cases' front-end decision-making considered long-term value to some degree but was restricted by value engineering limitations, which may not achieve desired value due to a lack of considering additional impact-oriented parameters.
- This discussion focuses on the limitations identified in selected infrastructure project cases, aside from value's limited exploration beyond functionalities.
- Market actors, such as suppliers, provided specialized advice during the front-end workshop activities towards better defining the cases' scope (e.g., less uncertainty) due to everyone's desire to deliver long-term value.
- Selected cases propose solutions to policy problems through front-end decision-making by justifying case needs as solutions to policy problems through their workshop activities.
- All cases followed the same logic as the value engineering approach to achieve the highest value possible aligned with actors' expectations and project goals through workshop activities, despite some flexibility observed in practice.
- Governance mechanisms play an essential role in aligning actors' value expectations, where specific key performance criteria, regular meetings, actor contributions towards specifying criteria, and appropriate communication levels were identified as factors contributing to goal-setting, monitoring, roles & decision-making, and coordination dimensions.
- The benefits management approach could complement the value engineering approach by exploring additional parameters beyond functionalities and unlocking more opportunities to better cope with the changes in the landscape or balance competing value expectations but presents various challenges such as evaluating impact.

Research Limitations

There were a few research limitations, including a disregard for value at different levels of analysis and a lack of interviews with participants from other organizations, such as environmental authorities. Additionally, value was considered from a single period of time, regardless of its dynamic behavior. Finally, there was limited in-depth investigation on governance mechanisms.

Conclusion

Integrating the benefits management and value engineering approaches can be achieved by incorporating them into the already-established value engineering multi-phase process. This requires considering all scales along which value evolves, starting from impact, and evaluating them once identified. By doing so, actors are equipped to take more parameters into account, mitigating the uncertainty between expected and realized value. Additionally, governance mechanisms play a crucial role in aligning all actors' expectations towards achieving high-value goals by bringing them together towards a shared goal.

Recommendations for practical implementation

To develop an impact-oriented mindset in the organization, it is recommended to conduct regular workshops across all departments to raise awareness and educate employees on the importance of adopting such a mindset. Additionally, recognizing that this requires time and effort from all employees is essential. The executive board and business lines can help drive this by maintaining impact as a strategic goal. Nevertheless, departments must also take responsibility for adjusting their work to better incorporate impact considerations. A feedback loop through reflective discussions in a regular basis can contribute in additional value. Organizations should maintain impact-oriented decision-making from the outset of every project, even if the client does not request it. Making impacts the prominent reason for undertaking any work is critical. Finally, impacts should be emphasized by merging them sustainably towards an end-goal. Since different impacts often compete with each other, properly integrating them can reduce resources required while still achieving desired results. In addition, assurance measures may be necessary to increase the likelihood of successfully implementing the proposed process.

Suggestions for further Research

To further enhance the study's outcomes, it is recommended to interview participants from various organizations, such as authorities, to gain more comprehensive insights into value creation. Additionally, exploring value dynamically by considering the expected impacts over different time periods could unlock additional value. Finally, conducting an in-depth investigation of governance mechanisms may reveal new insights for aligning actors' expectations towards achieving goals.

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Chapter 1

Introduction

This chapter sets the scene for the following research. Sections 1.1 and 1.2 define the context and problem statement. Sections 1.3 and 1.4 present the research aim and the main question. Finally, the chapter concludes with the research relevance and outline in sections 1.5 and 1.6, respectively.

1.1 Context

Traditionally, projects were considered output-oriented vehicles and judged against tangible values such as budget, time, and a defined quality (Andersen, 2016; Atkinson, 1999; Green & Sergeeva, 2019; Haddadi et al., 2016). A debate spanning the last two decades emphasized the need to consider other value types to meet the actors' expectations and broader organizational goals, such as strategic value (Atkinson, 1999; Martinsuo & Killen, 2014). The example of strategic value refers to a set of long-term objectives, such as ecological, economic, social, and safety (Martinsuo & Killen, 2014). Although value equals the balance between the realized impact over the resources used, it remains uncertain what value creation exactly is in a multi-actor context due to the actors' different perceptions (Laursen & Svejvig, 2016; Musawir et al., 2017; PMI, 2019). Due to the critique that projects like infrastructures still fail to meet these types, a new management approach may be required to adequate cope with them (Martinsuo & Killen, 2014; Mehta & Kiridena, 2019; Musawir et al., 2017).

Value engineering (VE) is a management approach used to achieve the desired functions (the term function represents what it should perform instead of what it is) of a project, service, or product at the lowest cost (Mousakhani et al., 2017; Rad & Yamini, 2016). The approach's primary intention is to achieve the highest value possible for the predetermined costs aligned with the actors' expectations and project's goals. This is achieved through a systematic analysis, accompanied by several workshop activities, to increase value while maintaining or reducing the resources used (Kelly, 2007; Rad & Yamini, 2016). In the early 1990s, the mentioned approach was adjusted, under the term value management (VM), to carry out proactively and reactively the actors' functional-oriented expectations by conducting the workshop activities among multi-organizational actors rather than the value engineers only (Green & Sergeeva, 2019; Kelly, 2007; Mousakhani et al., 2017).

There is no argument against the value engineering approach's potential to maximize value when carried out in the front-end phase (El-Din Helal et al., 2018; Mousakhani et al., 2017). Otherwise, if used later, additional costs are likely for necessary alterations and possible conflicts for change (El-Din Helal et al., 2018). Although the front-end definition varies in the literature, it typically includes all the activities, from conceiving the project's idea to the final investment decision (Williams & Samset, 2019). Notably, the front-end phase is crucial for value creation in infrastructure projects since the uncertainty and lack of information on the decisions made can influence the project's destiny. This is mainly due to the actors' complex and social-oriented ideas regarding value (Williams & Samset, 2019; Zerjav et al., 2021).

Although the value engineering approach is intended to optimize impacts and costs, emphasis was placed on reducing costs rather than increasing impacts (Laursen & Svejvig, 2016). Impacts, also called benefits, represent the measurable highest alterations that affect organizations, stakeholders, and the system, and it is the prominent reason for undertaking such projects (Laursen & Svejvig, 2016; Musawir et al., 2017; van Tulder, Seitanidi, Crane, & Brammer, 2015). This directs in acknowledging the value engineering approach's limitations. First, by defining value as functionalities over costs, the mentioned approach overlooks value beyond functionalities (Laursen & Svejvig, 2016; Rad & Yamini, 2016). Second, it is taken for granted that the relevant functionalities remain constant over time (Green, 1994). However, value evolves dynamically over the project's lifecycle and requires more effort to explore it (Martinsuo, 2020). Likewise, there is no doubt that such a dynamic behavior also depends on the actors' additional preferences due to continuous learning (Green & Sergeeva, 2019). Third, there is an assumption that each alternative design solution supplies an analogous level of performance, directing their efforts in cost comparisons only (Green, 1994). However, values often compete with each other, meaning one change will affect others (Martinsuo, 2020). Fourth, value engineering tends to strengthen the interests of the critical actors in contrast to others. This is achieved by steering the process toward meeting those actors' vested interests whether others participate. Fifth, by deemphasizing the significance of facts and logic, there is a tendency to prioritize the accomplishment of an effortless agreement in seclusion of any engagement with the proof, which would be difficult for others to defend. For instance, actors are typically highly experienced at mobilizing externally assembled scripts to serve their individual interests (Green & Sergeeva, 2019).

In recognition of the limitations above, adopting a holistic management approach that combines value, impacts, and costs instead of separating them would expand what exactly value means and identify and plan additional value (Laursen & Svejvig, 2016). Therefore, the potential solution relates to integrating the value engineering approach with an emerging approach: the Benefits Management (BM). Benefits management ensures the achievement of the different types and levels of impacts through a set of processes in the context of projects, programs, and portfolios (Musawir et al., 2017). Such an approach takes place over the entire lifecycle because its processes comprise identifying and planning the expected impacts and subsequent tracking, reviewing, and aligning them with the actors' needs until realized. Benefits management has been limitedly applied in infrastructure project practice, and client organizations generally struggle with its implementation, whereas only a few do it comprehensively (Mehta & Kiridena, 2019; Musawir et al., 2017). This is because actors often have an inconsistent way of identifying and planning the expected impacts due to various definitions and perceptions of the terms' value' and 'impact' developed by them. Furthermore, organizations may struggle to gain acceptance of such an approach due to implications that can affect their strategies in different levels and management domains, such as operational and value management (Breese et al., 2015).

Extending the notion of the benefits management approach, pursuing the appropriate project governance mechanisms is one of the most crucial factors in facilitating its adoption and successful implementation by creating roles, responsibilities, and accountabilities (Mehta & Kiridena, 2019; Musawir et al., 2017). The importance lies in ensuring that outputs and outcomes are continuously aligned with the expected impacts envisioned at the front-end (Musawir et al., 2017). The boundaries of the present research focus on the front-end as it requires a fundamental endeavor to ensure that infrastructure projects are selected, designed, and generated to the greatest extent possible (Mehta & Kiridena, 2019).

1.2 Problem Statement

The value engineering approach, later adjusted under the term value management, is a management approach used to achieve the desired functions of a project, service, or product at the lowest cost through a multi-phase process (Kelly, 2007; Mousakhani et al., 2017; Rad & Yamini, 2016). The approach's limitations include the limited exploration of value beyond functionalities, the assumption that functions remain constant over time, and the assumption that each alternative

design solution supplies an analogous level of performance and can only be compared in terms of cost (Green, 1994; Green & Sergeeva, 2019). Additional limitations include the actors' effort to strengthen the key actors' interests and to prioritize the accomplishment of an effortless agreement in seclusion of any engagement with the proof (Green & Sergeeva, 2019).

Integrating the value engineering and benefits management approaches could potentially expand what exactly value means and identify and plan additional value (Laursen & Svejvig, 2016). This can be achieved, for example, by considering more impacts at an additional cost (Laursen & Svejvig, 2016; Musawir et al., 2017). However, the benefits management has limited applicability to infrastructure projects because of the actors' inconsistent definitions and perceptions regarding value creation and its potential to affect their strategies in different levels and domains (Breese et al., 2015). In addition, the appropriate project governance mechanisms, one of the most crucial factors, aim to ensure that project outputs and outcomes are continuously aligned with the impacts envisioned at the front end (Musawir et al., 2017). Consequently, such an approach requires more research not limited to the corresponding processes but also the appropriate governance mechanisms. Despite the lack of current literature to understand these mechanisms, they are essential to facilitate their adoption and successful implementation (Mehta & Kiridena, 2019; Musawir et al., 2017).

1.3 Research Aim

The aim of this research is threefold:

- Understand what the value engineering and benefits management approaches are and which governance mechanisms interplay in the front-end of infrastructure projects.
- Understand how actors currently conduct value engineering at the front end of built environment projects.
- Develop a practical project governance process to consider value more holistically, accompanied by the appropriate governance mechanisms, at the front-end of infrastructures.

1.4 Research Question

The mentioned problem description leads to the main research question, which is as follows:

'*How can value engineering be integrated with benefits management in the front-end of infrastructure projects, accompanied by the appropriate governance mechanisms, to consider value more holistically?*'

To answer the main research question, four sub-questions are formed, which are as follows.

SQ1: What are value engineering and benefits management in the front-end of infrastructure projects?'

SQ2: 'How can governance mechanisms be conceptualized in the context of infrastructure projects?'

SQ3: 'How is value engineering currently conducted in the front-end of built environment projects?'

SQ4: 'What steps should be carried out to expand value engineering with benefits management to assist practitioners in considering value more holistically in the front-end of infrastructure projects?'

1.5 Research Relevance

1.5.1 Academic Relevance

Integrating the value engineering and the benefits management approaches could potentially add more value to infrastructure projects. This is mainly due to the consideration of impacts at an additional cost by combining value, costs, and impacts rather than maintaining or reducing costs (Laursen & Svejvig, 2016). Extending upon, pursuing the appropriate governance mechanisms promises the outputs' and outcomes' alignment with the impacts envisioned at the front-end (Musawir, 2017). Consequently, research requires the development of an integrated project governance process, accompanied by the corresponding processes, and governance mechanisms, ensuring that the value types envisioned at the front-end are identified and planned to the greatest extent possible (Mehta & Kiridena, 2019; Musawir et al., 2017).

1.5.2 Practical Relevance

Integrating an approach that combines value engineering and benefits management at the front-end of infrastructure projects can lead to better-informed decisions, higher quality results, and more meaningful and sustainable outcomes for all involved actors. This is due to the collaboration between facilitators such as value engineers at Witteveen+Bos and other multi-organizational actors who work together to identify cost-saving opportunities and ensure that selected options will deliver measurable impacts over the project's entire lifecycle. This integrated approach allows for a more thorough analysis of alternatives and their impacts, potentially reducing uncertainty in decision-making by considering additional parameters. Consequently, additional value is likely to circulate broadly to all actors towards more meaningful and sustainable decisions in identifying and planning value (Laursen & Svejvig, 2016).

1.6 Report's Outline

- **Chapter 2** (Research Design) presents the research design from start to finish, including the research strategy, methods, case selection, and research validity.
- **Chapter 3** (Theoretical Background) briefly describes project value, project front-end, benefits management and value engineering approaches, and governance mechanisms in infrastructure projects. Finally, the chapter concludes with a conceptual framework as a graphical representation that combines all the aspects addressed.
- **Chapter 4** (Results and Analysis) provides the qualitative analysis of results from each study case, accompanied by a brief description and the main lessons. After that, the results are analyzed through a cumulative cross-case, where a project governance process is developed. Finally, the chapter presents the suggested process' results derived from an expert workshop validation.
- **Chapter 5** (Discussions) consults the interpretations and implications of the theoretical and empirical results, and the research limitations.
- **Chapter 6** (Conclusions) concludes with brief responses to the main research question and sub-questions, recommendations for practical implementation, and suggestions for further research.

Chapter 2

Research Design

This chapter presents the research design, including the research strategy in section 2.1, and a comprehensive description of the research methods, case selection, and research validity in section 2.2.

2.1 Research strategy: multiple-case study

The strategy consisted of a multiple-case study to answer the main research question. Such a strategy was suitable since it allowed for an extensive investigation of the value identification and planning process, the actors' diverse perspectives regarding governing value, and the governance mechanisms across different cases. To increase the reliability of the insights, data triangulation, including interviews and documents, was utilized for each case toward a comprehensive analysis. The research strategy included four methods: a literature study, semi-structured interviews, cumulative cross-case analysis, and a workshop (Yin, 2003; Yin, 2018). Figure 2.1 portrays the entire sequence of research activities.

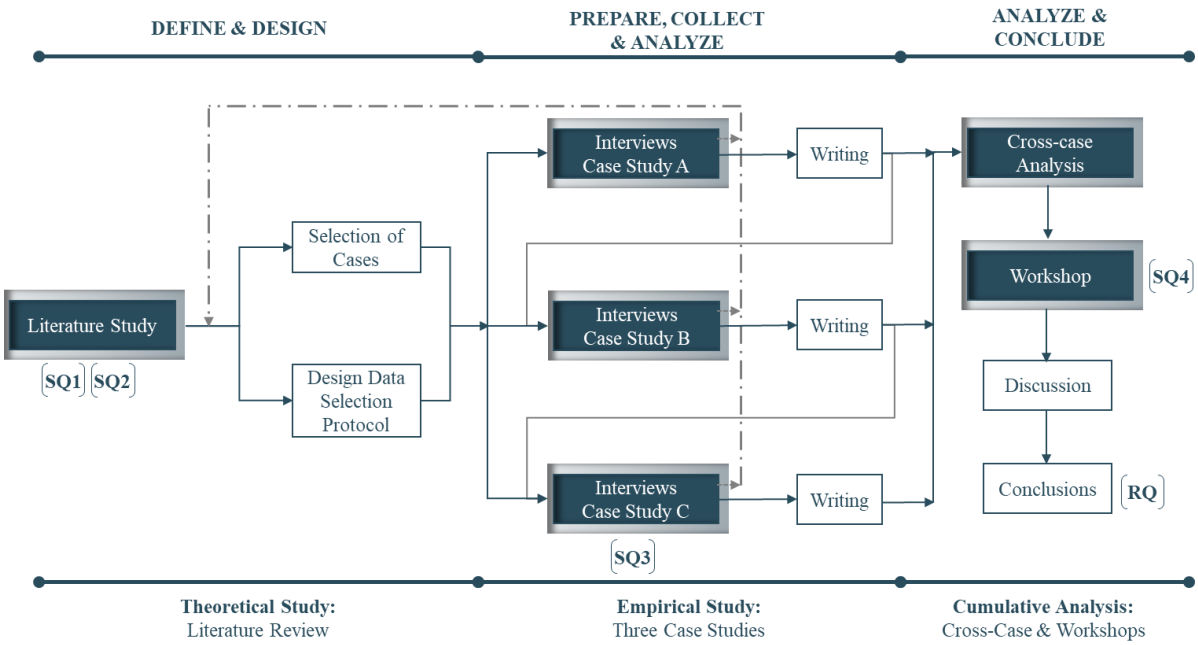

Figure 2.1 Research Strategy (Own illustration: Based on Yin, 2003; Yin, 2018).

The "Define & Design" phase consisted of the literature study, the selection of suitable cases, and the data collection process. Then, the "Prepare, Collect & Analyze" phase contained a whole study for each case via semi-structured interviews and documents, in which merging evidence pursued the results for each case. The dotted line represented a feedback loop and was only required if a sudden discovery indicated a misalignment of any case with the initial design. After that, the "Analyze & Conclude" phase contained a cross-case analysis in a cumulative way, where the appropriate results developed into a project governance process at the front-end of infrastructures and further validated through an expert workshop validation. Furthermore, discussions consulted specific points regarding the theoretical and empirical research results, and limitations. Finally, the conclusions exhibited brief responses to the main research question and sub-questions, recommendations for practical implementation, and suggestions for further research (Yin, 2003).

2.2 Research Methods

2.2.1 Literature Study

An integrative approach was selected as a literature review type to answer the first and second sub-questions. Such a type was selected because it aimed to evaluate, critique, and integrate the theoretical research in a way that enabled a recent topic to emerge. This was achieved by combining theoretical relevant insights, such as processes and governance mechanisms, rather than covering all the aspects ever examined (Snyder, 2019).

The strategy for document identification comprised search terms, specific databases, and inclusion criteria. To increase the quality of document identification, each document was initially selected by combining at least three of the search terms provided in Table 2.1. This enabled the researcher to mitigate the uncertainty of selecting more suitable documents. Next, the databases included Google Scholar, TU Delft Library, and Project Management Institute Library. After that, the inclusion criteria contributed further to the identification of documents while enriching the quality of information. These included documents published within the last 15 years in the project management sector, emphasizing scientific journals, books, and governmental publications. Likewise, the focus was directed towards documents with a high reputation in project management, such as 'International Journal of Project Management,' 'International Journal of Architecture,' 'Engineering and Construction,' 'International Journal of Managing Projects in Business,' and

'Project Management Journal.' These criteria were selected since the document identification was more likely to accompany all the possible parameters to answer the mentioned sub-questions (Snyder, 2019).

'value creation,' 'value chain,' 'front-end,' 'benefits management,' 'project success,' 'road infrastructure,' 'project value types', 'infrastructure projects,' 'project stakeholders,' 'levels of analysis,' 'benefits realization,' 'infrastructure indicators,' 'operationalization,' 'project management,' and 'organizational strategy.'	'project governance,' 'governance,' 'infrastructure projects,' 'dimensions,' 'governance structure,' 'governance framework,' 'organizational theory,' 'effective project governance,' 'front-end,' 'benefits management,' and 'governance practices.'

Table 2.1 Search terms for SQ1 and SQ2

Furthermore, the option for conducting the literature review consisted of reading the abstracts of approximately 350 out of 600 collected documents concurrently with a quick scan, as these complied with the above criteria. Positive decisions were made to read the entire text of 110 documents. In parallel, an additional scan of identifying additional sources within these documents, serving the same purpose, occurred. To answer (SQ1) and (SQ2), a total of 31 documents were carried out for the final analysis (Snyder, 2019).

After that, an analysis occurred by abstracting information from each document to conceptualize a particular idea from a theoretical perspective and findings. Following the reviewers' perspectives, including academics and practitioners with adequate expertise in the subject of study, the analysis process only required a detailed description of each abstracted information. Nevertheless, a common terminology was used to cope with the different terms in the documents. Concerning the non-strict standards within the integrative approach, a qualitative analysis was used to provide a holistic view of the topic. This was achieved by grouping insights from diverse sources representing similar themes or concepts toward richer conclusions, enabling the researcher better to understand their commonalities (Snyder, 2019). Lastly, the literature was critically written by breaking down the subject of study into four sections to strengthen further those not complete in

the literature (Torraco, 2015). Likewise, these sections contributed to the reviewers' understanding of each section's purpose.

2.2.2 Selection of Cases

The empirical segment of the study pursued to understand how actors currently conduct value engineering at the front end of built environment projects. Hence, three case studies were incorporated, each predicting similar and contrasting results but for predictable reasons, elaborated in the cases' criteria (Yin, 2003). The cases' selection criteria were the following:

- **Interorganizational projects with infrastructure and area development objectives initiated by public clients.** This is because public clients in area development projects often try to enrich their decision-making of impact-oriented objectives by engaging multi-organizational actors, such as future residents and market suppliers. Furthermore, infrastructure projects were selected to extensively investigate the different organizations' perspectives regarding value engineering at the front-end as the current research focuses.
- **The value engineering approach was carried out for each case's value identification and planning.** As discussed in section 1.1, many organizations struggle with implementing the benefits management approach. This is because of their often-inconsistent way of governing value and possible implications to affect their strategies, which results in a lack of diffusion of the corresponding processes and governance mechanisms (Breese et al., 2015; Mehta & Kiridena, 2019; Musawir et al., 2017). Following that, the value engineering approach was selected to obtain an adequate understanding of the organization's already multi-phase process. This enriched the potential of the benefits management principles to emerge if adjusted to organizations' already-used approach.
- **The location of the selected cases shall be in the Netherlands.** This is because the present research is positioned in the Dutch sector.

Based on the criteria mentioned above, the following three case studies were selected for the multi-case study analysis, and their suitability is presented in Appendix A1:

- **Case A**: New Connection N69 **| Client**: Province of North-Brabant
- **Case B**: Area development Floriade **| Client**: Municipality of Almere
- **Case C**: Area Development Lincolnpark **| Client**: Municipality of Haarlemmermeer

2.2.3 Semi-structured interviews

The semi-structured interviews aimed to answer the third sub-question. The main purpose of this method was to collect data in an organized manner while allowing some investigation when unexplored insights emerge. This is because it uncovered unknown issues and addressed complex topics broadly. Furthermore, participants were allowed to unveil themselves by providing insights in their own way. Consequently, semi-structured interviews resulted in a deeper understanding of their perspectives on the project governance process, which may not have been achieved otherwise (Wilson, 2014).

Once the purpose of the semi-structured was determined, then the process led to the participants' selection criteria which are the following:

- **They were involved in the governance of the project during the front-end phase**. This criterion was selected since they have knowledge about the value engineering approach and governance mechanisms used to achieve the predetermined objectives. Their roles included process managers, project senior managers, contract managers, stakeholder managers, technical managers, project managers, and more technical actors, such as sustainability advisors.
- **They comprised various roles within the front-end phase of the project**. This was selected to thoroughly explore their perspectives since value engineering is a joint collaborative approach. However, emphasis was placed on participants, such as (certified) value engineers, since they have more engagement in governing value identification and planning.
- **They shall have at least three years of experience**. This criterion was selected to mitigate the uncertainty of gathering insights which may not accompany as many additional parameters that could have been gathered by more experienced participants.

After that, the amount of semi-structured interviews was determined based on the data saturation, which indicates that no additional insights are identified, and data begin to repeat. Data saturation is an essential indicator of an adequate understanding of the project governance process, followed by the participants' perspectives (Hennink & Kaiser, 2022). As discussed in section 2.1, data triangulation, including semi-structured interviews and important documents, further enriched the

insights' reliability. Consequently, nine participants from different organizations were interviewed, and their insights were found adequate in understanding how actors conduct value engineering in the front-end of projects. The number of participants was determined due to their lack of unlocking additional value, which equals the data repetition over the researcher's interview protocol.

The process related to the participants' invitation was twofold. First, a message was sent out to participants by mail, briefly explaining the researcher's role, the name of the person who suggested them, and the scope of the semi-structured interviews. Participants were kindly asked whether they wanted to contribute further during that mail. Positive replies about their willingness to participate requested that the researcher suggest a few possible dates or directly invite them through their agenda. Second, an Outlook invitation was sent to them containing the informed consent set by the Human Research Ethics Committee (HREC). Participants were asked to sign that document and be returned back to the researcher before conducting the interviews. This document included the scope of the general agreement, including their voluntary participation, goals, potential risks (e.g., data exposure), the research's publications (e.g., TU Delft repository), dissemination (i.e., pseudonymized data before usage), and permission of reusing data for further research.

Although interviews were conducted in a hybrid version, online and physically for 60 minutes or more, they were all recorded in Microsoft Teams. The hygiene factors for conducting all interviews comprised a quiet and comfortable environment (e.g., a meeting room), a well-structured interview protocol, clear communication, and the availability of the required resources (e.g., a laptop). The interview started with a brief introduction about the researcher's background and the research's overall topic. Then, participants were asked general questions about their background, experience, and responsibilities. That enabled the researcher to understand their roles in the specific case further. After that, detailed questions were asked about the project governance process related to value identification and planning and the governance mechanisms aimed to achieve them. The questions concluded with the participants' lessons and what decisions would have been made differently. The interview protocol used for conducting the semi-structured interviews can be found in Appendix A2. The protocol was developed by considering several questions to cover the different topics related to the value engineering approach process and the governance mechanisms studied in the literature. This was because the participants were familiar with such an approach,

however, additional questions were followed. At the end, participants were asked whether they wanted to validate the extracted transcripts to ensure that that information was precise. A list of the participants can be found in Appendix A3. Therefore, the already-used approach and the project governance framework delineated in the literature study piloted the analysis structure and built solid foundations for this research's later stages.

2.2.4 Cumulative Cross-case Analysis

The purpose of the cumulative cross-case analysis was to partly answer the fourth sub-question. This method was selected for developing a project governance process at the front-end of infrastructure projects by merging this study's theoretical and empirical results.

The analysis of the developed process was in two parts. The first part was related to the empirical research results most suitable for infrastructures through an examination across the selected cases. These results were based on the organizations' already-used value engineering approach and the governance mechanisms carried out at the front-end. Furthermore, the lessons learned from each case contributed as more emphasis was placed on certain phases that required to be strengthened. The second part was related to the theoretical research results aligned with the principles of the benefits management approach. These principles were related to the holistic identification of value by adequately considering the terms of value, outputs, outcomes, impacts, and costs. To adequately serve this purpose, the benefits management products addressed in the literature were incorporated: the benefits register, benefits map, benefits realization plan, and business case.

The project governance process was developed into a flowchart with an extensive description of different phases and end products. In addition, the appropriate governance mechanisms were incorporated into the suggested process.

2.2.5 Workshop

Following the suggested project governance process developed, the workshop aimed to validate it. This is because the workshop enhanced the validity and reliability of such a process by collecting valuable insights based on the experts' experience, expertise, values, beliefs, and attitudes through a reflective group discussion. The planning to conduct it required adequately

addressing the experts' participation, social processes, and technical considerations (Freytag & Young, 2017).

Four experts from Witteveen+Bos participated, including two (certified) value engineers and two project managers. Such a selection was due to their diverse perspectives and the robust roles and responsibilities they have at the front-end of projects. The workshop was conducted in a hybrid version at the offices at Witteveen+Bos: Breda and Amsterdam for 90 minutes. Such a workshop mainly included a group discussion, where a set of questions was asked. A large monitor illustrated the suggested process through a PowerPoint presentation, facilitating the dialogue by visualizing its process (Freytag & Young, 2017).

In addition, experts were asked to reflect on the suggested process, accompanied by a set of questions. These questions were categorized into pre- and post-workshop surveys, and their reflection allowed for valuable and holistic insights. The facilitated workshop was divided into five sections to fully explore the participants' perspectives and identify opportunities and issues. The first section included the purpose and permission for their consent by reading all the points addressed in the informed consent for the semi-structured interviews. Secondly, a quick overview of the researcher's thesis journey and an explanation of some key terms used in the literature occurred since it contributed to a more efficient understanding of the following sections. Third, the pre-workshop survey emerged, where participants were asked to reflect on questions related to the extent these terms are actively managed by them and to what extent they find their current value engineering approach effective. Such a pre-workshop survey was essential as it enabled the researcher to better evaluate the added value of the suggested process during the analysis. Fourth, an extensive description of each phase of the suggested process occurred, including all the aspects incorporated. Lastly, the workshop concluded with the post-workshop survey, where participants were asked to reflect on the extent to which they find the suggested process feasible and practical for implementation, accompanied by suggestions for further improving it (Freytag & Young, 2017).

2.2.6 Research Validity

To make sure that the evidence of the multiple case study was validated and reliable, three principals related to data collection were considered, and these are the following (Yin, 2003):

- **The usage of multiple sources**: Different sources of evidence were considered for the selected case studies by using data triangulation. It consisted of important and often confidential documents (e.g., contract documents) and interviews with different roles at the front-end toward a more comprehensive analysis.
- **Develop a collection database**: All data were stored on the researcher's personal OneDrive at Witteveen+Bos since these were securely stored with access control within the company. That way, some of the collected data (e.g., participants' contact information) remained protected in the first place. Then, they were pseudonymized before usage in academic and practical publications and presentations. Likewise, a TU Delft storage (project drive) was developed to facilitate access to the data by the university committee. Data collection, analysis, and storage conformed with the Human Research Ethics Committee (HREC) guidelines of TU Delft.
- **Maintain a chain of evidence**: The collected evidence was organized so that the involved contracting parties of this research (i.e., TU Delft and Witteveen+Bos) could follow the derivation of any evidence along the entire research. That way, they could easily trace the reliability and validity of evidence.

Chapter 3

Theoretical Background

This chapter provides an overview of the theoretical background of the research. Sections 3.1 and 3.2 briefly discuss project value, accompanied by a benefits map, and the project's front-end importance for value creation. Then, sections 3.3 and 3.4 present the value engineering and benefits management approaches, respectively. After that, section 3.5 presents a framework for better grasping the different governance mechanisms that interplay in infrastructures. Finally, the chapter concludes in section 3.6 with a conceptual framework as a graphical representation that merges all the aspects addressed.

3.1 Project Value

The (project) value equals the net result of the realized impact minus the resources used to achieve it (Martinsuo et al., 2019; PMI, 2019). Extending the concept of value, it is a multifaced phenomenon that evolves across different scales and is observed in different levels of analysis, followed by the actors' often diverse viewpoints (Martinsuo et al., 2019; Vuorinen & Martinsuo, 2019; Zerjav et al., 2021).

Although value is the prominent reason for undertaking any project like infrastructure, the literature lacks a holistic definition and conceptualization of (project) value as these currently vary (Martinsuo et al., 2019; Zerjav et al., 2021). For that reason, van Tulder et al. (2015) developed a framework that chains the evolvement of value along its different scales. Once the inputs and activities by organizations have been determined, value evolves sequentially through the scales of outputs, outcomes, and, ultimately, impacts. Outputs represent the deliverables or results accomplished through a set of inputs and activities measured within the partnership. These are based on three criteria and the extent to which these have been achieved, including the actors' individual objectives, the project's objectives, and the goals' alignment. Then, outcomes simulate the effects or alterations derived from outputs measured within the broader community. Unlike outputs, these are much more inclusive of whether the anticipated output effects have been achieved (Laursen & Svejvig, 2016; van Tulder, Seitanidi, Crane, & Brammer, 2015). Finally, impacts represent the ultimate effects derived from outcomes, measured within the level of actors, the stakeholders, and the system (Fujiwara & Dass, 2020, p.7; Laursen & Svejvig, 2016; van

Tulder, Seitanidi, Crane, & Brammer, 2015). These outcome effects, seen as positive or negative specific impacts, contribute to achieving intermediate impacts, which in turn are further realized into end impacts and ultimately help to achieve more strategic objectives (goal/impact) in a collective way (Breese et al., 2015; Infrastructure and Projects Authority, 2017).

In addition, impacts seen as modifications are increments in the project's value from not only a shareholders' perspective but also from others (Breese et al., 2015). Specifically, value is studied in different levels of analysis, including micro (i.e., individual, team), meso (i.e., organizational), and macro (i.e., society, industries, networks) (Laursen & Svejvig, 2016). These levels articulate the actors' objectives, individually or in groups, which better indicate the public, private, and non-profit actors' varying perceptions about what constitutes value due to their differences in interests, organizational backgrounds, and knowledge (Ang & Biesenthal, 2017; Martinsuo, 2020; Martinsuo et al., 2019; Vuorinen & Martinsuo, 2019; Zerjav et al., 2021). Figure 3.1 depicts the project's value conceptualization through a graphical representation.

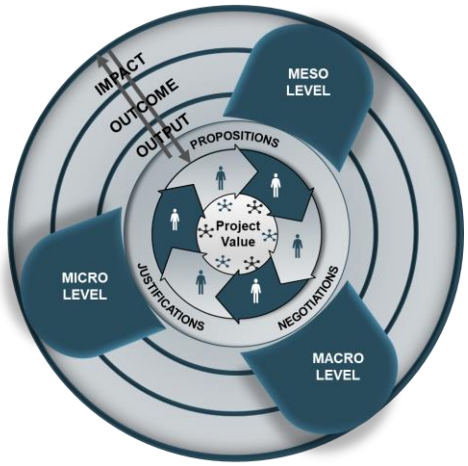

Figure 3.1 A graphical representation of Project Value (Own illustration: Based on Laursen & Svejvig, 2016).

Expanding upon the mentioned section, Figure 3.2 illustrates the different value types that interplay in infrastructure projects such as roads through a benefits map. The benefits map provides a graphical representation, including outputs, outcomes, impacts, and their interdependencies (PMI, 2019).

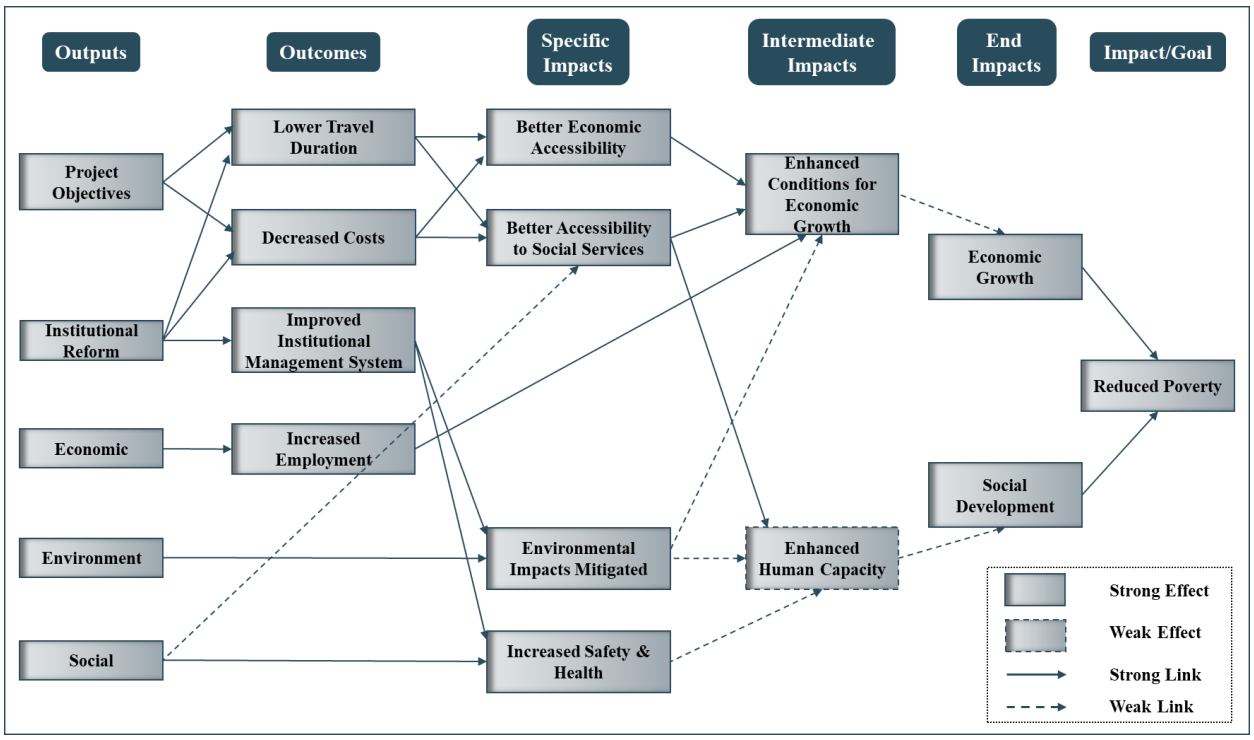

Figure 3.2 A Generic Benefits Map (Own illustration: Based on Zamojska & Próchniak, 2017).

A holistic management approach, such as benefits management presented in section 3.4, can only be effective regarding the project's success and strategy if the key actors, such as project clients, adopt an impact-oriented mindset around value. Furthermore, the narrative of the mentioned approach requires less emphasis on output-oriented values (Musawir et al., 2017). This mainly relates to enriching those actors' perspectives by emphasizing the impacts likely to affect the most and their interdependencies (Fujiwara & Dass, 2020, p.11).

3.2 Project front-end

Infrastructural strategic decisions for value creation are made in the early phases of the project's lifecycle, also known as the project front-end. The front-end typically includes a set of activities, from conceiving the project's idea to the final investment decision (Martinsuo et al., 2019; Williams & Samset, 2019).

The front-end phase, which occurs before the project starts, describes the project (Williams & Samset, 2019). This is because the decisions are based on two main areas: whether to proceed with the project's investment and the identification and planning of the corresponding goals, objectives

and expected value (Martinsuo et al., 2019). The organization that starts the project and intends to achieve the mentioned expectations is typically called the 'permanent organization.' Once these have been identified and planned, the 'temporary organization' undertakes the project's delivery, which is handed back to the permanent organization. Although there is a distinction between them (see Figure 3.3), the actors responsible for delivering the project may have already been included in the front-end to equip the permanent organization with advice about the process or the corresponding activities (Williams & Samset, 2019). Thus, the front-end is where the preliminary project's idea emerges based on the actors' interests recognition, which leads to an analysis of the corresponding opportunities, threats, problems, needs, and values and recognizes the actors' interests (Toukola et al., 2023; Williams & Samset, 2019). There is no argument against the existence of little information about the desired expectations, accompanied by high uncertainty (Williams & Samset, 2019).

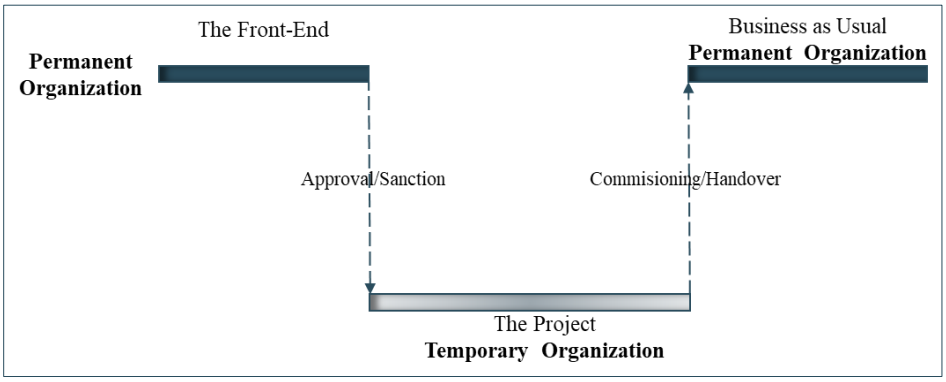

Figure 3.3 The front-end phase relationship (Based on Williams & Samset, 2019).

The front end is considered the most crucial phase for opportunities for value creation due to the strategic decisions made about the expected value (Liu et al., 2019; Williams & Samset, 2019). Notably, the front-end phase is crucial for value creation in infrastructure projects since the uncertainty and lack of information on the decisions made can influence the project's destiny (Zerjav et al., 2021). This is mainly due to the complex and social-oriented ideas of value (Williams & Samset, 2019; Zerjav et al., 2021). These ideas relate to the actors' often diverse viewpoints on value, which require them to interact and collectively contribute their ideas for value creation (Toukola et al., 2023). Consequently, the front-end phase requires a fundamental endeavor to ensure that infrastructure projects are selected, designed, and generated to the greatest extent

possible (Mehta & Kiridena, 2019). If actors underestimate its importance, various problems will likely occur in the later phases, such as additional costs, overruns, inadequate quality, and impact shortfall (Williams & Samset, 2019).

3.3 Value Engineering

As discussed in section 1.1, value engineering is an approach used to achieve the desired functions of a project, service, or product at the lowest cost (Mousakhani et al., 2017). This approach comprises eight phases: preparation, information, function analysis, creative, evaluation, development, and presentation (Mousakhani et al., 2017; Ramdien, 2016). Figure 3.4 presents the framework utilized to carry out the value engineering approach.

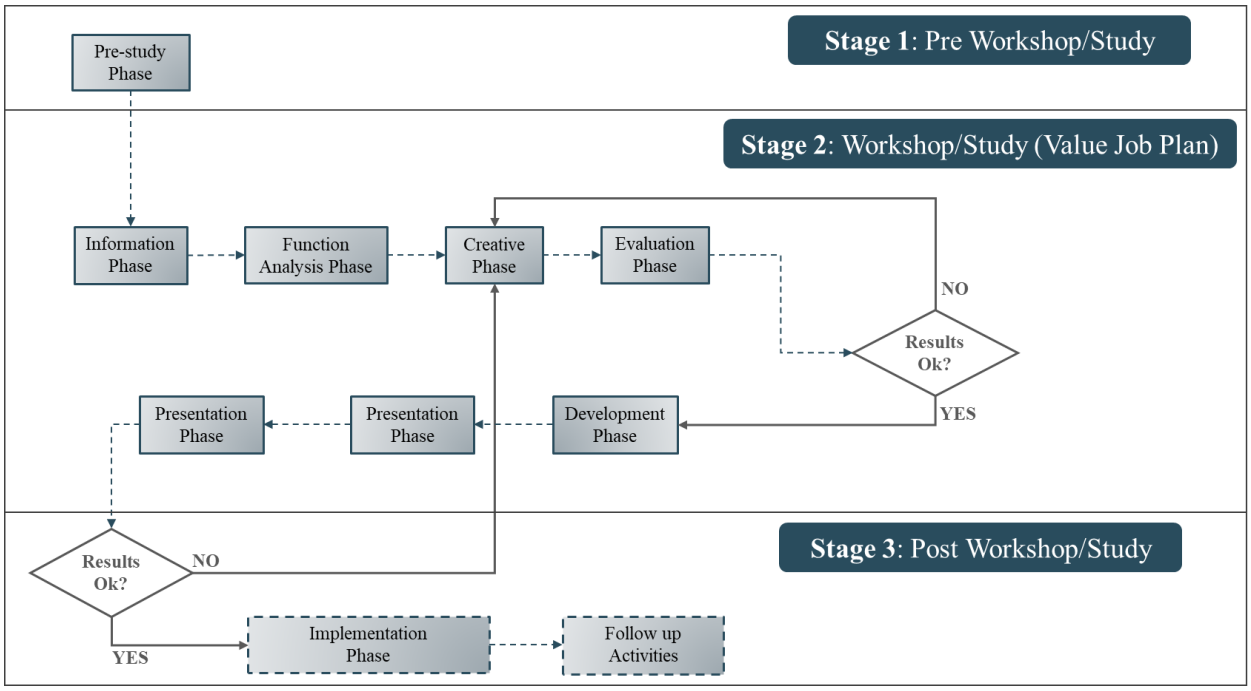

Figure 3.4 Value Engineering Framework (Based on Mousakhani et al., 2017; Green, 1994).

The "preparation phase" requires the value engineers to draw up a plan for the workshop activities and collect all the information necessary to bring the study to a good result (Mousakhani et al., 2017; Ramdien, 2016). Recognizing and engaging all the interest actors is crucial since it will enrich decision-making (Green, 1994). Once completed, the workshop activities start with the "information phase" (project definition and goals), which aims to equip the involved actors with equal knowledge of the problems, issues, bottlenecks, and each other's often diverse interests.

Then, the "functional analysis phase" (function definition and analysis) requires those actors to focus on the functionalities using the Function Analysis System Technique (FAST). Such a technique enables them to distance themselves from the physical designs, where there are questions related to the desired functionalities (e.g., what should the system do to connect ecological areas), which are further deepened (e.g., how large the animal population is). After that, the "creative phase" (identification of alternatives) directs actors to generate as many design solutions as possible through brainstorming (Mousakhani et al., 2017; Ramdien, 2016).

Once the brainstorming is completed, the process leads to the "evaluation phase" (structured evaluation of alternatives), which requires selecting and prioritizing the identified ideas based on compliance with the predetermined criteria. Next, the "development phase" (development of alternatives into proposals) stimulates the selected ideas to be tested for feasibility, of which their costs are evaluated, and an implementation plan is developed for each. After that, the "presentation phase" (report/presentation of the opportunities) aims to present the results of these workshop activities among the involved actors, and each result is assessed (e.g., what performance do these deliver at what cost) (Mousakhani et al., 2017; Ramdien, 2016).

3.4 Benefits Management

Following the discussion in section 1.1, the benefits management approach defines value in terms of impact, and then it works backward by using different processes and project governance mechanisms (Musawir et al., 2017). In recognition of the approach's implementation over the project's entire lifecycle, the front-end benefits management literature is restricted to two process phases: benefits identification and benefits planning (Mehta & Kiridena, 2019).

Benefits Identification Phase

The benefits identification acknowledges that once a need has been determined, the project's concept needs to be formed and communicated to the involved actors, including governance, stakeholders, specialists, and managerial roles (PMI, 2019; Mehta & Kiridena, 2019). Their early involvement better shapes the project's development, influencing its scale, location, and usefulness expected from its investment (Mehta & Kiridena, 2019). The process then leads to identifying the outcomes, which are then assessed for alignment with the organizational vision (Mehta & Kiridena, 2019). Such an identification requires more open and strategic outcomes rather than

solution-based (Infrastructure & Projects Authority, 2017). Once all the relevant expected impacts and outputs have also been identified through workshops, they are translated into a benefits map (see Figure 3.2) and documented in a benefits register (Mehta & Kiridena, 2019). Such a workshop requires the actors' consultancy to capture and obtain an agreement on all the possible impacts (both positive and negative) using an open-minded approach and formulating them into a list. There is no need for these outputs, outcomes, and impacts to be measurable or achievable instead of whether these retain any gains (Infrastructure and Projects Authority, 2017). The benefits register is an even more comprehensive table since it indicates who the impact is for (e.g., micro, meso, macro) and the timing of occurrence (e.g., short/long-term) (PMI, 2019).

Benefits Planning Phase

The benefits planning phase directs those impacts to be planned once identified. Each is broken down into different factors, which are analyzed through benefits profiling, further developed through a realization plan, evaluation, and then reported to the business case (Mehta & Kiridena, 2019; Musawir et al., 2017). The benefits profile requires each impact mentioned in the benefits register to be checked further and continuously updated against accountability, target outcomes, and other metrics (Mehta & Kiridena, 2019; PMI, 2019). The aspects considered relate to the actor responsible for delivering each impact and the criteria for its realization, such as risks, dependencies, and assumptions. These aspects are then summarized into a realization plan, explaining how each impact will be realized. A typical benefits realization plan includes the following aspects for each impact (PMI, 2019):

- Mapping the expected impacts with the corresponding components
- Information both for impact owners and beneficiaries
- An impact assessment through a set of indicators
- Risk assessment
- Monitoring indicators
- Targeted milestones
- Allocation of the responsible actor to deliver it
- Monitoring and communication processes for reporting the project's status
- An explanation of how each impact is to be realized

After that, the benefits evaluation measures each option's social and economic worthiness, enabling the selecting of the preferred option. Tangible impacts are evaluated through quantitative measures (e.g., return on investment, cost reduction, increased income generation) and scored under a cost-benefit analysis. In contrast, intangibles are evaluated through qualitative measures (e.g., reputation, social satisfaction, regulatory action avoidance) and scored under a multi-criteria analysis (Infrastructure and Projects Authority, 2017; PMI, 2019). The selected option is further detailed and documented in a business case, including the impacts, costs, financial analysis results, and the contractual form. Then, the business case is extensively reviewed by the senior executives and government officials to ensure the best project form has been developed (Mehta & Kiridena, 2019).

3.5 Governance

Project governance is a critical factor in facilitating the adoption and successful implementation of the benefits management approach by creating roles, responsibilities, and accountabilities (Musawir et al., 2017). In infrastructures, project governance comprises arrangements, organizational structures, and processes that coordinate, adapt, and safeguard exchanges among multi-organizational actors. These include contractual and relational approaches, allowing them to think together about the project's scope promptly and desired result and align their interests toward a shared goal. Hence, the framework of Kujala et al. (2021) was selected to serve the purpose mentioned through a set of dimensions, as depicted in Figure 3.5. These include goal-setting, capability-building, roles and decision-making, rewarding, coordination, and monitoring (Kujala et al., 2021). As discussed in section 3.2, a fundamental effort is required at the front-end to align the various actors' often diverse expectations (Williams et al., 2019). Consequently, these dimensions aim to mitigate potential conflicts in the front-end toward enriching the project's value.

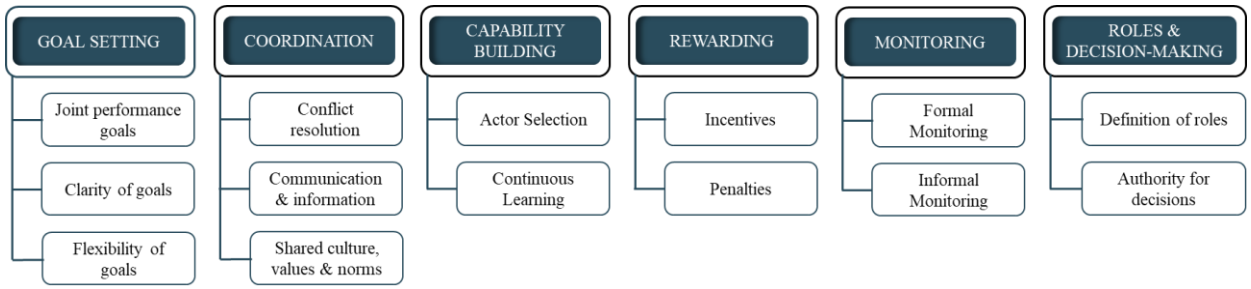

Figure 3.5 Project Governance Framework (Based on Kujala et al., 2021).

First, "goal-setting" relates to developing shared performance project goals that everyone understands. These can be either short or long-term, such as outputs or impacts, which must be defined during the actors' early involvement. Otherwise, it is less likely to obtain optimal solutions due to the actors' various perspectives, such as knowledge of each others' objectives. In addition, such a dimension seeks to promote much clarity and flexibility toward mitigating the actors' opportunistic behavior while at the same time ensuring adaptability to respond to possible threats and opportunities (Kujala et al., 2021). Its importance lies in aligning goals with each actor's strategy before commencing any significant work on the project toward better performance (Williams & Samset, 2019).

Second, "capability-building" requires the actors' potential and capability to meet the predetermined expectations. A fundamental effort is required to identify their skills and expertise before their involvement in developing a network with adequate resources. Beyond that, well-organized training and learning can enhance this dimension (Kujala et al., 2021). This is because the actors' focus at the front-end is not restricted to achieving the traditional iron triangle (time, cost, quality) but also more strategic values. In such confusion, the front end emphasizes the need for each project to be aligned with the project clients' strategy regarding what to do and how to do it, and enhancing "building-capability" is an essential factor (Williams & Samset, 2019).

Third, "decision-making" are about providing the correct information to the involved actors. Hence, everyone is aware of all the possible effects of the decisions made regarding the project's performance. That way, actors can make the right decisions up-front by considering additional aspects that can affect the project's destiny (Kujala et al., 2021). Although there is a set of various roles at the front-end, there is an effort to accompany standard definitions for the key actors, ensuring clarity for everyone (Williams & Samset, 2010). This is because the lack of impact ownership is a significant obstacle to the effective implementation of the practices of the benefits management approach (Musawir et al., 2017).

Fourth, "rewarding" contributes to aligning the goals of the involved actors towards a result that complies with everyone's expectations. Such a mechanism can include possible incentives (or penalties), remuneration rates, and the business model to meet the project's expectations (Kujala

et al., 2021). This is because governance can cause impact ownership by establishing impact-related goals and developing incentives for its implementation (Musawir et al., 2017).

Fifth, "coordination" is an essential catalyst since it ensures the actors' behavior is aligned toward an effective collaboration. It often requires standardized formal tools and processes written down in the contracts or implementation plans to coordinate the work to be executed. In contrast, "coordination" can also include informal types of coordination, such as values and behavioral norms, since they can strongly affect the project's performance. Another aspect related to "coordination" requires the availability of all the relevant and realistic information for the involved actors, which can be achieved formally and informally (Kujala et al., 2021). Such an aspect is the strongest forecaster for making authorization decisions in the business case (e.g., target benefits) toward project success (Musawir et al., 2017).

Sixth, "monitoring" ensures the involved actors' commitment to the services provided toward the project's fulfilment. The project's performance goals (e.g., milestones) shall be monitored and not just realized. That way, the involved actors can control and monitor the project's progress while ensuring their interests are met. Such a mechanism is typically specified in the project's contract utilizing monitoring procedures such as key performance indicators and others (Kujala et al., 2021).

As discussed, project governance requires an in-depth understanding. It is an essential catalyst for benefits management development and leadership due to the several dimensions incorporated into the corresponding process phases. Although these dimensions strongly contribute to the project's success, there is no evidence that they can fully cope with project governance (Kujala et al., 2021; Musawir et al., 2017).

3.6 Conceptual Framework

Figure 3.6 illustrates a conceptual framework accompanied by the literature's aspects. As discussed in section 1.1, integrating the value engineering and benefits management approaches at the front-end could potentially expand what exactly value means and identify and plan additional value (Laursen & Svejvig, 2016). This is mainly due to the value engineering approach's limitations, such as the lack of exploration of value beyond functionalities (Green, 1994; Green & Sergeeva, 2019). Regarding the benefits management approach's limitations, steering such an integrated

management approach based on the actors' already-used approach (i.e., value engineering) during the empirical research could enable the researcher to better cope with the value engineering approach's limitations.

In addition, recognizing governance as one of the most critical factors for adopting and successfully implementing the benefits management approach, incorporating the governance framework presented in section 3.5 aims to align the actors' expectations towards a shared goal. However, as these mechanisms may occur in various workshop activities, they are incorporated when first addressed.

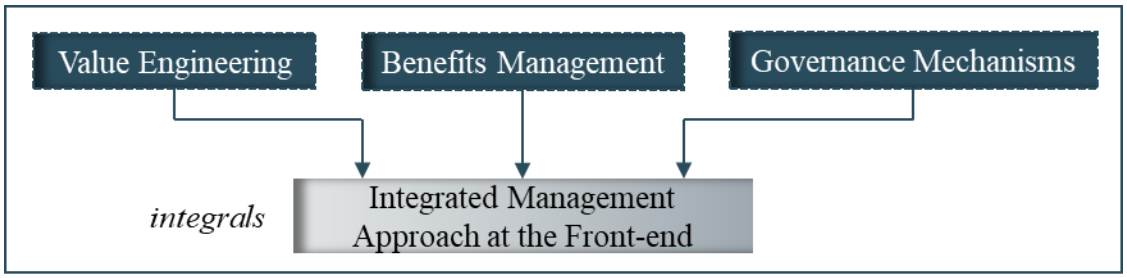

Figure 3.6 Conceptual framework

Chapter 4

Results and Analysis

This chapter analyzes the results from three case studies in sections 4.1, 4.2, and 4.3 via interviews and documents. Then, a cumulative cross-case analysis paves the way for developing a project governance process in section 4.4. Finally, the chapter concludes by validating the suggested process and the resulting outcome in sections 4.5 and 4.6, respectively.

4.1 Case Study A: Nieuwe Verbinding N69

4.1.1 Case Background

The Nieuwe Verbinding N69 (New Connection N69) is an 80km provincial road from the Luikerweg in Valkenswaard to the junction with the A67 in Veldhoven around Aalst and Valkenswaard, which has been operable since October 2021 [P1] [P2] [P3]. Apart from the project client, the Province of North Brabant, the various actors' involvement from the broader area contributed to an integrated solution. Such a commitment stimulated the development of a sustainable, safe, less traffic flow, less stealth traffic, and a more beautiful environment (Province of North Brabant; n.d.a).

4.1.2 Value Engineering Process

[I]: <u>Preparation Phase</u>

Once the usefulness of the VE approach was determined, discussed in Appendix A1, the "preparation phase" required the Province to draw up a plan for the workshop activities and communicate it to the actors who participated. These actors included the municipalities of Bergeijk, Veldhoven, Eindhoven, and Valkenswaard, Natuurmonumenten, Staatsbosbeheer, ZLTO, Water Authority de Dommel, Chamber of Commerce Brabant, and technical actors, such as financial analysts. Their tasks were to determine better Case A's scope, including the level of detail (Notitie Reikwijdte Ã Detailniveau), and the environmental impact assessment. Furthermore, residents and other stakeholders, such as local businesses, participated in the workshops (Provincie Noord-Brabant, 2012; Provincie Noord-Brabant, 2013).

The governance mechanisms incorporated regarding coordination and building-capability are as follows:

- **Coordination**: All communication process was set by the Province. Regular formal meeting discussions occurred among the Province, municipalities, authorities, and analysts towards enriching their decisions. This was achieved by analysing the actors' expectations and uncertainties on specific choices. Examples included the emissions produced, the residents' quality of life regarding noise pollution, and the water-flow crossing. In parallel to formal meetings, informal communication played an essential role since discussions related to softer aspects, such as how everyone could work together, better understand their expectations, and what was still to be discussed, were followed [P1] [P4]. Possible conflict resolutions required much discussion during the meeting among the Province's IPM team and the corresponding actors, and their main criterion was to ensure whether these contradict the predetermined goals [P1] [P3] [P4]. If there were no solution through those discussions, a mediator, an external actor operating those meetings, would have participated in facilitating the decision-making [P4]. When minor issue adjustments, such as technical specifications, the Province's contract manager was involved to ensure that the necessary alterations would be in effect [P1] [P4]. If the conflict was still not solved, the results from the previous discussions were further escalated to the Province's project directors to make the final decisions [P3].
- **Capability-Building**: The Province emphasized the importance of ensuring everyone's positive attitude and involvement regarding the business model, accompanied by the right skills and expertise. Such a positive attitude was required from the Province's IPM team [P1] [P3]. For that reason, a more efficient and effective process toward realizing the contracting actors' goals was ensured. Emphasis was also placed on ensuring that the required skills and experience are also present in the different levels of the contracting organizations. For instance, employers assigned by project directors from specific organizations may not be familiar with the business model(s) to be carried out [P3].

[II]: <u>Information Phase</u>

All actors were brought together to get equal knowledge about Case A's needs, bottlenecks, and issues. For decades, the Grenscorridor N69 region has been experiencing quality of life and accessibility problems due to the significant increase in lorries and cars driving daily (Provincie

Noord-Brabant, 2013). This is because of the long-term traffic congestion on the Huidige N69 road passing through the small town of Valkenswaard. Therefore, it was essential to eliminate such congestion and lead it outside the town [P1] [P4]. Furthermore, the municipality of Bergeijk wanted to tackle the congestion on the motorways around Eindhoven and the missing link in the network between the Netherlands and Belgium (Provincie Noord-Brabant, n.d.b). A strong emphasis was also placed on protecting the agricultural land, woodland, two wet nature reserves (natural pearls De Keersop and De Run), and the geological pipeline to the greatest extent. For instance, the high-pressure pipeline with the Saudi Basic Industries Corporation (SABIC) hydrocarbons also runs along the road route. Therefore, it was fundamental to avoid the pipeline's relocation as much as possible (Provincie Noord-Brabant, 2017). Considering all these aspects, the study area eventually led to the west, far from Valkenswaard [P1], and Case A's objectives were the following:

1. Maximize **traffic safety**, **accessibility**, and **quality of life** in the nearby areas during the realization, use, and long-term maintenance phases [P1] [P2] [P4]. These objectives were aligned with the 2040 ambitions for the Dutch infrastructure vision (Provincie Noord-Brabant, 2017).
2. Maximize the **sustainability** of the New Connection N69 in the context of the Sustainable and Green ambition [P1] [P2] [P3] [P4]. The Province was ambitious to make the most sustainable and greenest road in Brabant, including mitigating the landscape and natural value violations while enhancing sustainability through circularity of biobased materials. These objectives were aligned with the goals and transition following the Green Deal Sustainable Civil Engineering 2.0 and the Sustainable Civil Engineering Approach (Provincie Noord-Brabant, 2017).
3. Maximize **support** and **cooperation** with the actors of the New Connection N69 [P1] [P2] [P4]. These objectives were necessary for the area agreement Grenscorridor N69 signed on 27 June 2012 between the Province and 25 actors [P1] [P4]. Such an agreement required them to comply with the 'zero-plus' and 'area incentive' measures (Provincie Noord-Brabant, 2017). The 'area incentive' measures required an improved spatial quality plan focused on agriculture, nature, landscape, water, and recreation. In addition, the 'zero-plus' measures required an improved traffic flow on local roads, and anti-cut-through traffic measures promote the proper traffic flow on the correct route more quickly (Provincie

Noord-Brabant, 2013). For that reason, an active collaboration was essential by all the actors participating in identifying and mitigating all the risks, such as the quality of water management and protection of the Natura 2000 areas at an early stage. In addition, the involvement of local actors, such as residents, contributed to their quality of life in Case A's different phases. This was because residents were continually updated about the levels of nuisance and environmental effects during the phases of execution and operation (Provincie Noord-Brabant, 2017).

4. Maximize the **spatial quality** of the N69 environment. This was important for the spatial quality and environmental agreements about the road's architecture, landscape, structure, and the visual qualities of the public space and architecture (Provincie Noord-Brabant, 2017). The four zoning plans for the area were determined prior to the VE process by the municipalities of Veldhoven, Bergeijk, and Valkenswaard (Provincie Noord-Brabant, n.d.).

[III]: <u>Functional Analysis Phase</u>

The "function analysis phase" enabled actors to distance themselves from the physical design and examined Case A as a program by considering the desired functionalities [P1] [P2]. These included improved air quality, reduced noise pollution, reduced CO2 emissions, and increased animals' accessibility [P1] [P2] [P3]. Additional functionalities included reduced soil pollution, traffic, and preventing flooding and restoring the water system of Natura 2000 areas (Provincie Noord-Brabant, n.d.b) [P1] [P3]. The governance mechanisms incorporated about goal-setting, monitoring, and roles & decision-making are as follows:

- **Goal-setting**: Goals were all defined through a discussion among the Province of North Brabant and the 25 contracting actors since Case A was not only about a route but a whole new section [P1] [P3]. These goals related to project scope, market forces, turnaround time, freedom space, interfaces, complexity, hitting the OG's strategic goals, willingness and experience in letting go, experience with the functional specification or affinity, and employability of team members [P4]. Consequently, much effort was required to determine them properly in the whole area, such as aligning the mobility with the landscape [P3].
- **Monitoring**: Regular meetings were agreed to occur every two weeks among the contracting actors related to updates about the project's progress [P3]. Likewise, monthly

meetings occurred to ensure that the local authority's law regulations, such as soil conditions and building regulations, are aligned [P4].

- **Roles & decision-making**: Although the goals above were all defined by the contracting actors mentioned in the "information phase," only the Province of North Brabant had the authority for the final decisions, such as defining roles and responsibilities, selecting the actors suitable to contribute to the case [P1] [P2] [P4].

[IV]: Creative Phase

Once Case A's functionalities were determined, all actors started brainstorming possible design solutions through another workshop [P1] [P2] [P4]. The workshop's structure had no restrictions, and actors could suggest any possible solutions. These included, among others, adjusting the water management system, construction of structures, and ecological facilities. Such a sequential process enabled them to enrich decision-making on their choices. For instance, by considering the functionality of increasing the animals' accessibility, they devised a tunnel underneath the provisional road to achieve that [P1].

[V]: Evaluation Phase

Once the "creative phase" was completed, the Province prioritized and selected the design solutions aligned with the functionalities determined in the functional analysis phase [P1].

[VI]: Development Phase

This phase consisted of the environmental impact assessment (EIA) conducted two-phase research on four alternative routes developed by the contracting actors. Generally, EIA described the main conclusions and environmental considerations for each route, the measures due to increased nitrogen, and the limit values or effects due to increased disturbance from road traffic. Furthermore, EIA included the effects on the landscape regarding the affected landscape elements and the locations and extent of exceedances of noise standards and exceedances of guidelines due to vibrations. For example, the noise limits for existing homes within the noise zone required a preferred limit value of 48dB and a maximum of 58dB under the Noise Nuisance Act. A distance of 250 meters was determined on both sides of the road, and a maximum speed of 80km/h. In addition, the calculations were also based on the noise-reducing asphalt by 3dB, a one-meter height embankment, and one-meter height sound shielding on both sides at the elevated positions over the stream valleys. The results showed that nuisance was 1dB below the maximum limit value. In

parallel to the EIA, an investigation occurred on whether an exploitation plan was required for economic and social feasibility. However, an exploitation plan was not required since the plans were exclusively related to infrastructural works of art, including landscapes. Such a plan depends on the building plan category unless the costs are insured (Provincie Noord-Brabant, n.d.b).

Once determined, Case A's environmental impact assessment was documented in the integration plan, which assigned the destination to land and attached the corresponding rules about its use and building possibilities (Provincie Noord-Brabant, n.d.b).

[VII & VIII]: <u>Presentation & Reporting Phases</u>

The Provisional Council adopted the integration plan for the New Connection N69 [P1] [P2] [P3]. However, fifteen appellants have appealed against it. Almost a year later, the Division of Administrative Law of the Council of State identified some flaws in the plan and allowed the Province to rectify them (often called the administrative loop). The process led to the final judgment of the Council of State, after which the integration plan became irrevocable if the deficiencies had been reviewed correctly (Provincie Noord-Brabant, n.d.b).

4.1.3 Main Lessons

As participants replied, all the contracting actors were proud since Case A was quite successful [P1] [P2] [P4], and only two main lessons were provided. The first lesson was related to the actors' need to visualize the project during the meetings rather than at the end of the process through 3D impressions. Its importance relates to the various actors' backgrounds since only some were familiar with the technical aspects. Although such a consideration is quite costly, it would enable them to pose additional questions or discuss problems during those meetings, such as during the "creative phase" [P1] [P2]. The second lesson involved engaging the organizations supporting contracting actors, such as Witteveen+Bos, in their communication system. This was related to those actors' need to adjust their planning based on any alterations made by them. In addition, it would have ensured more control over obtaining the correct information or documents at the right time. Although such a suggestion requires time and money, it would enhance a more efficient process [P3].

4.2 Case Study B: Area Development Floriade

4.2.1 Case Background

Floriade is a new, green urban neighborhood between the A6 motorway and the Weerwater, across from the city center of Almere. With approximately 200,000 residents currently living in Almere and only halfway to its future size, the city's ambition was based on an innovative area development project, including different districts used for recreation areas, nature zones, and agriculture, contributing to the city's better and healthier living [P9].

4.2.2 Value Engineering Process

[I]: <u>Preparation Phase</u>

Once the usefulness of the VE approach was determined, discussed in Appendix A1, the "preparation phase" required the value engineers from Witteveen+Bos to draw up a plan for the workshop activities and communicate it to the actors who participated. These actors included the municipality of Almere (main contractor), the Amvest and Dura Vermeer Construction and Real Estate consortium, Witteveen+Bos, Floriade B.V. (a separate department hosted by the municipality to organize the event), and numerous market suppliers [P8].

The governance mechanisms incorporated regarding coordination and building capability are as follows:

- **Coordination**: There were three primary communication levels. First, there were quarterly meetings to discuss progress per subproject within the steering committee, including the project directors from the municipality and consortium. To enrich their decisions, additional design workshops were hosted by the project leader from Witteveen+Bos and the involved disciplines to evaluate alternative design solutions [P8] [P9]. Second, the innovation team by Witteveen+Bos hosted an additional workshop, presenting the suggested design solutions. Due to the solutions' feasibility uncertainty, following workshops with market suppliers took place to discuss all the pros and cons. Third, there was more external communication with Floriade B.V. Although the consortium was responsible for ensuring the area was ready to host the event, Floriade B.V. wanted to attract much external investment from third parties to promote their innovations during the exposition. Therefore, additional workshops were organized among potential sponsors to

discuss the conditions and whether they would be interested in sponsoring the exhibition [P8]. In parallel to the mentioned communication levels, possible conflict resolutions, such as whether to invest in specific solutions, were discussed with the project directors since they only had the authority to decide together. This was achieved by providing them with solutions' pros and cons since it facilitated their understanding of the expected value, planning, and the corresponding uncertainties [P8] [P9].

- **Capability-building**: After the finalized agreements regarding Case B's project objectives, the municipality searched for a collaborative actor different from a client and contractor relationship but more joint forces [P8] [P9]. The strategy required them to allow much flexibility to the market instead of telling them precisely their expectations and how to achieve them so the potential market suppliers could propose their vision of how the area could be best developed to achieve them [P8].

[II]: <u>Information Phase</u>

All actors were brought together during the "information phase" to get equal knowledge about Case B's needs, bottlenecks, and issues. Every ten years, an exhibition in the Netherlands showcases their newest innovations, such as climate-neutral and circular cities. Apart from the exhibition, the municipality decided to implement these innovations in a relatively short period, contributing to the city's better and healthier living [P9]. After the problem was determined among them, it was further discussed with the project client directors and the involved actors [P8] [P9]. Although the output-oriented project objectives were to realize a sustainable city district, a successful expo, set up a work company, and strengthen the city center, actors defined them in terms of impact-oriented project objectives. These included accelerating sustainable urban development, strengthening the city's image, and stimulating the economy. This level was of importance to the steering committee consisting of the responsible alderman and project director of real estate joint venture [P8] [P9].

[III]: <u>Function Analysis Phase</u>

The process led to the selection of the desired functionalities. These included reducing noise pollution, optimizing air quality, reducing environmental impact, increasing green space, integrating urban agriculture, promoting a healthy lifestyle, and realizing an inclusive neighbourhood. Additional functionalities included developing a construction program, reducing

nuisance and damage during construction, managing interfaces with third parties, facilitating rapid permit granting, timely management of execution quality, maximizing exposure of the Floriade expo, and responding to different target groups. This level is of importance to the different project managers [P8]. In parallel to the functionalities' identification, actors started evaluating them to the extent possible since it helped to align Case B's scope among everyone [P8] [P9]. The governance mechanisms incorporated regarding goal-setting, monitoring, and roles & decision-making are as follows:

- **Goal-setting**: Case B's goals were defined in more specific key performance criteria in a 0 to 5-point score [P8]. These included the attraction value, innovation value, value for residents, third-party involvement and contribution, affordability, technical feasibility, time feasibility, future-proof design, and degree of uncertainty [P8] [P9].
- **Monitoring**: These criteria were monitored via the project's report, and the work packages contributed to the objectives. This was achieved through a dedicated planner and a financial administrator for planning and budgeting, respectively [P8]. What was very important for Floriade was to ensure the alignment of the predetermined project objectives during those meetings. For that reason, via the value profile, these criteria were continuously monitored every quarter among the steering committee, accompanied by discussions of how actors could steer and adapt their efforts in maximizing the project objectives' value. Thus, there were more process agreements than concrete and specific targets and penalties [P8] [P9].
- **Roles & decision-making**: Although the steering committee defined these criteria, only the Board of Directors in the Floriade had the authority to make the final decisions, such as defining roles and responsibilities and selecting the actors suitable to contribute to the case [P8].

As participants replied, what distinguishes the VE process is that during the function analysis, actors can specify the project objectives and what the project needs to obtain at completion [P8]. An additional emphasis was placed on the phenomenon that clients often do not know what they need. Consequently, such an analysis helped them better specify their needs and decisions [P8] [P9].

[IV]: <u>Creative Phase</u>

Once the functional analysis was completed, the actors brainstormed alternative solutions to optimize the design through different brainstorming techniques to obtain the project objectives. These were related to realizing the new city district and enabling a successful Floriade 2022. This level was essential to the management committee, including the project directors from the municipality of Almere, Floriade BV, and the consortium [P8] [P9].

As participants pointed out, actors like engineers develop solutions before conducting problem analysis. To that end, such a workshop enabled to bring together different disciplines and facilitate the "creativity phase" only after the problem had been analyzed and the objectives were clarified. Based on that, the suggested solutions were found to be easier to implement, faster or cheaper, or can have added functionalities or performance. As a result, the VE implementation in projects is quite successful since it can be applied in different ways [P8].

[V]: Evaluation Phase

Then, actors evaluated all the suggested ideas and solutions by selecting, prioritizing, and clustering them in a functional diagram. These ideas were discussed with the project client directors, which they permitted to proceed further. There was a filter decision regarding the ideas and solutions to be developed and implemented further [P8].

[VI]: Development & Presentation Phases

In this phase, the selected ideas were tested for feasibility. These ideas were further elaborated, and an implementation plan was set up [P8]. The results were shared, and feedback was provided. There was another filter decision, where the steering committee proceeded with their investment decision [P8]. All these different phases highlighted how participants typically applied value engineering, which was further integrated into a project plan [P8].

4.2.3 Main Lessons

Many lessons were learned from Case B, of which the three most valuable ones were related to the key performance criteria. The first lesson was related to the project's team and how open actors are to adopting innovative-driven criteria. For instance, conservative actors can block the implementation of solutions into the project, but they can also contribute to implementing solutions by indicating risks and managing uncertainties. Implementing innovations is challenging, so a passionate project team is essential [P8] [P9]. The second lesson was related to the different actors'

knowledge of the project objectives, the cons and pros of various alternatives, and the impact of the decisions. However, it is essential to acknowledge that not everyone can understand adequately due to the different disciplines involved in such a complex project [P8]. Lastly, the third lesson was that the municipality started very well by giving much freedom to the market with the consultation and the negotiation phase of a half year to get to an agreement with the consortium. Nevertheless, in the end, the municipality blocked much innovation through many discussions and iterations, resulting in less value than could be achieved by providing actors with clear roles and responsibilities [P8].

4.3 Case Study C: Area Development Lincolnpark

4.3.1 Case Background

In the southeast of Hoofddorp, the municipality of Haarlemmermeer is developing an extraordinary area development with the consultation of market suppliers and residents, which will be operable in the next years. The municipality's ambition was to carry out the principles of sustainability, circularity, and innovation to the greatest extent (Gemeente Haarlemmermeer, 2020).

4.3.2 Value Engineering Process

[I]: <u>Preparation Phase</u>

Once the usefulness of the VE approach was determined, discussed in Appendix A2, the "preparation phase" required the value engineers from Witteveen+Bos to draw up a plan for the workshop activities and communicate it to the actors who participated. These included the municipality of Haarlemmermeer, consortium, authorities, Witteveen+Bos, and numerous market suppliers, such as designers [P5]. The governance mechanisms incorporated regarding coordination and building capability are as follows:

- **Coordination**: Case C had two different communication levels. First, the steering committee: project directors from the municipality and consortium had formal weekly progress meetings to set the actions and decisions. Moreover, there was a progress meeting called Design Studio every two weeks. Second, there was another line of communication between the consortium's team and an external design contractor [P5]. In parallel, possible conflict resolutions, such as good results and measurements, were discussed with the

project directors from the municipality and the consortium. Each idea was first discussed with the maintenance department of the municipality, and feedback was sent back to the actors. The feedback was then adjusted to these ideas, and decisions were made on whether to proceed [P6].

- **Capability-building**: There were no decisions but discussions. Everyone agreed that innovation contributes to better circularity. Therefore, much flexibility was provided since market suppliers could bring more innovative ideas. The strategy required leaving enough open space to them since the additional value may be achieved towards higher indicators and goals. For instance, it can be a different innovative material for the pavement, significantly contributing to a better environmental impact [P6].

[II]: <u>Information Phase</u>

As with Case B, actors defined them in terms of impact-oriented project objectives along with the primary Case C's needs and requirements [P5], and these were as follows:

1. **Energy neutral:** The municipality of Haarlemmermeer desired a neighbourhood that consumes the same energy generated, contributing to the energy transition. Furthermore, the municipality wanted limited energy consumption, prevent overloading of the electricity grid, and a flexible and adaptable energy system that can easily be scaled up with an increase in the number of homes and facilities (Gemeente Haarlemmermeer, 2020).
2. **Socially sustainable and inclusive:** Case C encouraged the involvement of residents, companies, and institutions in their living environment since such a neighbourhood is suitable for people with diverse housing needs and lifestyles. The municipality wanted social cohesion due to the residents' and users' experience of mental ownership of their living and working environment and the design layout of the living environment. In addition, self-reliance was essential to meet changing circumstances and needs and comply with the residents' short- and long-term living (Gemeente Haarlemmermeer, 2020).
3. **Healthy living:** Case C offers a living environment that contributes to the health of its residents and visitors through its design and use of materials (Gemeente Haarlemmermeer, 2020).

4. **Circularity:** Case C was to be realized with limited materials; while its value is retained during and after use, the total environmental impact of these materials is minimized (Gemeente Haarlemmermeer, 2020).
5. **Climate-proof, biodiversity, flexibility, and adaptiveness**: The urban structure, buildings, and outdoor space are climate-proof and adaptive, providing space for a robust and biodiverse ecosystem. In this way, the changing (internal and external) circumstances and (future) needs of residents and users were considered (Gemeente Haarlemmermeer, 2020).

[III]: <u>Function Analysis Phase</u>

The process led to the identification of the desired functionalities through a workshop. These included sustainable energy generation, preventing the use of fossil fuels, getting and moving in different areas, producing food locally, realizing diverse and inclusive designs, strengthening the ecosystem, designing climate-responsive space, strengthening natural restorative capacity resources, reusing products and raw materials, and using renewable energy [P5]. Additional functionalities included reduced maintenance, raw material scarcity, toxic use of materials, noise pollution, air pollution, heat stress, wind nuisance, materials' environmental impact, strengthening the ecosystem's biodiversity, and design of climate-adaptive space [P5] [P6]. In parallel to the "function analysis phase," the governance mechanisms incorporated regarding goal-setting, monitoring, and roles & decision-making are as follows:

- **Goal-setting**: The value profile derived from the function analysis with specific key performance criteria, and actors scored them in a 0 to 5-point score [P5] [P6] [P7]. These included the impact-oriented project objectives with a 4-point score, affordability with a 2-point score, timely achievability with a 3-point score, and feasibility with a 5-point score [P5]. Since the involved actors were quite uncertain about these scores, participants emphasized that each criterion was even more important to accompany a robust argument. For instance, the feasibility argument was related to all efforts made to guarantee feasibility through a landscape vision, sewer structural plan, water management plan, measurement plan, imbalance, and water level plan, of which the landscape vision forms frameworks for arriving at the correct integration of the intended areas [P5].

- **Monitoring**: These criteria were monitored every two months to optimize the project value through big value engineering charts. That way, it was also possible to understand how goals related to others along the different phases [P5] [P7].
- **Roles & Decision-making**: Although the steering committee defined these criteria, only the project directors from the municipality of Haarlemmermeer had the authority to make the final decisions, such as defining roles and responsibilities and selecting the actors suitable to contribute to the case [P8].

[IV]: Creative Phase

Once the functional analysis was completed, the process led to brainstorming design solutions among the involved actors through another workshop [P8]. For instance, the functionality of contributing to energy transition led to the need of storing and exchanging energy through smart LED lampposts [P5] [P6].

[V]: Evaluation Phase

Then, actors evaluated all alternatives and ideas by selecting, prioritizing, and clustering them in a functional diagram [P5] [P8]. These alternatives and ideas were discussed with the municipality and consortium project directors, which permitted them to proceed further.

[VI]: Development Phase

The process led to the environmental impact assessment, a risk and opportunity analysis, explained [P5] [P7]. Effort was only placed on evaluating the functionalities linked to the project objective of circularity, such as reduced maintenance, material scarcity, and the material's environmental impact [P5]. This was achieved by clarifying specific indicators, such as the environmental cost indicator (Milieu Kosten Indicator), used in civil works to recalculate the environmental impacts of specific categories. Therefore, all results were ready to be compared since they were already translated into euros. Additional indicators related to the use of primary materials, accompanied by checks regarding the materials' origin and long-term effects, were also carried out [P7]. Such an evaluation, conducted by actors from Witteveen+Bos, was broken down into four steps as follows. First, actors conducted extensive (not deep yet) research, where their decisions were strictly based on the rules of the spatial quality plan. Second, there was an effort to quantify the material's usage, such as pavements, since it helped to better define Case C's scope. The conclusion emphasized that the use of raw materials and not from secondary sources will maximize value.

Third, an analysis of the expected impacts using indicators occurred since it detected which aspects had the highest effects based on the material needed. Fourth, a deeper analysis of the material's reusability and the sustainable options for mitigating the environmental indicators. A strong emphasis was placed on the maintenance required, enabling them to calculate better the expected environmental impact with numbers [P6] [P7].

Furthermore, the opportunity analysis (linked to outcomes) contained probability, impact, project contribution ambitions, required commitment, and affordability scores. For instance, the opportunity of 'energy solar panels on company sheds,' linked with the outcome of sustainable energy generation, had a 3-point probability, 5-point contribution to the objectives, 2-point commitment, and 1-point on affordability [P5].

Once the opportunity analysis was completed, the actors conducted an extensive risk analysis. An example related to the risk register linked with timely feasibility and the work package of inventory research is as follows. As a result of <necessary studies for opinions have yet to be carried out >, <stagnation in preparation> may occur, which would lead to <delay necessary advice preparation stagnates>. The corresponding risk response consisted of promptly conducting an inventory of existing investigations and identifying which investigations still need to be carried out [P5]. The risk analysis is still in progress and is expected to take about half a year more.

4.3.3 Main Lessons

Although many lessons were learned from Case C, the three most valuable ones are as follows. First, participants emphasized that there is no need to quantify everything in the early phase because there is still much uncertainty, such as inflation rates. A more ideal approach would be to emphasize the steps required but not provide numbers yet [P6]. The second lesson was related to integrating different disciplines, where specific goals were either twisted or sometimes more value could be created by combining them. For instance, discussions shall be broader rather than direct since possible design options may affect other values that the involved actors, such as experts, may not have considered [P7]. The third lesson was related to the need for more insight into the municipality's decision-making process. This is because plans are delivered based on their sustainability goals, such as circularity. However, the municipality was afraid of implementing innovative solutions (e.g., reuse of materials) since they did not have the expertise and eventually

blocked it. Consequently, someone needs to make decisions regarding aspects, such as sustainability and energy systems, that could contribute to Case C's added value [P5].

4.4 Introducing the Project Governance Process

This section presents a governance process for front-end infrastructure projects based on both theoretical and empirical results. Although the proposed process illustrated in Figure 4.1 aligns with the value engineering approach, the light-blue colors are used to denote aspects mainly derived from the benefits management approach. The flowchart outlines a multi-phase process conducted among a set of actors, with each square rectangle representing a workshop activity and each oblong rectangle the end-product from its predecessor activities. Dotted lines represent sequential workshop activities, while solid lines indicate filter decisions on whether to proceed further. Additionally, several adjustments made during the process are described in detail.

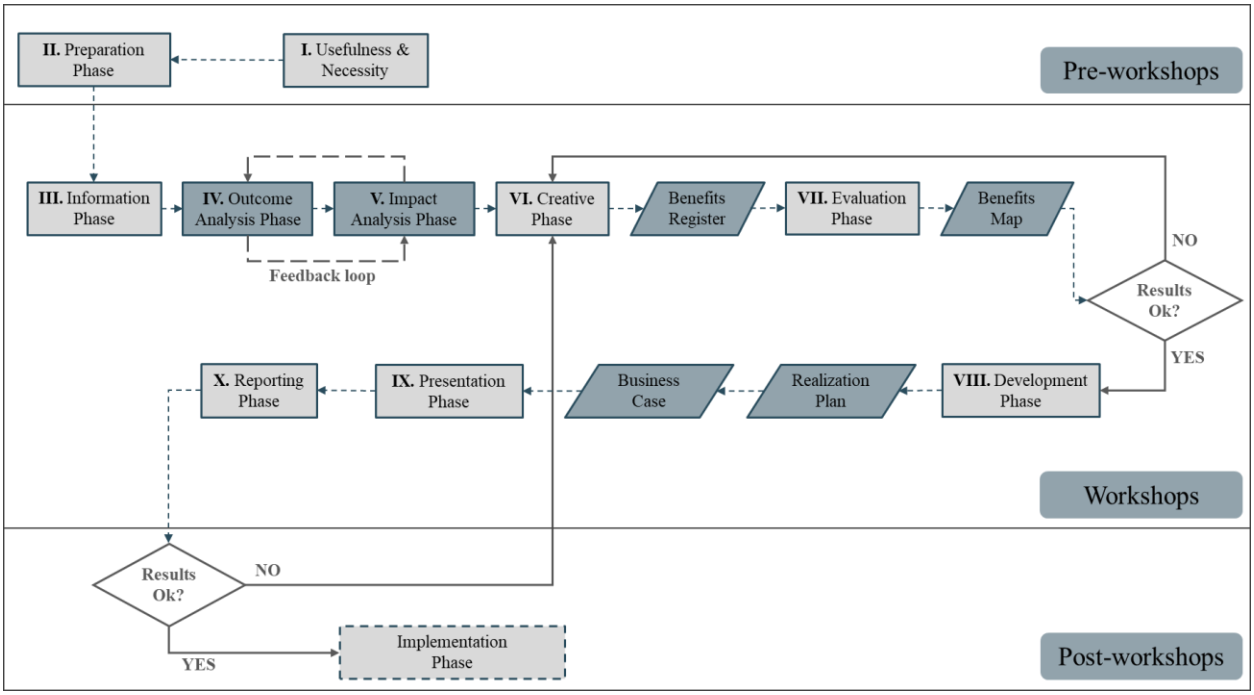

Figure 4.1 Preliminary Project Governance Process

[I] Usefulness & Necessity Phase

The current phase involves determining the usefulness and necessity of the suggested process through a discussion between the project leader at Witteveen+Bos and the corresponding client,

such as a municipality director. As mentioned, this process integrates the value engineering and benefits management approaches to enable practitioners to consider value more holistically in front-end infrastructure projects. While value engineering aims to achieve desired functions (what it should perform instead of what it is) of a project, service, or product at minimal cost, benefits management is used to achieve various types and levels of impacts (ultimate effect). Implementing this process consists of several advantages, such as meeting the actors' long-term expectations and broader organizational goals, strengthening decision-making, and integrating risk management considerations. Additional advantages include an increased productivity and organizational performance because the proposed process follows a similar logic with the multi-organizational actors' already-used value engineering approach.

If the discussion emphasizes that long-term value is the prominent reason for undertaking the project, then carrying it out can lead to more holistic decision-making in front-end infrastructures towards maximizing (project) value. This is mainly due the process's potential to unlock each both approach's limitations, such as limited exploration of value beyond functionalities.

[II] <u>Preparation Phase</u>

After the project client decides to proceed further, facilitators such as value engineers at Witteveen+Bos draw up a plan and communicate it to the actors who will participate in the process. These actors include the project client, authorities, municipalities, experts, and the market. This phase requires a fundamental effort for value engineers to identify the right actors who can enrich decision-making, and then request the clients' permission to invite them into the process. In addition, the "preparation phase" requires two main governance mechanisms: coordination and building-capability.

- **Coordination** is necessary due to the large number of actors involved in such a process. Effective communication is key; therefore, developing different communication levels is essential while considering regular formal meetings. Four prominent communication levels are among: project client directors, client teams along with authorities, and client teams along with external suppliers, such as innovation teams and designers. In parallel with communication levels set up during this phase are possible conflict resolutions regarding investing in specific solutions that require extensive discussion among involved actors. During discussions where there are disagreements between actors about solutions proposed

or not yet proposed but being considered for implementation after thorough review have been developed including pros and cons before escalation to directors for final decisions.

- **Building-capability** involves engaging actors with suitable skills who can provide knowledge required for undertaking work efficiently while ensuring alignment across all levels of market organizations (not only upper levels). Hence much flexibility must be provided when unlocking markets' skills through open tendering processes while ensuring familiarity with business models decided upon at every level of an organization so that selected market actors can perform effectively without requiring excessive investment for training or learning.

[III] Information Phase

The "information phase" is a workshop activity that involves all actors discussing relevant needs, issues, and bottlenecks to obtain an equal level of knowledge. This contributes to setting the foundations in better defining the project's scope and ensures that all actors have a deeper understanding of the inputs prior these to be considered. Otherwise, there is a risk of misdirected or inadequate objectives arising from them. In addition, this phase requires to addressing the organizational vision which refers to the actors' long-term goals and aspirations by mainly considering broader values, mission, and strategic objectives. Such a vision is critical for successful infrastructure development initiatives that deliver the expected impacts over the long term while everyone has a shared understanding of what is important and what they are working towards achieving.

During this workshop, all actors are given the opportunity to express their interests and exchange possible thoughts by addressing relevant needs, issues, and bottlenecks. These are then formulated into output-oriented objectives, but it still needs to be deeper. This is achieved during the "creative phase" where actors are brought together and brainstorm about design solutions in more detail. As discussed in section 3.1, outputs represent the results or deliverables achieved through input and activities. These are based on three criteria and the extent to which these have been achieved: project objectives, actors' individual objectives, and the goal-alignment among them (van Tulder, Seitanidi, Crane, & Brammer, 2015). A more detailed breakdown of some of the different categories and types of outputs for infrastructure projects:

- Physical assets: These refer to tangible outputs such as buildings, roads, bridges, and other physical structures that support transportation, housing and other needs.
- Time: Time-related outputs can include project timelines or deadlines for completing specific phases of the project. For instance, it could be the completion of a specific phase by a certain date or milestone.
- Cost: Cost-related outputs refer to budgetary targets or financial goals that have been met through project activities. These can include achieving cost savings relative to initial estimates or meeting the predetermined budget constraints.
- Quality: Outputs related to quality can include ensuring that materials used in construction are up to certain standards or meeting specified design criteria.
- Safety: Infrastructure projects must also prioritize safety as an output category in order to ensure that they are built in ways that minimize risks and hazards for workers and end-users alike.
- Sustainability: Sustainability-related outputs aim at reducing environmental, social, and economic impacts through green building practices and other measures.
- Social equity: These relate to infrastructure development initiatives particularly in urban areas where access to services and resources may be limited for certain communities.

However, "objectives" is a generic term that describes predetermined results towards which effort is directed in terms of outputs, outcomes, or impacts. Therefore, it is strongly advised that actors consider objectives beyond output-oriented to ensure they accurately capture the intended results. For instance, problems related to quality of life in a region resulting from high traffic congestion may require establishing objectives such as maximizing traffic safety, accessibility, and quality of life in nearby areas during the realization, use, and long-term maintenance phases. These may require to either implement a set of sub-systems such as traffic management or even create an additional system specifically designed for this region.

[IV, V] Outcome & Impact Analysis Phases

The process of identifying all possible outcomes and impacts in infrastructure projects involves two sequential workshop activities: outcome and impact analysis phases. A feedback loop between them, as depicted in Figure 4.1, allows facilitators to decide which phase to start with. While it may be necessary to allocate additional resources by conducting the outcome analysis phase prior

to the impact analysis phase, it is generally recommended that facilitators begin with this approach. This is because actors are more familiar with it, and conducting the impact analysis first could potentially create uncertainty. Nevertheless, there is no need for those outcomes and impacts to be measurable yet but to ensure whether retain any gains for the project's investment.

To begin with, outcomes simulate the effects or alterations derived from outputs measured within the broader community. Unlike outputs, these are much more inclusive of whether the these have been achieved (Laursen & Svejvig, 2016; van Tulder, Seitanidi, Crane, & Brammer, 2015). A more detailed breakdown of some of the different categories and types of outcomes for infrastructure projects:

- Economic: These include outcomes related to economic growth, job creation, and other financial effects or changes derived from outputs.
- Environmental: These include outcomes related to environmental sustainability, such as reducing greenhouse gas emissions or improving air and water quality.
- Social: These include outcomes related to social equity, such as improving access to services or promoting greater community engagement.
- Health: These include outcomes related to public health, such as reducing rates of disease or improving health care access.
- Safety: These include outcomes related to personal safety and security, such as reducing crime rates or improving emergency response times.
- Mobility: These include outcomes related to transportation accessibility and mobility, such as reducing traffic congestion or increasing public transit ridership.
- Accessibility: These include outcomes related to making services more accessible for people with disabilities or other special needs.

The outcome identification workshop is divided into two stages through the actors' reflection on questions about the desired effects or changes derived from outputs. The first stage includes more generic questions, such as what the outputs (deliverables or results) should do. An outcome example related to the actors' individual output of protecting native animal and plant species (Flora and Fauna Act) could be to increase the animals' accessibility by a certain extent. Another example related to a project's output could be to increase the capacity of a highway. Once collected, the second stage requires them to answer more extensive questions, accompanied by some research,

but still needs to be deeper. These include animal population size and type, as well as the amount of extra capacity required for vehicles and other related components in the broader area.

Next, impacts stimulate the ultimate effects derived from outcomes measured within the level of actors, the stakeholders, and the system (van Tulder, Seitanidi, Crane, & Brammer, 2015). These effects relate to the extent to which beneficiaries have been impacted by the outcomes achieved. The impact identification workshop involves two stages for actors to reflect on a set of questions. The first stage focuses on more generic questions such as what outcome effects should be and when they should occur (timing of occurrence). Building on the earlier outcome examples provided, actors may formulate questions regarding factors such as animal population size and type or population density benefited by increased capacity. Once collected, the second stage requires more extensive questioning accompanied by research but still needs to go deeper. These mainly include changes in the landscape until the impacts' timing of occurrence, and include digitalization, sustainability, resilience, and social equity. For instance, addressing resilience concerns may require designing a robust infrastructure system that can withstand potential hazards like extreme weather events or natural disasters. Following the outcome example of increased animals' accessibility mentioned earlier in this process of identifying impacts based on outcomes achieved through project activities; actors may need to consider additional factors like how much quality improvement is required for these animals. Similarly, if increasing capacity was an outcome identified earlier in this process then actors may need to consider how many people benefit from such an increase.

As explained, each of the outcomes' and impacts' identification involves two stages. However, the first stage requires the involvement of all actors, while the second stage typically requires more research by corresponding experts. For example, economic-oriented outcomes and impacts require research conducted by financial analysts who then communicate their findings to everyone. Although both outcome and impact analysis phases are limited to identifying them, actors can start thinking about the steps required to evaluate them and prepare a plan for subsequent phases. In addition, the "outcome and impact analysis phases" require three main governance mechanisms: goal-setting, monitoring, as well as roles and decision-making.

- **Goal-setting** is about setting the key performance criteria. These can relate to any mentioned expectations in the short-term, such as timely achievable, or long-term, such

as the users' satisfaction. This can be achieved by actors providing them specific scores at a 0–5-point scale based on how important these are to them. Once formulated, these are merged in a radar diagram and continuously updated. It is strongly advised that the right motivation accompanies each criterion to ensure clarity, flexibility, and joint performance goals. Incorporating such a motivation ensures the actors' equal understanding and commitment until realized.

- **Monitoring** is about the continuous update of the mentioned key performance criteria through big engineering charts via the project's report for the clients to understand the progress along the different phases. This can be achieved through a dedicated planner and a financial administrator for planning and budgeting, respectively. Such actors aim to facilitate those meeting discussions of how actors could steer and adapt their efforts to maximize value. Additional meetings shall also be conducted with the local authorities to ensure that progress complies with the law regulations, such as soil conditions and building regulations.
- **Roles & Decision-making**: Although the clients define these criteria, only the project directors have the authority to make the final decisions, such as defining roles and responsibilities and selecting the actors suitable to contribute to the project.

[VI] <u>Creative Phase</u>

After completing the previous phases, actors are brought together in another workshop to brainstorm all possible design solutions. During this phase, outputs such as physical assets are examined in greater detail while also considering broader outputs related to actors' individual objectives, such as budgetary targets. By positioning this "creative phase" after the "outcome and impact analysis phases," involved actors can provide solutions that ultimately lead to more value.

While it is important for design solutions to eventually align with identified outcomes and impacts, this does not need to happen immediately in this phase due to actors' different backgrounds. For instance, engineers tend to provide solutions carried out in their previous projects, which may not fit with the needs of the project examined. However, it is strongly recommended that all actors visualize the outcomes and impacts identified in the previous phases during the workshop. That will potentially mitigate the actors' additional resources in providing design solutions which align with their expectations.

[VII] Evaluation Phase

The "evaluation phase" is another workshop that requires all project outputs (i.e., physical assets) and actors' individual outputs (e.g., budgetary targets) to be scrutinized against identified outcomes and impacts. Once prioritized and selected, these are developed into a benefits register and benefits-map.

The benefits register, derived from the benefits management approach, is a comprehensive table that typically includes selected outputs, outcomes, and impacts. However, it provides even more information by including who these are for and when they are expected to occur. Once the benefits register is completed, it can be developed into a benefits map as shown in Figure 3.2. The benefits map is a graphical representation that includes outputs, outcomes, impacts, interdependencies, and key performance criteria (PMI, 2019).

Once developed, the benefits register and map are shared with the client project directors, who decide whether to proceed further. Based on their feedback, adjustments are possible by returning to the previous phases. This can be achieved by the first feedback loop depicted in Figure 4.1.

[VIII] Development Phase

The "development phase" is a long-term workshop that comprises several activities. These include an environmental impact assessment, a risk, and an opportunity analysis.

The environmental impact assessment (EIA) evaluates the outputs, outcomes, and impacts through indicators, such as the environmental cost indicator. In parallel, an investigation is required to check whether an exploitation plan in terms of economic and social feasibility is necessary. The exploitation plan depends on the building plan category. However, it is unnecessary for projects, such as roads, since plans are exclusively related to infrastructural works of art, including landscapes, unless the costs are insured. This process is broken down into two main steps, and these are as follows:

- The first step describes the main conclusions and environmental considerations for each design solution, the measures due to the increase of nitrogen, and the limit values or effects due to increased disturbance from road traffic on specific species of Natura 2000 areas. This is achieved by extensive research to adjust their decisions on the law regulations (i.e., spatial quality plan) and, therefore, quantify the material's usage. Furthermore, a deeper

analysis of the material's reusability and sustainable options for mitigating these effects is followed. A strong emphasis is placed on maintenance, enabling them to calculate better the expected environmental impact with numbers. Therefore, additional indicators for certain checks regarding the materials' potential effects on objectives, such as reusability, are needed.

- The second step requires the evaluation of the effects on the landscape, the valuation of affected landscape elements, and the locations and extent of exceedances of noise standards and exceedances of guidelines for nuisance/damage due to vibrations. This is achieved by analysing the expected impacts using indicators since it enables actors to detect which aspects have the highest effects based on the material needed.

The process then leads to carrying out a risk and opportunity analysis. The opportunity analysis requires actors to link each output, outcome, and impact and score them on a 0-5 point scale against probability, impact, contribution to the expected impacts, commitment, affordability, and others. Similarly, the risk analysis requires each outcome and impact to be linked with timely feasibility and the work package of inventory research. The outputs are then evaluated against economic and social merits, where experts such as financial analysts are involved. An example linked with timely feasibility and the work package of inventory research is as follows. As a result of <necessary studies for opinions have yet to be carried out >, <stagnation in preparation> may occur, which would lead to <delay necessary advice preparation stagnates>. The corresponding risk response consists of promptly conducting an inventory of existing investigations and identifying which investigations still need to be carried out.

Once the activities are completed, these are documented in the benefits approach's front-end products, including a benefits realization plan and a business case. A typical business case includes the selected outputs, impacts, costs, financial analysis results, and the contractual form (Mehta & Kiridena, 2019). In addition, a typical benefits realization plan includes the following aspects for each impact (PMI, 2019):

- Mapping the expected impacts with the corresponding components
- Information both for impact owners and beneficiaries
- An impact assessment through a set of indicators
- Risk assessment

- Monitoring indicators
- Targeted milestones
- Allocation of the responsible actor to deliver it
- Monitoring and communication processes for reporting the project's status
- An explanation of how each impact is to be realized

[IX, X] Presentation & Reporting Phases

The "presentation phase" is a discussion meeting among the client and the corresponding actors to discuss whether they agree with the results obtained. Once everyone agrees, the developed business case and benefits realization plan are reported to the project client directors, who scrutinize them. The "reporting phase" requires them to decide whether to proceed with the project's investment. Based on their feedback, adjustments are possible by returning to the previous phases. This can be achieved by the second feedback loop depicted in Figure 4.1.

4.5 Workshop Validation

This section describes the results from the workshop validation of the suggested process in section 4.4. These results are broken down into a pre- and a post-workshop survey to better evaluate the added value of the suggested process.

4.5.1 Pre-workshop Survey

The pre-workshop survey includes the results before the suggested process's presentation. The results are based on three questions about how Witteveen+Bos carries out the current value engineering process.

First, experts were asked to provide insights regarding the extent to which the terms of outputs, outcomes, and impacts are actively managed. These terms are actively managed but under the names in the value engineering functional diagram, which are placed from the right towards the left side of the diagram as they relate to the primary functionalities and higher goals, respectively. This is because identifying functionalities requires the involved actors to reflect on a set of 'how' questions, and identifying impacts requires them to reflect on a set of 'why' questions. The degree to which these terms are used effectively equals approximately 100 to 140 out of the 1400 actors working at Witteveen+Bos [E1] [E4]. Acknowledging the significance of the terms to be measured under the following year's environmental act, it would be remarkable for the terms outputs,

outcomes, and impacts to be incorporated since they provide a more straightforward pitch [E1] [E2].

Next, experts were asked to determine the effectiveness and practicality of the current value engineering approach. Although the mentioned approach is very effective and practical, it is still very small-piloted and incidental [E1]. This is because it is often carried out to optimize costs and not entirely [E2]. For instance, the approach's implementation in infrastructure projects is mainly steered by the corresponding project client business lines. However, this is different for area development projects, as experts can typically determine and suggest the extent of its implementation themselves [E1]. Therefore, those actors' engagement is limited to specific aspects in some projects, and their potential to unlock value in infrastructures is limited. One potential reason relates to the degree of experience that grows over time among business line managers who assign projects to their employers, and many project leaders need to be educated for such an implementation [E1] [E2]. Likewise, there is a phenomenon that many project clients are very output-oriented by focusing on specific solutions, such as reconstructing a road. However, their mindset should focus beyond that as outputs are not the primary purpose, or else the red line of reasoning, in a project [E2] [E3] [E4]. For that reason, much effort is often put by experts to advise their project clients where those project outputs (i.e., design solutions) will eventually lead, as clients may want something other than that [E1] [E2].

Thereafter, the pre-workshop survey led to discussions regarding the experts' suggestions for improving the current value engineering approach. As experts replied, the mentioned approach must be more explicit by better defining the project goals. This is because a better understanding of the desired expectations will be adopted [E1]. Emphasis was also placed on the need for such a way of thinking to be adopted by everyone [E2]. In addition, it would be exciting to check how the terms of outputs, outcomes, and impacts can be incorporated into the plan administration since the project's values require a robust meaning [E1].

4.5.2 Post-workshop Survey

The post-workshop survey includes the results after the suggested process's presentation. The results are based on three questions about the researcher's suggested governance process.

The discussion started with the experts' reflection regarding the suggested process' feasibility to be carried out and everyone fully agreed. This is because all the steps are clearly explained, accompanied by concrete results [E1] [E2] [E3] [E4]. Furthermore, such a process is open for creativity since such processes are often a black box. The suggested process facilitates new prediction error actors to grab something [E1].

After that, experts were asked to determine the extent of the suggested process' practicality. It is practical because it clearly describes the different phases and end products, so actors know the end results [E1] [E2]. In addition, the process follows a similar logic to the value engineering process Witteveen+Bos currently carries out. Surprisingly enough, some of the researcher's elements will be used by one expert in a small ongoing project [E2].

Lastly, the workshop concluded with the experts' suggestions to make the process more practical. As experts replied, there were three suggestions for the practicality of the suggested process, and these are as follows. The first was to link the suggested process phases with the work packages and milestones so that every actor knows the scope to be delivered effectively [E1]. Although the linkage with milestones is impossible as it requires a practical project, some work packages could be linked [E1] [E2]. This is because not everyone can understand the scope of what each actor needs to deliver. For instance, equip the project client director with a summary of what the suggested process delivers and in what way the added value from the various actors' engagement, such as economic analysts, will be [E1]. The second was to incorporate the techniques of risk analysis and opportunity analysis prior to the "creative phase" in terms of inputs towards exploiting them through brainstorming [E1]. Nevertheless, this is optional as the process already serves the purpose of what it delivers [E2]. Although the suggested process is practical for 80% of the actors [E1] [E2] [E4], the third suggestion was to make it more appealing for the remaining 20% for everyone to understand it. For example, this could be achieved by developing a flowchart full of icons and colours since some technical actors better understand by visualizing it [E1] [E2].

The section that follows presents the updated process that takes into account the expert suggestions.

4.6 Final Project Governance Process

The process for was initially explained in section 4.4. However, based on experts' feedback in section 4.5, the process has been updated with more specific details, and these are as follows:

- **Work packages**: The "preparation phase" requires a fundamental effort for value engineers to identify the right actors who can enrich decision-making, and then request the clients' permission to invite them into the process. Each permission is accompanied by a well-structured proposal (work package) that outlines each actor's scope and provides a clear understanding of their outputs, outcomes, impacts, and the required work to produce them. For instance, the financial analysts' role is about evaluating the project's feasibility and viability by assessing its costs, risks, and impacts. They aim to support decision-making processes by providing quantitative data and analysis that helps everyone better understand the expected impacts of different project options on finances and broader organizational objectives. Financial analysts may also be involved in developing financial models to estimate expected costs and impacts over time or conducting sensitivity analysis to assess related risks and uncertainties.
- **Change order**: Experts recommended a change order for the suggested process. Specifically, they suggested incorporating risk analysis and opportunity analysis techniques as inputs prior to the "creative phase" towards exploiting them through brainstorming. As a result, the "development phase" has been broken down into two parts. The first part now includes risk and opportunity analysis, while the second part encompasses all remaining activities.
- **Add colours and icons**: Experts suggested making the process more appealing for the remaining 20% in order for everyone to understand it. Some colour adjustments have already been made in Figure 4.1.

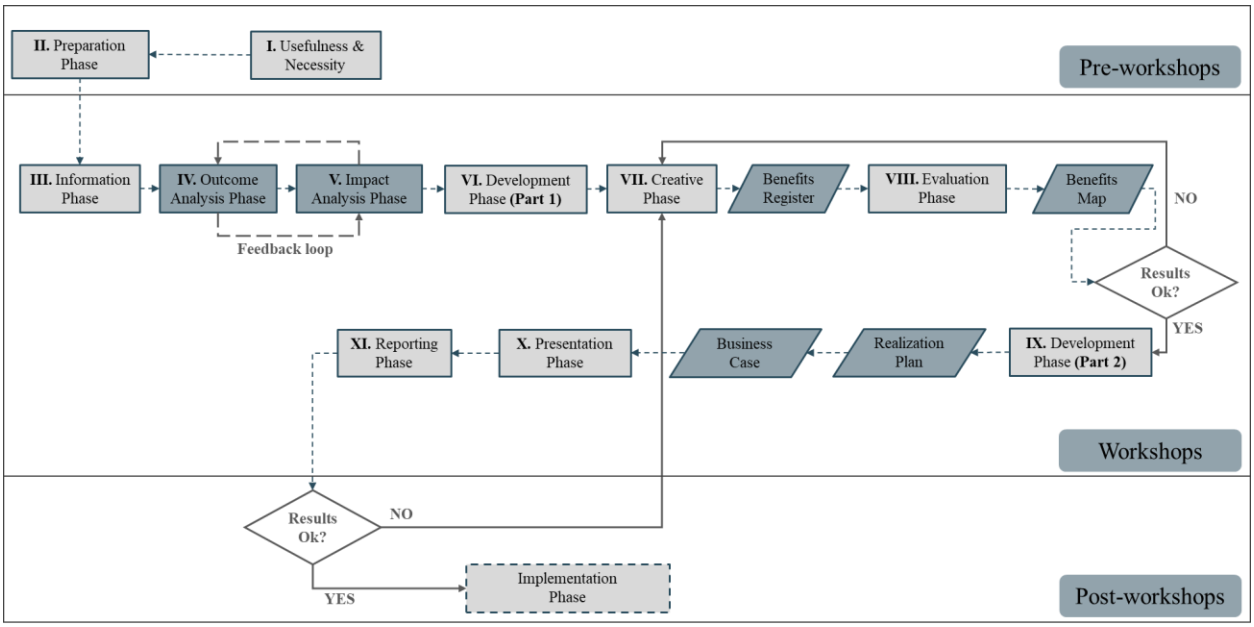

Figure 4.2 Final Project Governance Process

Chapter 5

Discussions

Acknowledging the value engineering approach's limitations discussed in section 1.1, integrating it with the benefits management approach could potentially expand what value means and identify and plan additional value (Laursen & Svejvig, 2016). Likewise, the appropriate governance mechanisms, one of the most crucial factors, aim to ensure outputs' and outcomes' alignment with the impacts envisioned at the front-end (Musawir et al., 2017). Hence, the results indicate how value engineering can be integrated with benefits management in the front-end of infrastructure projects, accompanied by the appropriate governance mechanisms, to consider value more holistically. This chapter discusses specific points and the research limitations in sections 5.1 and 5.2, respectively.

5.1 Discussions

With value being unclear as to what it means in a multi-actor context, the discussion starts with the degree of which long-term value considered in the cases' front-end. Despite the actors' effort to translate the corresponding problems into impact-oriented objectives during the "information phase" (workshop activity), such as stimulating case B's economy, value restricted within the value engineering limitations. Although value evolves through different scales, the selected cases' value was increased by adding more functionalities, mitigating the costs, or both. For instance, case B's functionalities included reducing noise pollution, increasing green space, and others. The degree to which (long-term) value considered partly contradicts with the theoretical results because it equals the balance between the net impact (i.e., ultimate effect) realized over the resources used (PMI, 2019). Although the functionalities considered will eventually turn-into impacts, it remains uncertain whether achieving the desired value. This is mainly due to those cases' lack of considering additional impact-oriented parameters towards mitigating the degree of uncertainty between the expected and the value realized.

This discussion builds upon previous point and focuses on the remaining limitations identified in the selected cases, apart from the value's limited exploration beyond functionalities. The second limitation relates to the assumption that functions remain constant over time, which was observed in all cases due to actors' desire to implement deliverables for the future without specifying when

impacts were expected. For example, the municipality decided to implement Case B's innovations, contributing to the city's quality of life in the future. The third limitation relates to strengthening the vested actors' interests regarding the decisions made. For instance, some innovations that could contribute to maximizing Case B's value were not considered despite suggestions from relevant actors. The fourth limitation is related to prioritizing easy agreement over engaging with evidence, although no such evidence was found in the selected cases. Finally, the fifth limitation assumes that each alternative design solution provides a similar level of performance, leading actors to focus on cost comparisons only rather than exploring possible alterations. At least Case A exhibits this limitation since adjustments were made by clients once functionalities were selected.

The discussion then proceeds with the temporary organization's (e.g., market suppliers) contribution to the front-end's decision-making. Due to all cases' desire to deliver long-term value, such as maximizing the quality of life, there was much uncertainty. By the market actors' involvement in the workshop activities, the pace of uncertainty became less due to the effort in better defining the cases' scope. This was achieved by equipping project client(s) with specialized advice with aspects related to market dynamics (e.g., financial fluctuations), emerging innovations, market competition, and others. This follows the same logic with the theoretical results since decision-making may be strengthened with market actors' substantial advice related to opportunities, threats, problems, value, and needs (Toukola et al., 2023; Williams & Samset, 2019).

The next discussion point briefly explores how selected cases propose solutions to policy problems through front-end decision-making. To examine this further, the focus lies on how workshop activities justify case needs as solutions to policy problems. Likewise, the multi-organizational actors' suggestions for solving transportation problems were investigated (Zerjav et al., 2021). The analysis showed that workshop activities justified case needs as solutions to policy problems by translating sector-specific challenges into long-term objectives. For example, Case A experienced quality of life and accessibility issues due to increased traffic from lorries and cars over several decades. Multi-organizational actors suggested solutions such as maximizing traffic safety, accessibility, quality of life, and more. Consequently, this analysis highlights how selected cases propose solutions to policy problems through front-end decision-making.

The following discussion point relates to the similarities or differences between the empirical and theoretical management approaches. As discussed in section 1.1, the value engineering approach intended to achieve the highest value possible for the predetermined costs aligned with the actors' expectations and the project's goals through a set of workshop activities (Kelly, 2007; Rad & Yamini, 2016). On the one hand, all cases followed the same logic with the value engineering approach, as addressed in the literature. For instance, during the "function analysis phase" (workshop activity), the multi-organizational actors' contribution resulted to the cases' increased value by selecting the desired functionalities. This was achieved through a workshop activity, where actors distanced themselves from the physical design and started reflecting on the desired functionalities, such as what the system should do instead of what it is, which were then explored more in-depth. Although all cases' workshop activities followed the same logic with the theoretical results, these activities were accompanied by much flexibility. This mainly relates to some phases' completion in different periods as long as the required information was available. For instance, case B's functionalities were evaluated right after identified, regardless of the phases in between.

After that, the role of governance mechanisms in aligning actors' value expectations (outputs, outcomes, and impacts) is crucial. While the benefits management literature lacks a comprehensive understanding of these mechanisms, Musawir et al. (2017) have investigated nine project governance aspects that can help shed light on this topic (Mehta & Kiridena, 2019). To that end, these aspects are compared to the governance dimensions found under Kujala et al. (2021)'s framework: goal-setting, monitoring, roles & decision-making, capability-building, coordination, and rewarding. Firstly, specifying key performance criteria with scores at a 0-5 point scale, accompanied by a robust argument for each criterion, achieves the "goal-setting" dimension (shared performance goals, clarity, and flexibility). This dimension aligns with governance aspects identified by Musawir et al. (2017), including PG5 ("*There were clearly defined criteria for reporting project status and for the escalation of risks and issues to the relevant organizational levels*"), and PG9 ("*The organization fostered a culture of frank internal disclosure of project management information*"). Secondly, regular meetings among one or more organizations facilitated updates about progress related to the "monitoring" dimension reflecting on criteria specified in the "goal-setting" dimension merged into a radar diagram. However, this dimension partly aligns with PG2 ("*Disciplined governance arrangements were applied throughout the project life cycle*") due to this research's front-end boundary. Thirdly actors' contribution towards

specifying key performance criteria under "goal-setting" towards mitigating uncertainty achieved "roles & decision-making" dimension as it aligned with PG1 ("management board had responsibility for project governance"), PG3 ("Roles/responsibilities defined clearly") and PG4 ("project's business case supported by relevant/realistic info providing reliable basis for authorization decisions"). Fourthly, "coordination" is achieved by setting up appropriate communication levels with conflict resolution procedures which aligns with PG6 ("Decisions made recorded/communicated"). Although Musawir et al. (2017)'s governance aspects were aligned with most of the Kujala et al. (2021)'s governance framework investigated in the selected cases, there was no alignment with the building-capability and rewarding dimensions.

Lastly, the benefits management approach could strengthen the value engineering approach in various ways. First, by exploring value beyond functionalities, the involved actors could potentially consider more parameters towards a more comprehensive value consideration. For instance, these additional parameters relate to the different levels of analysis (i.e., micro, meso, society), enabling actors to explore value beyond the project's functionalities (i.e., less uncertainty). Next, such an approach promises to unlock more opportunities by better understanding the way of which value evolves. For instance, the actors involved will potentially better cope with the changes in the landscape (e.g., pandemic crisis) or even better balance the competing value expectations. In contrast, there is no argument against the various challenges when implemented in practice. The most challenging task is the work required to identify and plan impact. This is because some impacts are difficult or impossible to be measured and require the actors' fundamental effort towards mitigating uncertainty. Another challenge relates to the complexity by the contribution of more actors, such as environmental analysts. This is due to the resources required, like advanced measurement techniques, in ensuring the approach's sucessful and comprehensive implementation. If these lack or not used properly, there is a high risk of not achieving these promising expectations.

5.2 Research Limitations

This section addresses the main limitations of the present research, which are as follows.

- By focusing on (project) value, the value for individuals and organizations was disregarded. Such an emphasis bounded the investigation in relation to the different levels

of analysis: micro, meso, and macro. Likewise, the interviews were not conducted among participants from more organizations, such as environmental authorities.

- Value was considered from a single period of time, in other words, the expected impacts were to be achieved once.
- There was limited in-depth investigation on the governance mechanisms because effort mainly directed on investigating additional aspects, such as the value engineering approach's process.

Chapter 6

Conclusions

This chapter answers the research questions formulated in Section 1.4, How can value engineering be integrated with benefits management in the front-end of infrastructure projects, accompanied by the appropriate governance mechanisms, to consider value more holistically?, and synthesizes the most important study findings in Section 6.1. Likewise, Sections 6.2 and 6.3 provide some recommendations for practical implementation and suggestions about future works to expand this topic.

6.1 Answer to the sub-questions and main research question

SQ1: What are value engineering and benefits management in the context of infrastructure projects?

The front-end benefits management and value engineering approaches aim to identify and plan multi-organizational actors' value expectations in project, such as infrastructures. Value has been characterized as a multifaceted phenomenon that evolves along sequential scales and is observed at different levels of analysis, followed by diverse viewpoints.

These scales include 'outputs,' which represent the deliverables or results accomplished through inputs and activities measured within the partnership based on three criteria: individual objectives, project objectives, and goal alignment. These are translated into project objectives, institutional reform, and economic, safety, and environmental values. 'Outcomes' simulate effects or alterations derived from outputs measured within the broader community. Unlike outputs, outcomes are more inclusive of whether anticipated output effects have been achieved. These are translated into decreased travel duration, low costs, and improved institutional reform. Finally, 'impacts' represent ultimate effects derived from outcomes measured within actors, stakeholders, and systems. These are translated into better economic accessibility, accessibility to social services, mitigated environmental and safety impacts leading to enhanced conditions for economic growth, human capacity development while reducing poverty.

Benefits management identifies value in terms of expected impacts over resources used and works backward using processes, project governance mechanisms while considering various factors

towards selecting designs that align with predetermined impact expectations aligned with project clients' strategies. In contrast, value engineering identifies value as balancing functionalities over costs by ensuring these are adequately incorporated into design solutions. Consequently, both approaches involve identifying actors' value expectations at different levels of analysis while incorporating governance mechanisms towards achieving predetermined impact expectations aligned with project clients' strategies in infrastructure projects.

SQ2: How can governance mechanisms be conceptualized in the context of infrastructure projects?

Governance mechanisms are critical in facilitating the adoption and successful implementation of the benefits management approach in infrastructure projects. Governance comprises arrangements, organizational structures, and processes that coordinate, adapt, and safeguard exchanges within the project's network while creating roles, responsibilities, and accountabilities. Contractual and relational approaches allow multiple actors involved to think together about the project's scope promptly and align their expectations toward a shared goal.

The Kujala et al. (2021) framework provides a foundation for governance mechanisms under six dimensions to which their importance is explained. First, the "goal-setting" dimension relates to developing an adequate understanding of value expectations among actors involved with shared performance goals, clarity, and flexibility. Second, the "capability-building" dimension requires actors' potential and capability to meet predetermined expectations aligned with the project clients' strategy. Third, the "monitoring" dimension involves continuous monitoring of predetermined performance goals by all involved actors while ensuring alignment of their interests. Fourth, the "coordination" dimension is essential in directing effective collaboration among actors through standardized formal tools along with informal types such as behavioural norms and relevant information availability. Fifth, the "roles & decision-making" dimension is about providing correct information to establish authority's organizational structure regarding final decisions to meet predetermined value expectations. Sixth, the "rewarding" dimension's importance lies in aligning actor goals including incentives or penalties, remuneration rates, and business models.

Thus, governance mechanisms can be conceptualized in infrastructure projects by applying these six dimensions towards coordination, adaptation, safeguarding exchanges within the project

network while creating roles, responsibilities, accountabilities among multiple actors involved towards achieving predetermined value expectations aligned with the project clients' strategy.

SQ3: How do actors currently conduct value engineering in the front-end of built environment projects?

In the front-end phase of built environment projects, actors conduct value engineering through a multi-phase process. This process also involves several governance dimensions such as coordination, building-capability, goal-setting, monitoring, roles & decision-making that are applied to achieve efficiency and clarity among participating actors towards mitigating uncertainty.

The first phase is the "preparation phase," where value engineering facilitators draw up a plan for workshop activities and communicate it to participating actors. The "coordination" dimension is achieved by setting up appropriate communication levels (i.e., meetings among certain actors) towards mitigating their uncertainty before the meetings with the project clients. This dimension also comprises conflict resolutions through the following sequential steps: more communication with reflection on the pros and cons by the conflicting actors, involvement of a mediator to operate the meeting, and escalation to the project directors. The "building-capability" dimension is achieved by the market's open tendering process (i.e., flexibility) towards assuring actors with the right skills and knowledge. Actors' expertise with the business model (e.g., investments and training) is an advantage towards safeguarding efficiency.

The next phase is the "information phase," (workshop activity) where involved actors discuss different issues, needs, and bottlenecks to obtain an equal level of knowledge. This activity allows them to express their interests and exchange any possible thoughts toward formulating each case's objectives through group discussions.

The following phase is "function analysis," (workshop activity) where primary needs and requirements are formulated by selecting desired functions for idea generation. In this phase, value engineering stands out as it requires specifying what the project needs after completion. The governance dimensions of goal-setting, monitoring, and roles & decision-making are applied here to specify key performance criteria while ensuring clarity among participants towards mitigating uncertainty over time. First, the "goal-setting" dimension was achieved by their effort to specify

the cases' key performance criteria (outputs, outcomes, and impacts) with scores at a 0-5 point scale. Due to the high uncertainty, each criterion accompanied a robust argument about its importance. This dimension's relevance was even more apparent in the case B's later phases due to some alterations in decision-making. For instance, some actors blocked the implementation of a few innovations regardless of their initial permission. Second, the "monitoring" dimension was achieved with regular meetings among one or more organizations, where a large monitor often facilitated their update about the cases' progress and preparations about the following activities. Such updates were predominantly achieved by their reflection on the criteria specified in the "goal-setting" dimension, merged in a radar diagram. Third, the "roles & decision-making" dimension was achieved by their contribution to specify the key performance criteria under the "goal-setting" dimension towards mitigating uncertainty by considering more parameters while ensuring clarity among them. Despite their contribution, the final decisions were up to the project clients, such as directors.

After that comes the "creative phase," (workshop activity) requiring involved actors to brainstorm design solutions while applying different brainstorming techniques. Finally comes the "evaluation phase" requiring evaluating all alternative ideas by selecting, prioritizing, and clustering them based on feasibility.

The last two phases are "development" (workshop activity) where selected ideas are tested for feasibility before elaboration in an implementation plan followed by "presentation & reporting" (group discussion) which directs results sharing among all participating actors before presenting results for commissioning approval by directors.

SQ4: What steps should be carried out to expand value engineering with benefits management to assist practitioners in governing value identification and planning in the front-end of infrastructure projects?

To expand value engineering with benefits management in infrastructure projects, a suggested project governance process was developed through a cumulative cross-case analysis, validated by an expert workshop. The process incorporates outputs, outcomes, and impacts to enable actors to explore value beyond functionalities while incorporating governance mechanisms across different cases.

The suggested process consists of seven phases accompanied by governance mechanisms and end-products. These include:

- In the "usefulness & necessity phase," project clients discuss the importance of implementing the proposed process based on aligning long-term objectives, reinforcing decision-making, integrating risk management, and increasing productivity and organizational performance.
- In the "preparation phase," facilitators draw up a plan for workshop activities to engage actors with the right skills and knowledge for better decision-making. The governance dimensions of "coordination" and "building-capability" are used to plan an effective communication system and engage actors with the right skills and knowledge, respectively.
- In the "information phase" (workshop activity), involved actors express their interests towards formulating output, outcome and impact-oriented objectives during workshops.
- In the "outcome and impact analysis phases" (workshop activities), involved actors distance themselves from the project outputs by prioritizing the outcomes' and impacts' identification through a set of questions among everyone. Likewise, key performance criteria are set up via governance dimensions like goal-setting, monitoring, and roles & decision-making and continuously updated in mitigating uncertainty over time.
- In the "creative phase," actors brainstorm design solutions (or project outputs) while visualizing them during workshops since aligning proposed project outputs with predetermined outcomes/impacts is quite challenging due to the actors' different backgrounds.
- In the "evaluation phase," all outputs (i.e., project objectives/actors' individual objectives) are scrutinized against envisioned outcomes and impacts. Then, these are developed into a benefits map including outputs, outcomes, impacts, interdependencies, and the key performance criteria.
- Finally, several activities take place in the long-term workshop of the "development phase" (workshop activity) towards evaluating outputs, outcomes, and impacts through an impact assessment (e.g., environmental impact assessment), and a risk/opportunity analysis.
- Once the results have been agreed by all actors, the developed business case and benefits realization plan are reported to project client directors in the "presentation/reporting phases." Feedback may require returning to previous phases for adjustments.

An expert workshop validation confirmed the suggested process's feasibility for implementation since all steps are clearly explained with concrete results. It also provides new prediction error actors with something tangible while remaining open for creativity. To make the process more practical, it is linked with work packages (where possible) aligned with predetermined milestones. Incorporating risk analysis and opportunity analysis techniques before brainstorming during the "creative phase" can further exploit potential gains. Finally, making it more visually appealing through flowcharts or similar methods helps technical actors better understand it.

RQ: How can value engineering be integrated with benefits management in the front-end of infrastructure projects, accompanied by the appropriate governance mechanisms, to consider value more holistically?

Integrating value engineering with benefits management in the front-end of infrastructure projects can be achieved by incorporating benefits management principles into the already-established multi-phase process of value engineering. The purpose of these principles is to extend beyond simply exploring value in terms of functionalities. To achieve this integration, the suggested project governance process can be implemented that defines value in terms of impacts, and then works backwards through a set of processes. This approach requires consideration of all scales along which value evolves - outputs, outcomes, and impacts - but from the opposite direction. Once expectations have been identified, they can be evaluated accordingly. By integrating benefits management principles into value engineering in this way, actors are equipped to take more parameters into account which will eventually mitigate the uncertainty between expected and the value realized. Additionally, governance mechanisms play a role in aligning all actors' expectations by bringing them together towards a shared goal. These mechanisms were found under six governance dimensions promising to ensure holistic consideration of value throughout the project's lifespan.

6.2 Recommendations for Practical Implementation

This section presents four recommendations for practical implementation, and these are the following:

- Workshops should be conducted regularly across all departments to help raise awareness and educate employees on adopting an impact-oriented mindset. This will help to ensure that everyone within the organization has a consistent perception and definition of value

creation beyond outputs or outcomes. By leveraging diverse perspectives, the organization can take more parameters into account when advising clients.

- To develop a consistent impact-oriented mindset, it is essential to recognize that this requires time and effort from all employees, including those at the executive board level, business lines, and groups. The executive board and business lines can help drive this by making impact a top priority in their strategic goals. However, the various groups must also take responsibility for adjusting their work to better incorporate impact considerations. A feedback loop through regular and reflective discussions can help unlock additional value.
- Making impacts the prominent reason for undertaking any work is critical; even if the client does not request it, organizations must maintain impact-oriented decision-making from the outset of every project. This can facilitate work production in cases where client requirements are vague or unclear towards avoiding any potential misdirection.
- Sustainable impacts should be emphasized by merging them towards an end goal. Since different impacts often compete with each other, properly integrating them can reduce resource requirements while still achieving desired results.
- To increase the chances of successfully implementing the proposed process, some assurance measures may be necessary. One potential solution could involve penalties and rewards for lower and higher realized value, respectively. Although this is a challenging task, it could be achieved only if the organization who will be held accountable will also be part of the client's future projects in the nearby area. By doing so, the process's potential for clarifying expected value can be maximized while minimizing risks associated with implementation.

By implementing these recommendations, Witteveen+Bos can better equip project clients with additional consultancy value and high-quality design solutions while proactively enriching clients' decision-making processes through benefits management principles and an impact-oriented mindset throughout the organization's hierarchy.

6.3 Suggestions for further Research

This section presents three suggestions for future research to outline how it could be moved forwards concretely, and these are the following:

- To broaden the consideration of value, it is recommended to conduct interviews with a more diverse set of participants from various organizations, such as authorities. This can help identify additional parameters that may contribute to a more comprehensive understanding of value.
- By considering value at different time periods, such as every ten years within a long-term vision, and taking into account the expected impacts that are likely to occur more than once, an opportunity arises to unlock additional value. Such dynamic consideration has the potential to enhance value creation.
- Governance mechanisms play an essential role in aligning actors' expectations regarding outputs, outcomes, and impacts. A more in-depth investigation of governance mechanisms could potentially strengthen alignment while also uncovering new mechanisms to be incorporated. This would further support producing high-quality design solutions for built environment projects.

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Appendix A

A.1 Selected Cases' Suitability

Case A - (New Connection N69): The 'Border Corridor N69' covers Eindhoven to Belgium and Eersel and Veldhoven to Heeze-Leende. For that reason, an integrated solution was required by the various actors' involvement, such as nearby municipalities and authorities. This was because Case A is not just about the road's construction but about maximizing the border area's quality of life while at the same time ensuring its potential for future projects (Provincie Noord-Brabant, n.d.b). For instance, effective collaboration was essential among actors to mitigate uncertainty on aspects such as protecting the agricultural land, woodland, two wet nature reserves (natural pearls De Keersop and De Run), and the geological pipeline to the greatest extent.

Case B - (Floriade Area Development): Floriade is an international horticultural exposition hosted in the Netherlands every ten years to display the latest innovations [P9]. For 2022, the municipality of Almere was awarded to host the event, which would run for six months. The site construction started in 2019, and its delivery was expected in the fall of 2021 [P8]. Due to the limited sustainability of such a concept, the municipality decided to implement them into an area development project, contributing to the city's quality of life [P9]. However, much uncertainty existed due to those long-term objectives and the relatively short period to be carried out. For that reason, the VE approach was adopted to optimize the decisions that had to be made through flexibility in project control, working towards targets, and working explicitly (Witteveen+Bos, n.d.).

Case C - (Lincolpark Area Development): The municipality of Haarlemmermer wanted to develop an extraordinary development project with the principles of sustainability, circularity, and innovation to its greatest extent. Due to the city's unique character, potential to grow, and long-term ambition, the municipality was to implement it with the residents and many market suppliers. Therefore, the VE approach was suitable to enrich the municipality's decision-making to achieve these objectives. This is typically because of developing measurable functional project objectives, realizing objectives along the entire project's lifecycle, encouraging broad cooperation among numerous actors, and incorporating future residents' objectives to determine the project's ultimate success (Gemeente Haarlemmermeer, 2020).

A.2 Interview Protocol

SECTION I: Introduction (< 5min)

The interview starts by introducing the following aspects:

1. Researcher Introduction: Introduction of myself.
2. Purpose: The purpose of the semi-structured interviews is to answer **SQ3**: 'How do actors currently conduct value engineering in the front-end of built environment projects?'. In addition, the interviewers will be asked to provide possible governance mechanisms to achieve these expectations.

SECTION II: **General Questions** (< 5min)

It consists of the participants' general questions, including the following questions:

3. What is your background and experience?
4. When did you get involved in [project name]?
5. What were your roles and responsibilities in [project name]?

SECTION III: **Identify and Plan Value Expectations (what & how)** (< 20min)

It consists of questions about 'what' (content-related) and 'how' (process-related) the project's value expectations were identified, and planned, accordingly.

6. What was the expected impacts (i.e., ultimate effects) of [project name], and why?
7. Was there any measurable target for achieving these expected impacts (e.g., 40% higher economic revenues)?
    - If so, what was the target for each one, and how did you plan to meet them?
    - If not, how did you ensure that these expected benefits would be fulfilled to their desired extent?
8. What were the related outputs (i.e., project objectives + individual objectives) to achieve each of the expected benefits, and to what extent these were achieved?
9. In your effort to determine those outputs, were any intermediate effects (e.g., desired functionality) of the created system incorporated into the project's objectives, And if so, what was it about?

10. What was the structure of the value engineering approach? What activities did the process include for discovering and realizing the project's expectations? By whom were these facilitated?
11. Besides the mentioned organizational structure, was there any systematic way (e.g., implementation plan, work packages) of safeguarding the realization of the project's expectations? If so, which aspects were included?

SECTION IV: **Planning & Governance Practices** (< 25min)

Followed by the discussion about the content and process of value identification and planning, this section comprises more detailed questions about the governance mechanisms (e.g., monitoring, communication) aimed to achieve these expectations (Kujala et al., 2021).

12. (**Goal Setting**): How were the project's long-term goals defined, and who was involved in their definition? Were there any predetermined criteria on which these goals (e.g., sustainable development goals) were based?
13. (**Rewarding**): Were any rewards or penalties given to the actors (e.g., contractors) towards safeguarding the project's delivery within the desired expectations? If so, what was it about?
14. (**Monitoring**): How was the project's progress monitored, and by who? Which KPIs were used to keep track of the progress (e.g., cost, completed work, time), and how these were communicated to others?
15. (**Coordination**): How was communication between actors formally organized during the VE approach? In addition, were any informal types of coordination (values, norms, and expectations) incorporated? If so, what were they about?
16. (**Roles & decision-making**):

- Who was responsible for the identification and planning of value expectations?
- How did you decide on a conflicting resolution among the actors' often diverse expectations?
- How did you monitor the achievement of short-term project/actor objectives?

17. (**Capability-Building**): Were any decisions made regarding mechanisms in the tendering process to enrich the actors' (e.g., contractors) performance? If so, what was it about?

SECTION V: **Close-out** (< 5min)

18. Looking back to the project you were involved in, what main lessons did you learn? Would you have made any different decisions?

A.3 List of Interview Participants

Participant 1	P1	Technical manager	27/06/23
Participant 2	P2	Stakeholder manager	27/06/23
Participant 3	P3	Project manager	10/07/23
Participant 4	P4	Contract manager	17/07/23
Participant 5	P5	Project/stakeholder manager	11/08/23
Participant 6	P6	Project engineer/advisor	06/07/23
Participant 7	P7	Project engineer/advisor	27/07/23
Participant 8	P8	Value engineer, innovation manager	01/08/23
Participant 9	P9	Project director	11/08/23

Table A.1 List of participants