Integrating Biodiversity-Increasing Measures in Infrastructural Projects: A Contractor's Perspective

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Abstract
The central government of the Netherlands wants to protect, restore, and promote sustainable use of the built environment to halt and reverse land degradation and biodiversity loss by increasing biodiversity. This paper explores strategies to enhance the integration of biodiversity-increasing measures in infrastructural projects. Recognising biodiversity as a form of innovation, the study developed a theoretical framework that considered innovation implementation across project phases and identified success factors specific to this context. The research involved the analysis of seven case studies to determine the actual implementation of biodiversity-increasing measures in construction projects and the reasons for their successful implementation. To further explore these reasons, interviews were conducted with seven cross-case experts. The combination of the case studies, adjacent literature, and expert interviews identified several success factors. A schematisation outlines the implementation of these factors. All identified success factors influence three aspects of the implementation process: 1) characteristics of the measures, 2) the construction process, and 3) organisation. In conclusion, a contractor should consider these three aspects to increase the chances of successfully integrating biodiversity-increasing measures in infrastructure projects.

Index Terms – Biodiversity - Critical Success Factors (CSFs) – Infrastructure projects

I. Introduction

To meet, among other things, the urgent environmental challenges that our world faces, a set of 17 interconnecting universal goals, the Sustainable Development Goals (SDGs), was produced in 2012 (Fei et al., 2021). Sustainable Development Goal 15 (SDG15) aims at "protecting, restoring, and promoting sustainable use of terrestrial ecosystems, sustainably managing forests, combat desertification, and halt and reverse land degradation and biodiversity loss" (UN.ESCAP, 2022). In response to this, the central government of the Netherlands, in cooperation with all provinces, created an ambition towards biodiversity in which they acknowledge the problem of biodiversity loss and state to contribute to increasing biodiversity by "strengthening and improving where it works and broadening and connecting where it needs to improve" (Ministerie van LNV, 2019).

To contribute to these ambitions, great potential lies in urban areas. Beatley (2000) acknowledges that urban areas have great potential to increase biodiversity because the key to maintaining species' presence is to preserve the species' habitat. This can be achieved by creating integrated ecological systems of connected greenspaces and habitats (Beatley, 2000). Preserving biodiversity in urban areas involves safeguarding remaining natural habitats and strategically planning, designing, and implementing green infrastructure (Beninde et al., 2015). Green infrastructure is a network of green spaces and features with multiple functions. The integration of green infrastructure throughout the city creates various natural, restored, and constructed habitats, collectively enhancing conditions for biodiversity in both public and private lands. Patch areas and corridors have the most potential to affect biodiversity significantly (Beninde et al., 2015).

Despite the national urge to include biodiversity-increasing measures, the cooperating contracting company notices that the client's wishes and demands in contracts for constructing infrastructure assets contain something other than biodiversity on a standard basis. Factors that might play a part in the decision-making process of the procurement content are the complexity of measuring biodiversity, the fact that changing the system is complex, and the willingness of inhabitants to cooperate (Kennisportaal Klimaatadaptatie, 2023). Mommers et al. (2021) conclude that bottlenecks during nature-inclusive building projects are a need for knowledge, existing policy, financial resources, and lack of focus.

To contribute to the national government's ambition to increase biodiversity, contractors have implemented the ambition to support biodiversity in their projects but struggle to achieve this ambition. Therefore, this study aims to determine the opportunities a contractor has to integrate biodiversity-increasing measures in infrastructural projects, which is researched by answering the following main research question:

How to integrate biodiversity-increasing measures in infrastructure projects from a contractor's perspective?

This paper outlines the research and consists of several sections. The first main section provides detailed insights into the literature review, divided into three distinct sections: biodiversity-increasing measures, biodiversity as an innovation in infrastructure projects, and successfully implementing innovations in infrastructure projects. The second main section elaborates on the methodology employed and the decisions made in the research strategy. Subsequently, the following section presents the research results, focusing on implementing biodiversity-increasing measures across project phases and the factors that potentially impact this process. Finally, the conclusions are presented, and the research implications are discussed in the dedicated section.

II. Theoretical Background

This section elaborates on the theoretical background essential to execute this research. In the first section, an understanding of biodiversity is created to determine what to focus on when designing biodiversity-increasing measures. Secondly, since the literature on biodiversity-increasing measures in construction projects is scarce and biodiversity-increasing measures are considered an innovation, the second section elaborates on the implementation of innovation. This section elaborates on the classification of innovation and its implementation in project phases. The last section elaborates on the Critical Success Factors (CSFs) of implementing innovation.

i. Biodiversity and Opportunities to Increase

This section elaborates on biodiversity-increasing measures by first explaining the concept of biodiversity and what to focus on when designing biodiversity-increasing measures. Furthermore, examples of biodiversity-increasing measures will be mentioned.

Biodiversity

Biodiversity is “a comprehensive umbrella term for the extent of nature's variety or variation within the natural system, both in number and frequency” Rawat and Agarwal (2015). Biodiversity is commonly interpreted as the extensive diversity of plants, animals, and microorganisms, including the genes they harbour and the ecosystems they collectively create (Rawat & Agarwal, 2015). However, it also includes the genetic differences within species and the variety of ecosystems in a landscape. Therefore, biodiversity can be divided into three interconnected types: genetic diversity, species diversity, and ecosystem diversity (Rawat & Agarwal, 2015) (Coleman, 1996).

Ecosystem diversity relates to “the variety of habitats, biotic communities, and ecological processes in the biosphere” (Rawat & Agarwal, 2015, p.20). Biotic and abiotic factors shape an ecosystem. Biotic factors are the living organisms, and abiotic factors are the non-living elements in an ecosystem (Suzuki et al., 2014).

Genetic diversity refers to the range of hereditary information units (genes) within a species, transmitted from generation to generation. This diversity gives rise to variations, serving as the fundamental wellspring of biodiversity (Verma, 2017). The extent of genetic variation forms the bedrock of speciation, and low genetic diversity will increase the extinction risk (Hoban et al., 2020). This genetic diversity equips a population to adapt to its environment, playing a crucial role in natural selection (Verma, 2017).

Diversity in species can be characterised by richness, evenness, and variety (Don & DeLong, 1996). Species vary not only in size, function, feeding habits, and distribution but also in relative abundance (Savard et al., 2000). Therefore, species diversity is measured by the number of species in an area and the relative number among species. Colwell (2009) states that: “The species that characterise any natural community differ in relative abundance, usually with a few species quite common and most species much less so”(Colwell, 2009, p.258). “Conservation biologists are concerned with relative abundance because rare species are more vulnerable to extinction. Some rare species in one community are common in another, but some species are scarce everywhere they occur” (Colwell, 2009, p. 259). Furthermore, some species have a more significant effect on an environment than others. A keystone species is a species that has a disproportionately large impact on its natural environment relative to its abundance. Bond et al. (1994) even suggest that keystone species should be conserved primarily because of their disproportionate effect on the persistence of other species.

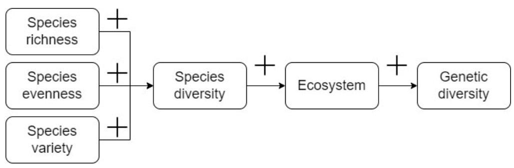

Figure 1: Positive effects of biodiversity

All three types of biodiversity interconnect, as presented in Figure 1. Genetic diversity rises with increased ecosystem diversity (Verma, 2017), and sufficient species diversity contributes to better ecosystem diversity (Goedkoop et al., 2023). Therefore, a positive change in biodiversity generally starts with increasing species diversity (Goedkoop et al., 2023). Because of this, ecological diversity is represented mainly by species diversity (Hamilton, 2005).

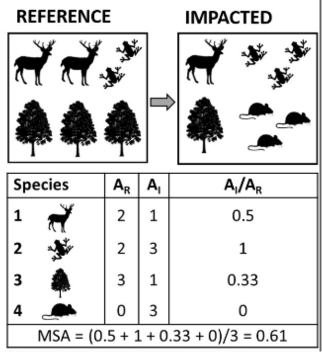

Figure 2: Calculation of the mean species abundances

Mean Species Abundance

To determine how to increase species diversity, it is essential to understand how species diversity is measured and how to impact the outcome of the measurement positively. An internationally known indicator of species diversity is the relative Mean Species Abundance (MSA) of originally occurring species (Rijksoverheid, 2016). It is defined as the average population size of native species relative to their population size in an undisturbed situation (Rijksoverheid, 2016). Calculated by dividing the abundance of a species in the impacted situation (Ai) by the abundance of a species in the reference (undisturbed) situation (Ar) and calculating the arithmetic mean over all species present in the reference situation, as can be seen in Figure 2 (Schipper et al., 2020). However, to avoid inflation in the indicator due to species benefiting from habitat disturbance, the increases in individual species abundance are limited when comparing both situations (Schipper et al., 2020).

Figure 3 shows the MSA calculated worldwide (blue graph), in Europe (purple graph), and the Netherlands (green graph) in different years. The MSA is lower in the Netherlands compared to Europe and the world. In 2000, the MSA worldwide was 70%, Europe 40%, and the Netherlands 15%. The MSA in the Netherlands in 1900 was 40%, and in 2000, 15% (CBS et al., 2013). Several factors cause the loss of biodiversity, many related to human activities, such as pollution, land use, overexploitation of resources, fragmentation, climate change, and the spread of invasive species (Damiani et al., 2023). The European Union created the European Union's biodiversity strategy for 2030 to stop biodiversity loss and protect nature. This strategy aims to put the biodiversity in Europe on a path to recovery by 2030. The strategy focuses on adapting a framework to create, among others, "better respect for nature in public and business decision-making" (European Commission, 2020).

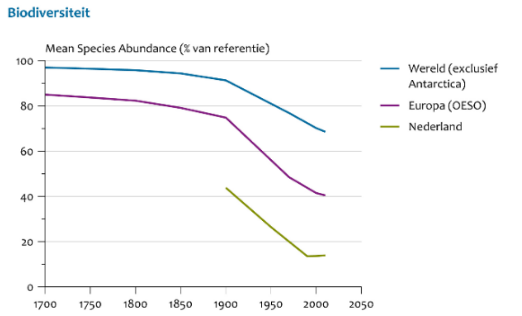

Figure 3: Results mean species abundances calculation 1700-2010 (CBS et al., 2013)

In conclusion, to contribute to the strategy to recover European biodiversity and increase the MSA, the focus should be on maintaining species present in the impacted situation in reference.

Increasing biodiversity as a contractor

For contractors with the ambition to contribute to achieving the European Union's strategy, respecting nature in their decision-making and increasing biodiversity on project sites is essential. These decisions for civil engineering contractor companies consider infrastructure and aim to respect better nature in infrastructure projects in urban and rural environments. Implementing biodiversity-increasing measures in projects is a common way to enhance biodiversity. Biodiversity-increasing measures are changes made to either positively contribute to biodiversity or minimise adverse effects on biodiversity on the project site, both of which lead to stopping biodiversity loss. The positive impact of biodiversity-increasing measures can be substantiated with an increased MSA. Since, in this research, the desire is to increase biodiversity levels, the focus should be increasing Ai (Figure 2) by maintaining and potentially improving the abundance of species of the reference situation in the impacted situation.

Since the project sites of projects of the considered contracting company are relatively small, the biodiversity-increasing measures should be able to impact the relatively small scale. On a smaller scale and in densely populated urban settings, species primarily establish their habitats in open spaces characterised by vegetation and water. To attract winged animals such as birds and insects, a safe habitat with nesting opportunities and food options should be created (Baden-Böhm et al., 2023). Parks, as a specific category of urban open space, have been demonstrated to serve as vibrant hotspots for various species within the cityscape and have the potential to become a biodiversity hotspot (Nielsen et al., 2013). Creating urban parks will positively impact biodiversity in urban areas since the diversity of animals and plants correlates with habitat complexity and diversity (Nielsen et al., 2013).

If creating a park is not feasible, the focus should be on creating a safe environment where animals do not feel threatened and where there is sufficient food, shelter, and nesting space (Baden-Böhm et al., 2023). Measures to create this environment differ for different species. For example, a national operating bee foundation in the Netherlands aims to preserve wild bees. They encourage people and companies to sow leguminous plants and bulbs, reduce the use of pesticides, build bee hotels, and convince the Dutch government to implement a bee-friendly maintenance strategy for public green spaces (Bijen educatiecentrum, n.d.). To attract hedgehogs, the advice is to create natural borders with a sufficient number of openings to increase the accessibility of the area, create a nature-friendly bank to provide water and leave branches and leaves for them to build a nest (Zoogdier vereniging, 2009).

ii. Biodiversity as Innovation in Infrastructure Projects

The previous section defined the focus when designing biodiversity-increasing measures. If the desire is to increase the biodiversity at the project site, implementing the designed biodiversity-increasing measures is essential. To determine the implementation strategy of these measures, this section elaborates on implementing innovation in project phases since biodiversity is considered an innovation.

Biodiversity as innovation

In civil engineering projects, innovation is "the development and potentially successful implementation of new ideas, products or processes in the design and realisation" (Lenderink et al., 2020). Implementing biodiversity-increasing measures in construction projects is a relatively new process in the construction industry and, therefore, can be considered an innovation. Winch (1998) stated, "Unlike other industries, innovations in construction are typically not implemented within the firm itself, but on the projects upon which firms are engaged". In these projects, the type of contract determines the responsibilities, activities, and opportunities of the involved parties (Noktehdan et al., 2019).

Integrated contracts

Approximately 90% of the projects at the considered contracting company in this research are contracted by integrated contracts. Integrated contracts are contracts in which the contractor is responsible for the design, price formation, and execution phase (TAUW, n.d.). These contracts are "often used for larger and/or more complex projects where the additional value from early involvement of the contractor is foreseen" (Lenderink et al., 2022b, p.2). Examples of integrated contracts are a Design and Construct (D&C) contract and a "bouwteam" contract. In D&C contracts, the contractor is responsible for both the design and the construction of the project and, therefore, can advise and implement solutions before the start of the design (Pianoo, n.d.). In theory, D&C contracts give a contractor design freedom and opportunities to apply process and product innovations (Priemus, 2009), (Larsson et al., 2022). Nyström et al. (2016) concluded that D&C contracts "provide an improved opportunity for the contractor to come up with innovative solutions" (Nyström et al., 2016).

Another example of an integrated contract is a "Bouwteam" contract. In "Bouwteam" contracts, the contractor and client collaborate and share responsibilities for the design and execution phase (van Riggelen, 2019). Because of this cooperation, this type of contract provides opportunities for innovation implementation (van der Pas, 2021). A "Bouwteam" contract has a two-phased contract; the first is for the design phase, in which the team consists of the contractor, the client, and possibly other parties working in equal partnership. The second contract is the project execution agreement for which, between the phases, a price is conducted (van der Pas, 2021).

Innovation in project phases

Since construction projects are dynamic, the levels of uncertainty, the organisation's size, and the people involved change significantly through the project phases (G. M. Winch, 2009). To be able to identify the implementation of biodiversity-increasing measures in a project phase, the following phases are determined for both D&C and "Bouwteam" contracts (Beurze et al., 2020), (Noktehdan et al., 2019):

- Phase 1: Tender phase – from the market demand to submitting the action plan and price.
- Phase 2: Design phase – from the award to completing the final design
- Phase 3: Realization phase – from preparation execution to completion of the asset.

Research has shown that the implementation of innovation in infrastructure projects differs per project phase (Noktehdan et al. 2019). This research has demonstrated how innovation behaviour changes through the defined project phases. Data from a database containing over 500 innovations was collected and categorised by a developed classification model. The innovations were classified by type, novelty, and benefit and mapped against the project phases (Noktehdan et al., 2019). Since biodiversity-increasing measures have a similar benefit and a comparable novelty, only a classification in the type of innovation is intriguing.

Innovation type is divided into tool, function, method, technology, design, and product with the following definitions (Noktehdan et al., 2019):

- Tool innovation is "new machinery, equipment or tool in the construction project.
- Function innovation is "new tasks developed or introduced in the construction project".
- Method innovation is a "combination of tool and function innovation that involve both the new tool and task".
- Technology innovation is a "new design coupled with a new material or product".
- Design innovation is a "new and innovative plan, design, sketches or concepts for the final building".
- Product innovation is "new construction materials and products developed in the projects.

The changing trend in the number of reported innovations categorised by type and presented per phase is shown in Figure 4. Analysing Figure 4, the conclusion can be drawn that technological innovations occurred the most in the tender phase compared to the other phases. Innovations classified as a method, design, and product are primarily implemented in the design phase. Innovations classified as tool and function innovations are mainly implemented in the realisation phase. In total, the implementation of innovation is low in the tender phase compared to the other phases. Therefore, the implementation of innovation mainly occurs in the design and realisation phase.

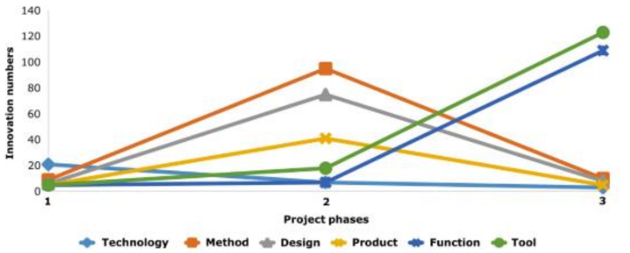

Figure 4 : Changing trend in the number of reported innovations categorised by type (Noktehdan et al., 2019)

iii. Success factors of implementing innovation

Integrated contracts offer an excellent opportunity for innovative solutions, but these are not naturally implemented since implementation success depends on several factors (Järvenpää et al., 2019). This section elaborates on the meaning and determination process of Critical Success Factors (CSFs) and then highlights the suggested CSFs of construction innovation.

Identification of CSFs

Critical Success Factors (CSFs) are defined by Leidecker & Bruno (1984) as: "those characteristics, conditions, or variables that, when properly sustained, maintained, or managed, can have a significant impact on the success of a firm competing in a particular industry" (Leidecker & Bruno, 1984, p.24). There are three levels of analysis at which the concept of the CSFs is applied, each with a broader focus (Leidecker & Bruno, 1984). These levels and their aim are (Leidecker & Bruno, 1984):

- Firm-specific analysis – Enlighten possible internal CSFs within a company.
- Industry level – Determining the position of the assessed company in the industry.
- Environmental analysis - Determining factors that impact the assessed company's performance.

CSFs of innovation

Literature highlights multiple CSFs that could potentially benefit the implementation of innovation. Firstly, in designing an innovative measure, Liu et al. (2014) concluded that it is essential to identify the user's needs. Considering these needs while creating a measure and fulfilling these needs with the measure should achieve the desired outcome and satisfy the stakeholders. Furthermore, the client's wishes and demands should be considered when designing a measure. For example, if a client is driven to implement cost-effective measures, the contractor should consider that when designing a measure. According to Ozorhon (2013), a client with that driver is more likely to approve implementing cost-effective measures than relatively expensive ones.

In summary, the following CSFs are identified through literature that could be considered while designing a measure:

Success Factors – Characteristics of the measure
Identify and design through user's needs (Liu et al., 2014)
Design cost-effective measures (Ozorhon, 2013)

Secondly, the literature shows that actions taken during the construction process could significantly impact the implementation of innovation. From a contractor's perspective, a project starts with the procurement phase, which determines which contractor will proceed and execute the project. According to Banihashemi et al. (2017), an effective tendering method is crucial to winning the procurement.

Furthermore, several CSFs have been identified that are important to consider when proposing innovation despite the project phase. Liu et al. (2014) concluded in their research that the definition of responsibilities should be clear to all involved parties. Furthermore, allocating risks and interests must be appropriate (Liu et al., 2014).

According to Banihashemi et al. (2017), a CSF for integrating sustainability in construction projects is providing adequate design details and specifications when proposing measures to a client (Banihashemi et al., 2017).

In summary, the following CSFs are identified through literature that could be considered during the construction process:

CSF – Construction process
Identify responsibilities and allocation of risks and interest (Liu et al., 2014)
Providing adequate design details when proposing a measure (Banihashemi et al., 2017)

Lastly, the organisation's organisational structure and soft skills seem important in implementing innovation. According to Liu et al. (2014), success depends on the communication and relationship between contractor and client. A harmonious relationship with mutual trust between contractor and client will increase the chances of success in conversations on implementing innovation (Liu et al., 2014). The client's involvement in the project is essential to create a harmonious relationship. Liu et al. (2014) considered the involvement and leadership of the client as a CSF in implementing innovation in construction projects. Another determined CSF that considers the client's organisation is the commitment of the management to implement innovation in the project's scope.

Many important factors are determined regarding the contractor's behaviour and knowledge when implementing an innovative solution in a construction project.

Starting at the top, the management of the contracting company should be committed to innovating in projects and changing policies (Liu et al., 2014). Banihashemi et al. (2017) argue that implementing policies supporting sustainability principles constitutes a CSF for achieving sustainability in construction projects. Creating an organisational culture that stimulates effective and ongoing learning and innovation will increase the chances of successful innovation implementation (Liu et al., 2014).

Järvenpää et al. (2019) stated that integrating innovative solutions is not evident in integrated contracts since it depends on the contractor's initiative and the client's approval. Furthermore, Li et al. (2011) identified project team motivation as one of the most critical factors for success in green building construction projects.

The team's motivation will ensure perseverance through obstacles in the implementation process. Besides motivation, team expertise in innovation and integration processes is essential (Liu et al., 2014). Besides team motivation, team communication is of significant value. Effective and open internal and external communication and cooperation will increase the chances of successful implementation and potentially establish conflict-resolving communication strategies (Liu et al., 2014).

According to Liu et al. (2014), the experience in cooperation and innovation and the partners' credibility are essential. Partners are considered the involved contractors and sub-contractors. Yong & Mustaffa (2013) agree that, in their study of CSFs in Malaysian construction projects, they concluded that the most significant CSF is the contractor's competence and experience. This assertion is supported by Banihashemi et al. (2017) statement that the: "use of lessons learned in previous projects by the project management team" is a CSF for implementing sustainability in construction projects (Banihashemi et al., 2017, p.1107).

In summary, the following CSFs are identified through literature that considers the organisation:

CSF – Characteristics considering the organisation
Harmonious relationship between contractor and client (Liu et al., 2014)
Top management is motivated to increase the biodiversity on the project site (Liu et al., 2014)
Implementing company policy to implement measures (Banihashemi et al., 2017)
Project team motivation (Li et al., 2011), (Järvenpää et al., 2019)
Project team expertise (Banihashemi et al., 2017), (Liu et al., 2014), (Yong & Mustaffa, 2013)

III. Methodology

This section elaborates on the methodology applied in this research. First, the research objective elaborates on the primary purpose of this research and the research question. Secondly, the research design is outlined, and the boundary conditions of this research are described. In the third section, the scope of this research is set by setting the boundaries. Next, the five parts of this research are explained in the research strategy, which is designed per part. The fourth section elaborates on the data collection methods; therefore, the methods to collect the necessary data during all parts are explained. Lastly, the data analysis techniques describe how the collected data was analysed.

i. Research objective

The main objective of this research is to define how a contractor can integrate biodiversity-increasing measures in infrastructure projects. This research aims to determine the actual implementation of biodiversity-increasing measures in projects of the considered company and to explore the factors that influence the implementation of biodiversity-increasing measures. The research will be performed to answer the following research question:

How to integrate biodiversity-increasing measures in infrastructure projects from a contractor's perspective?

ii. Research design

Since the literature review revealed that research on the implementation of biodiversity is scarce, this research is categorised as exploratory research. This research consists of identifying factors that could potentially positively influence the implementation of biodiversity-increasing measures through inductive research. This theory will be used in day-to-day practice and, therefore, is practice-oriented. Results will be based on primary data from interviews with people employed at a single contracting company with different branches. Thus, the success factors are defined on a firm-specific analysis level (Leidecker & Bruno, 1984). The success factors are identified using business experts, company assessments, expert interviews, and case studies (Leidecker & Bruno, 1984). Interview questions will elaborate on the successes, failures, barriers, and simulations during the implementation of these measures. Therefore, this research can be considered qualitative research.

iii. Research scope

This research uses data and experts from one contracting company. This company does not execute projects considering asset maintenance, so maintenance is excluded from the project's scope. The company's expertise lies in integral, complicated projects; almost each is performed with a D&C or "Bouwteam" contract. Therefore, case studies with these two types of contracts are selected, and results will be based on these contracts. Because of the limitation of the project database, projects for which the tender documents were submitted in or after 2019 are considered input for the categorisation.

iv. Research Strategy

The research strategy is derived from the elements mentioned in the research design and consists of 5 parts.

The first part involved conducting a semi-systematic literature review and compiling a theoretical framework. First, broad knowledge of biodiversity was necessary to determine how measures could increase biodiversity and what aspect these measures should focus on. Furthermore, a theoretical framework representing a foundational review of existing theories was mapped, serving as a roadmap for constructing the arguments utilised in further research. This framework elaborates on the implementation of innovation in civil engineering projects. It consists of literature on the implementation of innovation in project phases and the Critical Success Factors (CSFs) of the implementation of innovation.

The second part involves collecting secondary data from the cooperating company's database, including all participated tenders and belonging documents. This data was analysed to select relevant case studies, create an overview of the number of projects that included anything considering biodiversity in the tender documents, and categorise these projects.

The third part of this research involves two focus group sessions, during which participants gave insight into projects from interesting categories. Questions were asked to determine the implementation strategy and the success and failure factors.

The fourth part elaborates on a multi-case study. Performing a case study aligns with the qualitative research approach (Starman, 2014). Cases were selected based on the professional expertise of the focus group and the categorisation of part two. The seven selected case studies have the implementation of biodiversity in the project in common but differ in the implementation strategy applied; therefore, the results are different but comparable. The results of the case studies are the actual implementation of biodiversity in the considered project phases and the factors that influenced the implementation of biodiversity-increasing measures.

Furthermore, seven experts with cross-case functions will be interviewed to create a more valid list of influencing factors. Based on the findings, the determined factors are divided into three categories: characteristics of the measure, construction process, and organisation. The determined factors that apply to the characteristics of the measure are interesting to consider in the process of designing a measure. The factors that apply to the construction process are interesting to consider in the determined project phases when the ambition to implement biodiversity-increasing measures arises. Lastly, the factors that consider the organisation should be considered when compiling a project team if the ambition to implement biodiversity-increasing measures arises.

v. Data collection methods

Background information on biodiversity and construction project phases is gained by desk research. The theoretical framework was compiled by using a semi-systematic literature review. A semi-systematic literature review is suitable for research into multi-disciplinary topics such as the topic of this research (Snyder, 2019). Relevant scientific papers were searched using keynotes compatible with the research topic. Three main relevant background topics for this research were determined: biodiversity, implementation of innovation, and CSFs of innovation. These three topics were elaborated on to create a deep understanding of the background of this research and map a theoretical framework for implementing innovation in projects.

Part two of this research categorises the tender documents available in the construction company's database. This database consists of all procurement documents from projects for which the company participated in the tendering process. After an analysis, the projects could be categorised, and the contractor's and client's documents were individually reviewed. From the contractor's perspective, a distinction was made between financial stimulation, ambition, or nothing regarding biodiversity in the plan of action. From the client's perspective, a distinguishment was made between nothing, ambition, and financial stimulation in the procurement documents regarding biodiversity. The project documents were analysed and categorised using Table 1.

	Financial stimulation in procurement documents	**Ambition in procurement documents**	**Nothing regarding biodiversity in procurement documents**
Tangible measures in plan of action	Category 1	Category 4	Category 7
Ambition in plan of action	Category 2	Category 5	Category 8
Nothing regarding biodiversity in plan of action	Category 3	Category 6	Category 9

Table 1: Project categorisation

For part three of this research, two focus group sessions were held to gain practical information on part two's assessed projects and identify interesting case studies for part four. The focus group was compiled using Table 1. Members of the focus group had experience with multiple projects from the considered categories. The first session was with a group of employees at a different company branch compared to the second session group. During both sessions, the groups were asked the same questions to determine project failure and success factors and define the opportunities for implementing biodiversity-increasing measures in projects. Projects derived from the categorisation were shown and discussed as a guideline through the questions.

A multi-case study research approach was executed to create an in-depth overview of the actual implementation of biodiversity-increasing measures, the concurred failure factors, and the achieved success factors. The selection of case studies was based on the categories shown in Table 1. Categories 4, 7, and 8 were considered interesting case studies since these projects are an example of implementation on the initiative of the contractor. Category 1 is an interesting case study since the direct effect of financial stimulation can be discovered by comparing the results to categories 4 up to 9. Category 9 seemed an uninteresting category in part 1 of this research. However, since the focus group mentioned a project in which biodiversity was implemented after the tender phase, this project is considered an interesting case study. Projects from categories 3 and 6 are deemed uninteresting since implementing biodiversity-increasing measures was not a conscious choice of the contractor. Categories 2 and 5 could be interesting. However, there were either no projects that met the requirements of the category, or the project team was no longer available for interviews. Hence, case studies from categories 1, 4, 7, 8, and 9 were selected.

Data was collected from case studies by conducting semi-structured, in-depth interviews with an expert involved in the project. Experts were selected based on their role within the project and their availability and ability to conduct interviews.

During the interview, the interviewees were presented with the objective of this research and asked several different questions. The interview questions for the semi-structured interviews were general questions on the project scope, contact with the client, and the biodiversity-increasing measures. Each case had a different approach to implementing biodiversity-increasing measures and success and failure factors during this process. Therefore, in-depth questions differed per interview based on the answers to the more general questions (Ryan et al., 2009).

To create the opportunity for data triangulation, the data from the case studies and literature review was verified through expert interviews with experts with cross-case expertise. The interviews were semi-structured, and the questions were specifically designed for each specialist. The selected specialists had different functions and expertise, like biodiversity, the tender phase, and contact with a client. Even an interview with a significant client in the Netherlands was conducted to create a perspective from a different point of view. The choice was made to perform the same interview approach as applied to the case study interviews rather than submitting the results of the case study interviews and validating them. This method expanded the exploration of factors and revealed new factors during these interviews, thus adding extra success factors.

vi. Data analysis techniques

After collecting data through documents and interviews, this data was analysed using the techniques explained in this section.

Literature was conducted using a semi-systematic literature review. The literature was analysed based on its relevance to the research. Starting with the theoretical framework, the relevance and quality of the literature were assessed.

The analysis of the tender database had to be structured since the database contained many projects that were not all relevant to this research (Rasmussen, 2002). The goal was to select appropriate projects for this research by filtering the projects. Because this research investigates all project phases, all projects in the database that the considered contractor did not execute were eliminated. After eliminating projects on these two criteria, the database contained 276 projects. To identify the number of projects in categories 1 up to 8 based on the categorisation in Table 1, the projects were filtered by topic, and the available documents were read to determine the belonging category.

Transcripts of the interviews and focus group sessions are the results obtained from the interviews in parts 3, 4, and 5. Transcripts translate from an audio recording of the interview or session to a textual document (Castleberry & Nolen, 2018). A thematic analysis method was applied to analyse these transcripts. A thematic analysis is a data analysis strategy often used for qualitative data to identify, analyse, and report patterns within data (Castleberry & Nolen, 2018). The transcripts were analysed, and different themes were marked. The themes included project phases, success factors/stimulations, and failure factors/barriers. After the analysis, the marked statements from all interviews per part were combined, forming the results. These results are the input for the data triangulation used to validate the results of the different research strategies. Data triangulation is “the use of multiple methods or data sources in qualitative research to develop a comprehensive understanding of phenomena” (Patton, 1999). The three data sources address different subjects, considering the factors influencing the implementation. The relevant data is outlined per subject, and other statements from various sources are mentioned. However, since this research aims to explore factors that influence the implementation of biodiversity, the validation will not exclude or rank the factors.

IV. Results

This section elaborates on the data gathered in this research and its interpretation. First, the actual implementation of biodiversity-increasing measures in projects is determined through a case study. Second, the factors that contributed to the successful implementation in the case studies are determined through a cross-case analysis by elaborating on the similarities and differences between the cases. Third, a triangulation is performed to validate the identified success factors using the input of the case studies, experts, and literature. Lastly, a strategy was mapped to map the implementation of the identified success factors.

i. Actual implementation of biodiversity-increasing measures in projects

Seven projects were selected to analyse and determine the actual implementation of biodiversity-increasing measures in projects. This section describes the results of the 7 case studies by elaborating on the biodiversity-increasing measures applied in the cases and the implementation phase. The applied biodiversity-increasing measures are categorised by type of innovation and mapped in a graph visualising the implementation across project phases. The project phases are:

- Phase 1: Tender phase – from the market demand to submitting the action plan and price.
- Phase 2: Design phase – from the award to completing the final design
- Phase 3: Realization phase – from preparation execution to completion of the asset.

Case Study 1 – Category 1

The project of case study 1 is executed in a “bouwteam” contract, and the client's procurement request included a criterion for demonstrating how biodiversity could be improved on the project site. Subsequently, the contracting company hired an ecologist who determined specific measures to increase biodiversity that were implemented in the action plan. These measures were:

- Designing and building a fish passage
- Designing and building a Tiny Forest
- Designing and building a nature-friendly shore at the water
- Sowing a mixture of flowers and herbs
- Hanging nesting boxes for bats and birds
- Hanging an insect hotel

Figure 5 shows the distinction in the type of measures implemented in the procurement phase (Phase 1). After the award, during the design phase of the "bouwteam" contract, decisions were made regarding which measures would be implemented and which would not. During the after-award discussion, it became clear that, for the client, the focus was mainly on costs, while for the maintenance department, it was primarily about the necessary maintenance and corresponding expenses. Therefore, the decision was made to implement the relatively inexpensive and low-maintenance measures and dismiss or redesign the more expensive and high-maintenance measures. Furthermore, no extra biodiversity-increasing measures were added in the design phase (Phase 2) and the execution phase (Phase 3).

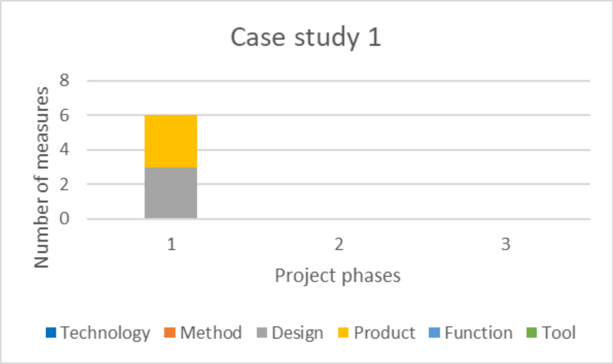

Figure 5: Number of measures case study 1

Case Study 2 – Category 5

In the documents provided in the procurement request, the client stated an ambition in which they expressed their desire to contribute to the experiential value by paying attention to, among other things, biodiversity, but no specific award criteria were created for biodiversity. The tender team of the contractor addressed this ambition during the tender writing process, explored the possibilities within the project, and assessed the costs of those measures and what they would yield in terms of hypothetical discounts. No questions were asked during this tender in the clarification memorandum from the contractor's strategic perspective. Subsequently, the team included the ambition for a nature-inclusive site design in the action plan, which will be designed in cooperation with an ecologist. Figure 6 shows this measure is a design measure. The project is currently in the design phase. Therefore, the execution of the measures has yet to be discussed.

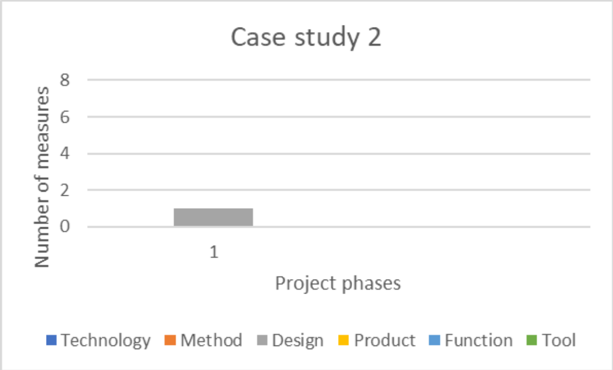

Figure 6: Number of measures case study 2

Case study 3 – Category 4

In the procurement request for this project, the client expressed an ambition regarding biodiversity and the desire to build the project in a nature-inclusive manner. The contractors' tender team has engaged a sustainability specialist for the entire duration of the project. In response to the client's ambition, sessions were organised with the whole team to explore the possibilities within the project. Ultimately, the following measures were added to the plan:

- Plant a hedge where animals can find shelter
- Sowing a mixture of flowers and herbs near the trees
- Hanging nesting boxes for bats and birds
- Hanging an insect hotel
- Designing and building a nature-friendly shore at the water
- Designing and building nesting sites underwater
- Designing and building a nature-based playground

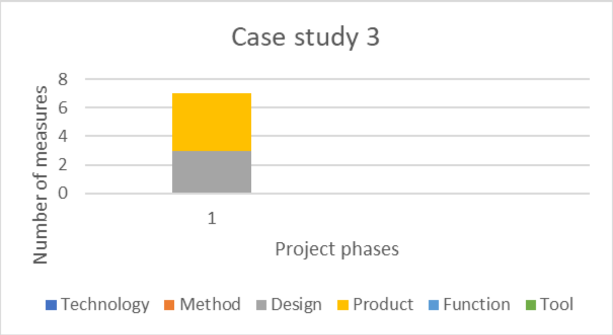

Figure 7: Number of measures case study 3

The distinction in the types of measures can be seen in Figure 7. After the award, discussions were held with the client to determine the next steps regarding the proposed measures. However, for this project, the primary focus is on circularity, and the conversation has mainly revolved around the circularity of the bridge. The design phase has only recently begun, so the project team has not yet started on the specific implementation of nature inclusivity in the project. The interviewee states, "The framework within which we can work with biodiversity has been established, and it will be further elaborated upon later".

Case Study 4 – Category 7

During the tender phase, a strategy session was held with the contractor's tender team to identify a strategy. The contracting company and the team have intrinsic motivation for sustainability despite the client's lack of ambition or stimulation. The team allocated a budget in the calculation to implement specific initiatives. During the competitive dialogue in the tender phase, sustainability was discussed. The team noticed that the client considered it an important topic but not necessary enough to include it as an award criterion.

The possibilities of implementing biodiversity were limited by the environment where the project is located and because the client wanted to avoid incurring maintenance costs associated with it. The tender team concluded with an ecologist that measures to improve the underwater world are most suited, and the following specific measures were added to the action plan:

- Apply porous concrete where plants and mussels can grow on the surface
- Place river wood on the bottom of the water to create shelter for fish
- Designing and building multiple 'biohuts' where fish can take shelter and use as a nursery
- Coconut matting to create a biological concrete surface

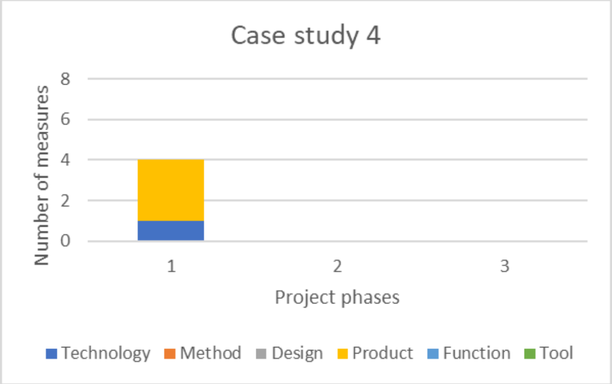

Figure 8: Number of measures case study 4

After the award, the measures were discussed with the client. Some proposed measures were discarded, mainly because of cost and maintenance reasons. The porous concrete was discarded because of the potential influence on the primary construction. Measures that were implemented were environment-friendly, relatively cheap, maintenance-free, and did not affect the primary structure. Figure 8 shows the number of measures added to the plan of action in the procurement phase.

Case Study 5 – Category 7

The client's request included the award criterion of landscape integration. During the tender phase, an attempt was made to obtain information in a dialogue session with the client. From this session, the client considered it very important for the road to fit into the area. The tender team had intrinsic motivation to implement biodiversity-enhancing measures, and when addressed in the dialogue sessions, the client did not dismiss it. Therefore, the decision was made to implement measures in the action plan (see Figure 9). These measures were:

- Plant fruit trees
- Hanging insect hotels
- Hanging nesting boxes for birds and bats
- Sowing a mixture of flowers and herbs
- Designing and building a nature-friendly shore at the water

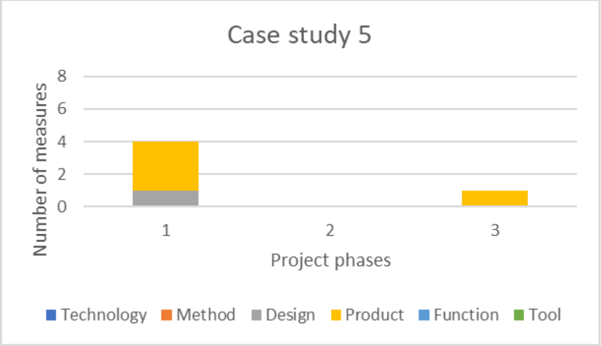

Figure 9: Number of measures case study 5

After the award, the client, contractor, and maintenance company entered into discussions with each other, and the proposed measures were discussed. The maintenance company rejected some of the proposed measures because the required maintenance needed to align with their policy. Other measures that did fit the policy and vision of the client were accepted.

During the execution phase, Phase 3, additional personnel from the client joined the team. They were very enthusiastic about a specific biodiversity-increasing measure, an insect hotel integrated into a bridge's structure. The contracting company designed the measure, and it was executed after the client approved it.

Case study 6 – Category 8

The client has expressed its ambition for sustainability by including sustainability in the request award criteria. The contractor chose to include two biodiversity-increasing product measures in the plan of action to score on the sustainability criteria (see Figure 10). These measures were designing a green area with:

- Sowing a mixture of flowers and herbs
- Plant a hedge where animals can find shelter

This company has a policy of always scaling biodiversity under sustainability to achieve its biodiversity goals. After awarding, the contractor discussed implementing biodiversity-increasing measures with the client. The client indicated that the proposed ideas were good, but the project site is believed to be unsuitable for other grass species and animals. Therefore, the possibility of increasing biodiversity was eliminated at the beginning of the design phase.

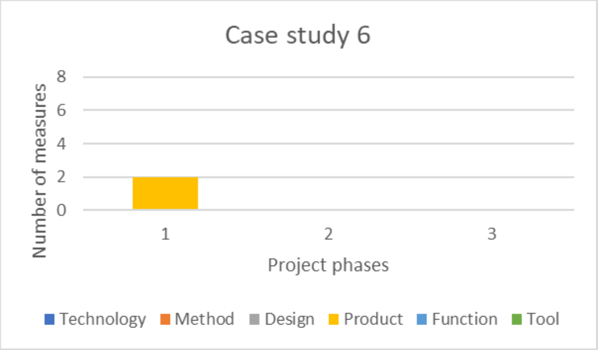

Figure 10: Number of measures case study 6

Case study 7 – Category 9

In this project, the client expressed their ambition for sustainability in the requested award criteria. The contractor's tender team chose not to offer any measures regarding increasing biodiversity in the plan of action and to focus on providing a low price.

Therefore, in Figure 11 the number of measures in the procurement phase is zero. After the award, a sustainability session was held with both parties. During this session, the client's biodiversity ambition emerged, mainly driven by a project team member with intrinsic motivation. This individual had control over a sustainability budget within the organisation, which had yet to be utilised and, therefore, was available for this project. Specific plans were devised with an ecologist to increase biodiversity, which was implemented in the design. These measures were:

- Planting hedges to provide shelter for animals
- Sowing a mixture of flowers and herbs
- Creating shelter for animals with different types of wood

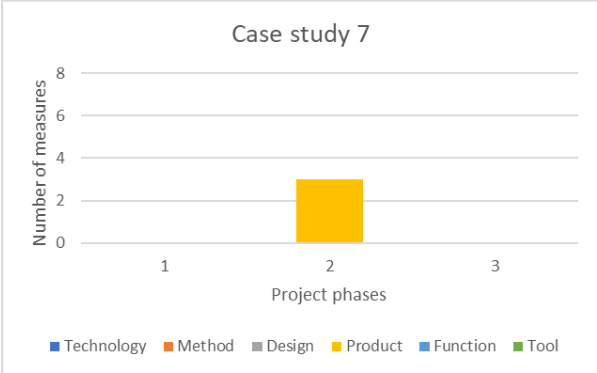

Figure 11: Number of measures case study 7

Cross-case analyses

Seven case studies were analysed to determine the actual implementation of biodiversity-increasing measures in the considered company. Table 2 shows the implemented measures and in which cases they are implemented. The table shows that multiple measures are implemented in a single case and multiple measures are implemented in several cases.

When the results of the case studies are combined, the total number of implemented measures cross-case is determined, as shown in Figure 12. This figure shows that when comparing the implementation in the considered phases, most measures are implemented in the procurement phase. However, since the case studies show implementation in all phases, the conclusion can be made that implementation is possible in all phases.

This figure shows that only measures categorised as technology, design, and method innovation are applied. The reason why the other types of innovation are not applied could be the characteristics of biodiversity-increasing measures, the company policy, or the type of projects selected for the case studies. The discussion section will discuss further implications of the results.

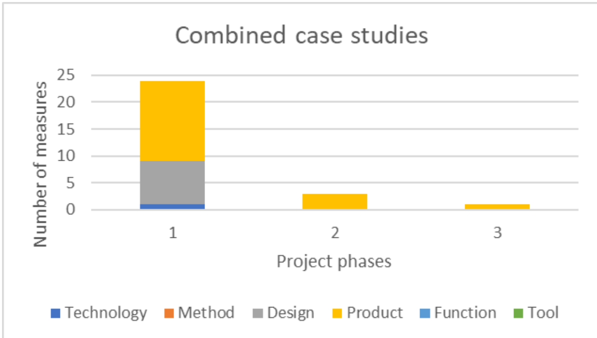

Figure 12: Number of measures cross case

Type of innovation	Measure	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Design	Designing and building a fish passage	V						
	Nature inclusive design		V					
	Designing and building nesting sites underwater			V				
	Designing and building a nature-based playground			V				
	Designing and building a Tiny Forest	V						
	Designing and building a nature-friendly shore at the water	V		V		V		
Product	Sowing a mixture of flowers and herbs	V		V		V	V	V
	Place river wood on the bottom of the water to create shelter for fish				V			
	Designing and building multiple 'biohuts' where fish can take shelter and use as a nursery				V			
	Hanging nesting boxes for bats and birds	V		V		V		
	Plant a hedge where animals can find shelter			V			V	V
	Hanging an insect hotel			V		V		
	Coconut matting to create a biological concrete surface				V			
	Plant fruit trees					V		
	Creating shelter for animals with different types of wood							
Technology	Apply porous concrete where plants and mussels can grow on the surface				V			

Table 2: Implemented measures cross-case

ii. Influencing factors of actual implementation

All cases show different strategies for implementing biodiversity-increasing measures with different results. This section compares these strategies to determine which factors influence the implementation of biodiversity-increasing measures. The influencing factors are distributed into three sub-categories in this section, factors that consider the: characteristics of the measure, the construction process, and the organisation. The determined factors that consider the characteristics of the measure are interesting to consider in the process of designing a measure. The factors that apply to the construction process are CSFs that are interesting to consider in the determined project phases when the ambition to implement biodiversity-increasing measures arises. Lastly, the factors that consider the organisation could be considered when compiling a project team if the ambition to implement biodiversity-increasing measures arises.

Influencing factors considering the characteristics of the measure

The implemented biodiversity-increasing measures in the case studies have differences and similarities compared to each other. All case studies have in common that specific measures were proposed, which means that the measures were explicitly designed or chosen for the project or project site. Furthermore, case study 1 is executed in a bouwteam contract; therefore, the total price of the execution was determined after the design. Because of the client's cost restraints, the measures proposed in the action plan were disregarded or minimalised. Case study 4 had the measures implemented in the plan of action and included the measures in the proposed prize. However, to decrease the maintenance costs, the measures that were relatively inexpensive and required no maintenance were accepted. Furthermore, to decrease extra costs related to the design, the contractor disregarded the measures that could potentially affect the primary construction. In case study 5, the approved measures are an addition to the environment, relatively affordable, and low maintenance. The measure implemented in the execution phase of case study 5 was designed through the client's vision. It could be implemented after the design phase because the measure did not impact primary construction, required no maintenance, and was relatively inexpensive to implement.

In summary, the following factors that potentially increase the implementation are identified through case studies:

Influencing factors – Characteristics of the measure
Design project-site-specific measures
Design measures that do not influence the primary construction
Design cost-effective measures
Designing measures that require low maintenance

Influencing factors considering the construction process

The cases have different strategies for implementing the measures in the project's scope. This section discusses the potentially influencing factors per phase. The considered phases are the procurement phase, the design phase, and the execution phase. The procurement phase is the first phase of a project from a contractor's perspective and includes the design process of the plan of action. The following phase is the design phase which starts after the award of the project and ends at the start of the execution and therefore includes the total design process. The last phase is the execution phase which starts with the start of the execution activities and ends with the completion of the asset.

Procurement phase:

Whether the procurement documents provided by the client contain an ambition or stimulation toward increasing the biodiversity on the project site is of great importance in determining a strategy in the design phase. If the procurement documents mention such ambition, contractors must respond accordingly to increase the chance of winning. Case studies 1, 2, and 3 exemplify clients' ambition, leading to proactive contractor responses. Conversely, case studies 4, 5, 6, and 7 reflect scenarios where clients did not prioritise biodiversity, resulting in different outcomes. Cases 4, 5, and 6 highlight contractor initiatives in biodiversity implementation, driven by internal sustainability goals rather than client stimulations.

In cases 1, 2, and 3, contracting companies displayed similar approaches, reacting directly to client ambition or stimulation. The interviewee of case study 3 considers the client's ambition a crucial success factor: "If they do not want to, it will not happen". Contractors, such as those in case studies 1, 2, and 3, incorporated biodiversity-increasing measures in response to client ambition or stimulation, recognising the strategic advantage of aligning with client goals.

Cases 4, 5, and 6 highlight contractor initiatives in biodiversity implementation by implementing measures in the plan of action and prize formation.

Design phase:

The post-award discussions highlighted by the interviewee of case study 4 underscore the importance of initiating conversations at the onset of the design phase because “the contractors should always initiate dialogue to ensure alignment on project measures”. This notion finds widespread support across the case studies where such conversations were held. However, in most cases, the conversation aimed to discuss the proposed measures in the plan of action and give a go or no-go to implementing the measures in the design. However, case study 7 is an example of a project where the after-award discussion led to implementing measures in the design phase. Implementing measures during the design phase allows for smooth incorporation into the project because the measures can be incorporated into the design. Incorporating a measure in the design allows for applying permits on schedule and executing the project in the planned timeline.

Execution phase:

Case study 5 is the only example of a project in which measures were implemented in the execution phase. Implementation was spearheaded by the client's wishes and provided budget and possible because of the measure's characteristics and the contractor's assertive reaction and enthusiasm.

In summary, the following factors that potentially increase the implementation are identified through case studies:

Influencing factors – Construction process
Adding measures to the plan of action
Discuss measures with the client during the after-award discussion

Influencing factors considering the organisation

The cases show that the people operating in the projects play a crucial role in implementing biodiversity-increasing measures. Influencing factors regarding organisations are discussed in the section per type of organisation divided into the contractor, client, and maintenance company.

Contractor

Implementing biodiversity-increasing measures in the action plan without stimulation depends on team dynamics and organisational ethos. In cases 2, 3, 4, 5, and 6, driven by intrinsic motivation for biodiversity, tender teams pursued implementation despite the projects' limited (financial) stimulation. Reasons to do so were intrinsic motivation, company policy, and company goals. The contracting companies of cases 5 and 6 have implemented the policy consistently to add biodiversity-increasing measures to a plan of action if sustainability is an award criterion. Cases 4, 5, and 6 highlight contractor initiatives in biodiversity implementation, driven by internal sustainability goals rather than client stimulations. Case study 4 emphasises the role of team motivation, suggesting that policies can encourage biodiversity initiatives by enhancing client satisfaction because “I believe it should always bring a plus and be appreciated by a client when you do something extra”. Conversely, case study 7 demonstrates a tender team’s decision not to implement biodiversity-increasing measures in the procurement phase, while the client’s request contained sustainability as an award criterion. The measures were not implemented in the procurement phase because it was not included in the action plan.

Client

The success of implementing biodiversity-increasing measures in construction projects is contingent upon the client's ambition toward biodiversity enhancement. For example, in case study 6, during the after-award discussion, the client listed limitations of the location and project size and concluded that biodiversity-increasing measures should be on the table. The client considered both fauna and flora on the project site undesirable, deciding not to implement any proposed measures. Conversely, case studies 2 and 3 are examples of projects where biodiversity measures are included in the scope but are not a priority for the client and, therefore, are not yet further discussed.

Case study 7 presents a project in which the client spearheaded biodiversity measures. The client’s team’s intrinsic motivation to increase biodiversity on the project site and the available budget drove this initiative. In response, the contracting company explored options and collaboratively designed a design to fulfil the client's ambition and vision.

Case study 5 further illustrates the significance of intrinsic motivation within the client's team regarding biodiversity. The client’s team had an example of a specific measure that would suit the project location, and therefore, the client engaged in discussions to explore options.

Maintenance company

During the after-award discussion, the party responsible for managing the project opposed Cases 1, 4, and 5. The managing company viewed the proposed biodiversity-increasing measures as incompatible with its management strategy and anticipated increased expenses. In all three cases, the maintenance company could agree on implementing relatively inexpensive measures to execute and maintain and required low maintenance.

In summary, the following factors that potentially increase the implementation are identified through case studies:

Influencing factors – Organisation
The client is motivated to increase biodiversity
Involvement of the maintenance company in the design process
Company policy to standardize the potential implementation of biodiversity-increasing measures
Intrinsic motivation to increase biodiversity in the project team

iii. Analysis of influencing factors

This section represents a triangulation that explores factors that influence the implementation of biodiversity-increasing measures. After researching the factors that influence the implementation of innovation and the factors that influence the actual implementation of biodiversity-increasing projects, this section verifies these two sources with a third source: expert interviews.

Influencing factors considering the characteristics of the measure

When designing a measure, the characteristics of the measure have proven to be of great importance. According to Banihashemi et al. (2017), a CSF for integrating sustainability in construction projects is “providing adequate design details and specifications” (Banihashemi et al., 2017, p.1107). Each case study has proposed project-specific measures rather than general measures. A project-specific measure is a measure specially designed for the considered project. Cases 1, 3, 4, 5, and 7 included measures that required a design. When designing a new measure, the development costs are higher compared to the consisting measures. However, a project-specific measure is not automatically a measure that never has been implemented before. Cases 1, 2, 3, 5, 6, and 7 included measures that did not require specific calculations or designs for the implementation.

The interviewed biodiversity experts are convinced that biodiversity-increasing measures should be project-specific from an integral approach. Research into the area and the flora and fauna present will significantly increase the chances of an increase in biodiversity. Focus group two agreed and stated that every area is different, and the possibilities must be assessed per project. However, in contradiction, focus group 1 disagrees and sees great potential in developing standard measures to increase project biodiversity, reduce the costs of developing a measure, and get clients acquainted with the concept to make it standard procedure. However, the disagreement is disregarded since designing standard measures is interesting because of the reduction of costs, according to focus group 1. In summary, designing a project-specific measure will potentially increase the possibility of a successful implementation compared to a measure that is not project-specific.

In case study 5, the applied measures were designed with the vision to fit the client’s perspective on the project. The measures were suited for the environment and considered to add value to the stakeholders. A project leader acknowledged that creating a design and being able to design a measure with the aesthetics that suit the client and fit the project's vision will interest the client and increase the chances of engaging the client in the design and, therefore, winning a project. Case study 7 is an example of a project where the client showed initiative to implement biodiversity-increasing measures on the project site. The contractor's project team responded by designing measures to fit the client’s vision on the site. Therefore, designing a measure through the client’s vision could be an influencing factor since the client might be more willing to accept the measure.

Furthermore, Liu et al. (2014) concluded that it is essential to identify the user’s needs. Holding these needs into account while designing a measure and fulfilling these needs with the measure should achieve the desired outcome and satisfy the stakeholder and, therefore, the client.

A tender manager stated that implementing biodiversity-increasing measures goes hand-in-hand with products or processes that do not affect the primary construction. Looking at the case studies, all case studies that successfully implemented biodiversity-increasing measures have implemented measures that do not affect the primary construction. In case study 4, measures that could affect the primary construction were eliminated from the design since the client insisted on receiving calculations on the consequences of the primary construction when implementing these measures. The project leader of case study 4 should have considered the proposed measures since performing the calculation would cause a delay in the project schedule and an overrun in time. This was considered “simply not worth it”. Therefore, designing a measure that does not affect the primary construction could potentially positively influence the implementation of biodiversity-increasing measures.

When the contractor's project team proposes measures and the client expresses the driver to implement cost-effective measures, the cost-effective measures are more likely to be implemented than measures with high costs (Ozorhon, 2013). Interviewee 1 agreed because, in all projects, the client's project team is held responsible for the project's costs. Therefore, the more expensive, non-essential measures are often cancelled after the award. Case studies 1, 4, 5, and 6 are examples of projects where measures got cancelled because of the budgetary limitations of the project. Focus group 1 experienced that if, in this case, the project leader of the contracting company advocated to implement the measures anyway, the contractor was responsible for the extra costs. However, project leaders at the contractor level are accountable for the project's financial aspect and must make as much profit as possible. Therefore, according to the focus group, paying for the measures is often impossible. The focus group acknowledged that sustainability does not always have to be more expensive than traditional methods. According to a tender manager, offering a sharp price should not be an issue since “biodiversity measures are generally not very expensive”. Especially with a measure that does not affect the primary construction, no extra calculations or design activities are necessary; therefore, the costs can stay relatively low. Case studies 1, 4, and 5 are examples of projects where expensive measures were eliminated from the scope, but inexpensive measures were approved. Since the implementation of cost-effective measures was more successful than the implementation of expensive measures, the cost-effectiveness of measures is an influencing factor.

According to the interviewed biodiversity expert, “maintenance is the most important factor in making the whole vision last”. Any measure should be maintained appropriately to ensure that the results are achieved. Therefore, the maintenance strategy must be determined in the design phase and approved by the maintenance company. However, in the case of study 4, the contractor could not get approval from the maintenance company and, therefore, designed maintenance-free measures. Thus, the client approved the implementation of the measures without the consent of the maintenance company. In case study 5, the implemented measures were low-maintenance despite the enthusiasm of the maintenance company because the aim was to keep the life-cycle costs as low as possible. Therefore, designing a measure that does not require significant maintenance influences the implementation process.

In summary, the following factors that potentially increase the chance of successful implementation are identified:

Influencing factors - Characteristics of the measure	**Literature**	**Cases**	**Experts**
Design project-site-specific measures		V	V
Design measures through the vision of the client			V
Identify and design through user’s needs	V		
Design measures that do not influence the primary construction		V	V
Design cost-effective measures	V	V	V
Designing measures that requires low maintenance		V	V

Table 3: Success factors triangulation characteristics of the measure

Influencing factors considering the construction process

Procurement phase

All interviewees employed at a contractor agreed with the statement that whether biodiversity is part of the ambition and procurement strategy of the client is an essential factor in the further strategy of a contractor. According to a significant client in the Netherlands, the procurement strategy depends on the budget, the location, the size, and the client's project team; a contractor does not influence this. To win the procurement, an effective tendering method is a crucial success factor (Banihashemi et al., 2017). The interviewed tender managers agreed with this statement and stressed the importance of a sufficient tender strategy. This tender strategy entirely depends on the project, the procurement documents, and the client's ambition. However, a sufficient design and a sharp price combination seemed essential in most projects. Ideally, the contractor would discuss the project's vision during the tender with the client, but this is only sometimes possible or strategically beneficial. Case studies 4 and 5 are projects where the tender team inquired about the client’s biodiversity ambition during a competitive dialogue. In both cases, the clients showed a semi-enthusiastic response during the dialogue, and therefore, the tender teams decided to proceed with the measures. Interviewee 5, an experienced tender manager, explained the strategic consideration towards engaging this dialogue since all competitors are shown the answers to the questions and, therefore, have the same benefit. Interviewees 1, 2, and 7 view the dialogue as an opportunity to test the client’s ambition. Therefore, addressing biodiversity in the dialogue session is considered a factor that could positively influence the implementation of biodiversity-increasing measures.

According to a tender manager, when biodiversity-increasing measures are part of the project’s scope in the procurement documents, it is crucial to implement them in the contractor's tender strategy. Directly reacting to the procurement request will increase the chances of engaging the client and winning the project. Case studies 1, 2, and 3 are examples of projects where the tender team incorporated biodiversity-increasing measures in response to client ambition or stimulation, recognising the strategic advantage of aligning with client goals. Therefore, the tender teams in these cases decided to implement project-specific measures to the action plan.

Suppose a client does not intend to increase the biodiversity in the project’s scope in the procurement documents. In that case, the tender strategy and implementation process differ from the situation where the client does show this ambition. Case studies 4, 5, 6, and 7 are examples of projects where the client did not stimulate the biodiversity-increasing measures in the procurement phase. Reasons why the implementation was successful in these cases differ. However, in cases 4, 5, and 6, the tender team decided to implement project-specific measures in the plan of action, and in case 7, the measures were implemented in another phase. Therefore, adding measures to the plan of action is considered a critical success factor in the implementation of the procurement phase. This conclusion is substantiated by the members of focus group 2, who believe that a policy in which the contracting company standardly includes biodiversity-increasing measures in the plan of action if the award criteria contain sustainability can increase the implementation of biodiversity-increasing measures in projects. A relatively experienced contractor in biodiversity emphasises the need to implement biodiversity-increasing measures in the procurement phase of projects. Focus group 1 agrees and states that frequently proposing measures in the action plan and regularly suggesting measures to clients will have the client think about biodiversity in the project scope. However, the decision must be made whether the space for the text in the plan is worth it since contractors have a limited number of pages to deliver. Focus group 2 strongly stated that this limitation to the number of pages is already too tight to address the award criteria, let alone address extra possibilities. Implementation success in this phase lies in powerful writing in the plan of action to convince the client of the benefit.

Design phase

After the award, the measures proposed in the action plan will be discussed when the contracting company has the first conversation with the client at the start of the design phase.

Case studies 1, 4, 5, 6, and 7 are examples of projects where the proposed biodiversity-increasing measures were discussed, implemented, eliminated, or changed during this meeting. However, case studies 2 and 3 did not discuss the measures in the after-award conversation because the priority was on different subjects. Therefore, the measures were not implemented in the design phase. If a client can allocate an extra budget to improve sustainability, this often comes up during this conversation, like in case study 7. According to focus group 1, this situation is most likely to occur in a project with a bouwteam contract since the contractor and client collaborate on making the design. Therefore, the contractor has more of a say in the measures implemented compared to a D&C contract where the criteria are prearranged. In a bouwteam project, the client, the contracting company, and the managing company discuss implementing extra measures in the after-award discussion. Since the managing party is involved early on, they "cannot make last-minute demands" in phases later on in the process, which prevents discussions in these phases, according to Focus Group 1. Initiating the after-award discussion and starting the conversation on implementing biodiversity-increasing measures can increase the possibility of successful implementation.

During this after-award discussion when proposing the biodiversity-increasing measures, an interviewed expert experienced that successful implementation goes hand in hand with expertise. Banihashemi et al. (2017) agreed and concluded that providing adequate design details and specifications when proposing measures to a client is crucial when integrating innovation (Banihashemi et al., 2017). Clients are often unsure and act traditionally, requiring relevant reference projects and results. The interviewed contractor speaks with experience that the client is more likely to approve the measures when a contractor can present them with sketches, reference projects, and results. Therefore, providing adequate design details with relevant reference projects and results when proposing a measure could be considered necessary during the implementation process.

Furthermore, Liu et al. (2014) concluded in their research that the definition of responsibilities should be clear to all involved parties when integrating innovation. Furthermore, allocating risks and interests must be appropriate to integrate the measures (Liu et al., 2014).

Execution phase

"In the execution phase, it is possible to achieve qualities in terms of biodiversity", according to the biodiversity experts. The materials can be changed when busy preparing the work methods and buying the products. According to focus group 1, measures that do not affect the design can be added after the design phase.

The interviewed ecologist addressed that considering the project planning, it is essential to consider the ecology at the project site and, for example, work around the breeding season. Breeding animals will not be disturbed by the construction activities, which will benefit biodiversity, and the construction activities will not be disturbed by the breeding animals, which will help the project planning. Besides adjusting the planning, executing the work in the right circumstances considering the flora and fauna positively affects biodiversity, especially in the long term. To summarise, creating awareness among the people responsible for the execution of the asset could potentially lead to a change in workways and, therefore, a positive effect on the biodiversity on site.

In summary, the following factors that potentially increase the chance of successful implementation are identified:

Influencing factors – Construction process	**Literature**	**Cases**	**Experts**
Address biodiversity in the dialogue session to try to gauge the clients' opinion			V
Adding measures to the plan of action		V	V
Discuss measures with the client during the after-award discussion		V	V
Identify responsibilities and allocation of risks and interest	V		
Providing adequate design details with relevant reference projects and results when proposing a measure	V		V
Creating awareness among employees responsible for the execution			V

Table 4: Success factors triangulation construction process

Influencing factors considering the organisation

The client

A project starts with the client, who determines the project request and the award criteria. The involvement and leadership of the client are seen as a success factor in implementing innovation in construction projects (Liu et al., 2014). According to focus group one, the goals and ambitions of the client determine the interpretation of the award criteria in the tender strategy. The interviewed tender managers agree with this statement and emphasise the importance of reacting to the procurement documents in the plan of action. When the clients' project team does not share the intrinsic motivation to apply biodiversity-increasing measures, the focus group notices that the proposed measures are quickly discarded.

To implement the measures in a project, it is essential that the client is motivated and strongly emphasises this ambition in the project. A biodiversity expert stated that "people determine a lot in the matter of implementation, especially those who have the lead. If the client is interested, they will ask the contractor about the opportunities at the project site".

Case study 5 further illustrated the significance of intrinsic motivation within the client's team regarding biodiversity. The client's team had an example of a specific measure that would suit the project location, and therefore, the client engaged in discussions to explore options. On the contrary, case study 6 is an example of a project with a client's project team without intrinsic motivation to increase biodiversity, and therefore, all suggestions were deflected. The motivation to increase biodiversity on the client's project site is considered a critical success factor.

According to Liu et al. (2014), a harmonious relationship with mutual trust between contractor and client will increase the chances of success during the discussions on implementing innovation. Therefore having a harmonious relationship with the client is considered an influencing factor in the implementation process.

The maintenance company

Suppose either the client or the contractor has a budget available. In that case, the contractor's project leaders often encounter difficulties with the company responsible for maintaining the asset, according to both focus groups. Focus group 1 stated that if the contracting companies would like to implement biodiversity-increasing measures in projects but encounter resistance from the client or maintenance party, the project leaders eliminate the proposed measures because the process becomes too complicated.

Biodiversity experts viewed that a managing company often has an aversion to biodiversity since "the required maintenance does not fit in their workways". However, properly maintaining the measures is essential to achieve the desired results. If the managing company cannot agree on the required maintenance, the measures must be eliminated since the implementation will not benefit without proper maintenance. The severeness of the approval of the maintenance company is shown in case studies 1, 4, 5, 6, and 7 since these are examples of projects where measures were deflected because the maintenance company did not approve them. Therefore, the involvement of the maintenance company in an early stage of the project is considered an influencing factor in the implementation of the biodiversity-increasing measures.

The contractor

The key to a contractor's success is creating a project team with the right people to elaborate on a client's request. According to an ecologist, this starts with assembling a motivated, professional, and well-trained tender team. Li et al. (2011) concluded that project team motivation is one of the most critical factors for success in construction projects. The project team should be motivated to implement biodiversity-increasing measures into the plan of action to create the opportunity to implement these measures in the project's scope. A project leader claimed that a person on the project team must show ambition to make changes, research the benefits and possible disadvantages, and propose this to the client's project team. The interviewed project manager has seen examples of this situation where a motivated employee changed the design of green areas from traditional vegetation to nectar-rich vegetation, which lures bees and butterflies and increases biodiversity. Even the people working outside during the execution phase can implement biodiversity-friendly workways when motivated. Besides the people working on the project, Liu et al. (2014) concluded that the motivation of the management is crucial in implementing innovation.

Banihashemi et al. (2017) concluded that implementing policies that support sustainability principles in construction projects is a success factor for implementing sustainability. Part of the focus group is employed at a company with the policy to standardly include biodiversity-increasing measures if the procurement request involves anything considering sustainability. The focus group expressed that this policy has led to the integration of biodiversity in several projects. Furthermore, interviewed experts believe implementing a company policy that encourages critical review when selecting disciplines for project teams can enhance awareness and minimise the risk of overlooking valuable opportunities. Then, knowledge and experience in the affiliated subjects are accessible to the team. In conclusion, changing company policy could contribute to successfully integrating biodiversity-increasing measures in projects.

However, according to a biodiversity expert, this knowledge should be available in the company, which is crucial for successful implementation. To propose proper measures involving an ecologist is crucial because they can view more extensive solutions in a larger area. According to biodiversity experts, having an ecologist on the project team is essential to know how to interpret the implementation of biodiversity since applying measures for absent animals can be considered useless. All case studies that successfully implemented biodiversity-increasing measures have included an ecologist in the project team. After the award, the interviewed ecologist experiences that clients are relieved when a contractor can enlighten the ecological bottlenecks of the project and show expertise and knowledge. Yong & Mustaffa (2013) researched the CSFs for Malaysian construction projects and concluded that the most important success factor for implementing innovation in construction projects is the contractor's competence and experience (Yong & Mustaffa, 2013). According to the interviewed expert, clients often ask for reference projects and proven results, and if a contractor can show these, the chances of successful implementation are higher. Another benefit of having experience with specific measures is that the project team can review the mistakes made at other projects and correct them in the design. The literature supports this statement since the "use of lessons learned in previous projects by the project management team" is a CSF for implementing sustainability in construction projects (Banihashemi et al., 2017, p.1107). Therefore the presence of expertise on the suggested biodiversity-increasing measure is considered an important influencing factor in the implementation process.

In summary, the following factors that potentially increase the chance of successful implementation are identified:

Influencing factors - Organisation	**Literature**	**Cases**	**Experts**
The client is motivated to increase biodiversity		V	V
Harmonious relationship between contractor and client	V		
Involvement of the maintenance company in the process		V	V
Intrinsic motivation to increase biodiversity in the project team	V	V	V
Company policy to standardize the potential implementation of biodiversity-increasing measures	V	V	V
Expertise with biodiversity-increasing measures in the project team	V		V

Table 5: Success factors triangulation organisation

V. Implications research

The factors that influence the implementation of biodiversity-increasing measures in construction projects were identified through triangulation. These 18 identified success factors influence three aspects of the construction project process and are categorised accordingly, as presented in Table 6. The three categories are characteristics of the measure, construction process, and organisation.

The identified success factors that consider the characteristics of the measure should be considered during the design of the biodiversity-increasing measure to potentially positively affect its implementation in the project.
The identified success factors considering the construction process could positively contribute to implementing biodiversity-increasing measures during the total construction process.
The identified success factors that consider the organisation can positively affect the integration of biodiversity-increasing measures if sustained properly when compiling the organisation and project team.

Category	**Number**	**Measure**
Characteristics of the measure	1	Design project-site-specific measures
	2	Design measures through the vision of the client
	3	Identify and design through user's needs
	4	Design measures that do not influence the primary construction
	5	Design cost-effective measures
	6	Designing measures that requires low maintenance
Construction process	7	Address biodiversity in the dialogue session to try to gauge the clients' opinion
	8	Adding measures to the plan of action
	9	Discuss measures with the client during the after-award discussion
	10	Identify responsibilities and allocation of risks and interest
	11	Providing adequate design details with relevant reference projects and results when proposing a measure
	12	Creating awareness among employees responsible for the execution
Organisation	13	The client is motivated to increase biodiversity
	14	Harmonious relationship between contractor and client
	15	Involvement of the maintenance company in the process
	16	Intrinsic motivation to increase biodiversity in the project team
	17	Company policy to standardize the potential implementation of biodiversity-increasing measures
	18	Expertise with biodiversity-increasing measures in the project team

Table 6: Identified success factors

An implementation strategy, mapped in Figure 13, can be used by a contractor to implement these identified success factors for the integration of biodiversity-increasing measures. The schematisation includes all three phases that can be considered separately. It also includes several boundary conditions that are identified as important factors in the implementation process. Furthermore, the schematisation contains all identified success factors mapped in the identified phases.

The schematisation must be read from top to bottom and starts with whether the ambition or financial stimulation to increase the biodiversity on the project site is part of the provided procurement documents. After every boundary condition, the schematisation is split into a ‘yes’ or ‘no’ where the ‘yes’ represents meeting the boundary condition and the ‘no’ represents not meeting the boundary condition. Following the option relevant to the project’s situation will lead to applicable success factors or actions. All success factors are represented with a number referring to the number in Table 6: Identified success factorsFurthermore, the three different phases are represented in the schematisation and separated by a dotted line. The arrows representing the transition to another phase are dotted lines.

VI. Discussion

The theoretical background started with elaborating on a deep understanding of the concept of biodiversity and how it can be increased. Goedkoop et al. (2023) their research concluded that increasing biodiversity starts with species diversity and, therefore, the focus should be on maintaining species that originally occurred in the considered area. After investigating the case studies, the results showed which measures were applied in the considered projects. All measures applied aimed to provide food or a living area with shelter to species such as insects, birds, bats, fish, or small land mammals. These species originally occurred in the project areas and are relatively easy to maintain or increase. Since the implemented measures in the case studies are focused on originally occurring species, this aligns with the conclusion and recommendations of Goedkoop et al. (2023).

Furthermore, the analysis of the actual implementation of biodiversity-increasing measures highlighted the number of measures currently implemented across the three defined project phases. These phases included the procurement phase, design phase, and realisation phase. The maintenance phase was excluded from the research because of the expertise of the cooperating company and the direct connection to the research of Noktehdan et al. (2019).

Several discoveries were made during the research, the first being that only biodiversity-increasing measures classified by the type ‘design’, ‘method’, and ‘technology’ were implemented. On the contrary, research by Noktehdan et al. (2019) showed the implementation of all considered types of innovation. The different characteristics of biodiversity-increasing measures could cause inconsistency compared to innovation.

Secondly, the majority of biodiversity-increasing measures, considering all types, are implemented in the procurement phase. The case selection process could explain the contrast between innovation and available data since innovation is mainly implemented in the design and realisation phase. Furthermore, the company focuses on the implementation in the tender phase since this phase is considered the phase with the most potential to include these measures in the project scope and price.

The implementation of technological measures is, for both innovation and biodiversity-increasing measures, the highest in the procurement phase compared to the design and execution phase. The reason could be that technological innovations or measures have characteristics that significantly impact the project process. Therefore, early implementation is essential for successful integration.

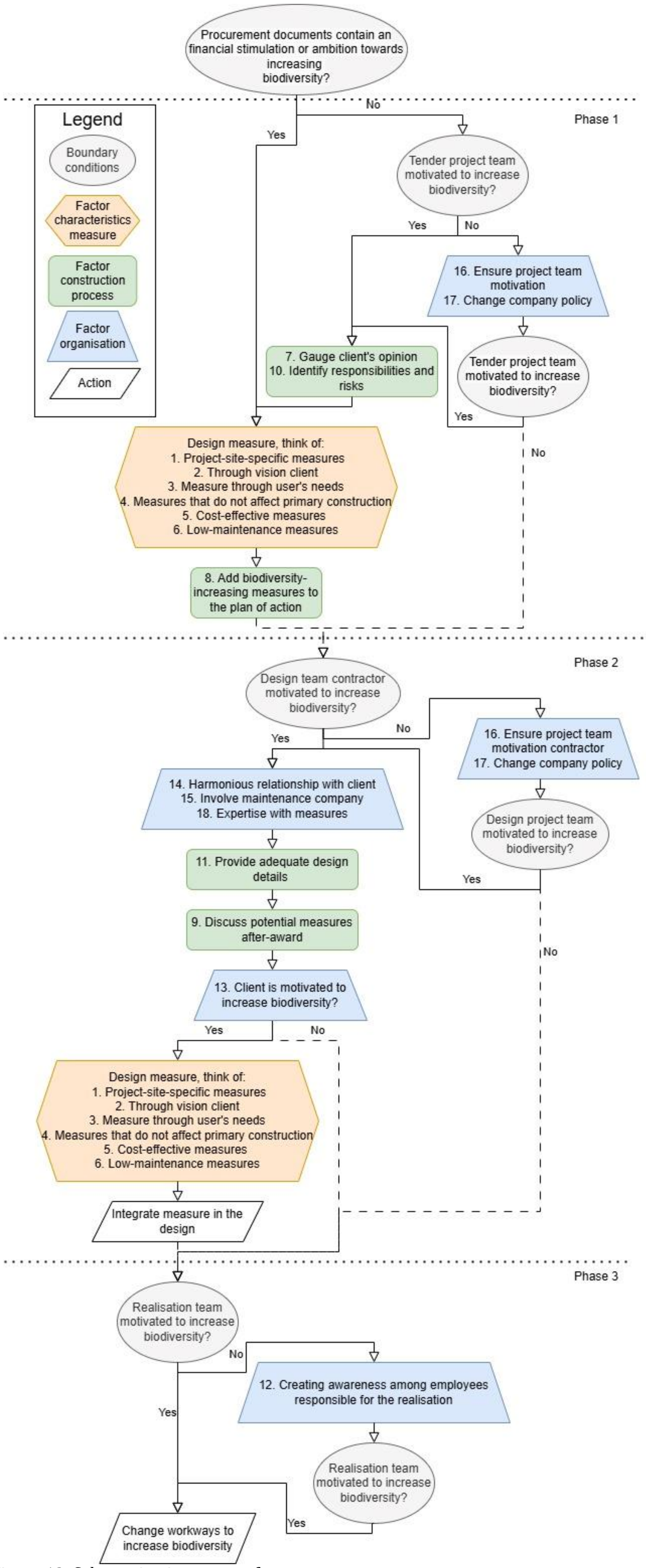

Figure 13: Schematisation success factors

Considering the design and method types of measures contrasts with findings by Noktehdan et al. (2019) about the implementation of innovation, which suggests that design and method types of innovation mainly occur in the design phase. The inconsistency may be attributed to differences in case selection methods, the size of measures, and the characteristics of biodiversity-increasing measures compared to innovation. Noktehdan et al. (2019) reported many tool and function innovations in the execution phase, whereas this study found no tool or function-related biodiversity measures in any phase. This is explainable since a tool innovation is a new machinery and a function innovation is a new task, both not in line with the characteristics of biodiversity-increasing measures.

The second part of this research consisted of determining influencing factors that could contribute to implementing biodiversity-increasing measures across the phases. Research by Liu et al. (2014), Ozorhon (2013), Banihashemi et al. (2017), Li et al. (2011), Järvenpää et al. (2019), and Yong & Mustaffa (2013) discussed the CSFs of the implementation of innovation in the construction sector. Together, it showed nine identified CSFs focusing on the project organisation, the characteristics of the measure, and the construction process. In addition, analysing case studies and interviewing experts with cross-case functions led to the possibility of performing a triangulation, which led to 18 identified success factors. Five of these factors were only derived from one source, eight factors were derived from two sources, and four factors were derived from all three sources.

Furthermore, in the validation, the differences in categorisation are visible; for example, the factors that consider the project's organisation are relatively extensively validated since these factors are considered important in each source. All considered research focused on the project organisation; therefore, the other two subjects are relatively neglected in the validation with literature. Only Liu et al. (2014), Banihashemi et al. (2017), and Ozorhon (2013) identified success factors in the other two categories. On the contrary, from the case studies, the main factors that consider the characteristics of the measure were identified. Potentially due to the focus of the questions, the interviewees' expertise, or the case's characteristics. The cross-case experts showed a broad validation of all considered categories which might be explainable by the interviewee's broad scale of functions and different projects.

VII. Conclusion

This study has provided a detailed exploration of how biodiversity-increasing measures can be integrated into infrastructure projects, aligning theoretical insights with practical applications. The theoretical background underscored the importance of maintaining species native to the area, a principle reflected in the measures implemented across the case studies. These measures, aimed at providing food and living areas with shelter for local insects, birds, bats, fish, and small land mammals, align well with the literature's emphasis on conserving native species.

The analysis of project implementation revealed that biodiversity-increasing measures were exclusive of the design, method, and technology types of innovation. Most measures, 24 to be precise, were implemented during the procurement phase, only three were implemented in the design phase, and only one was implemented in the execution phase. Therefore, it can be concluded that implementation is possible in all phases but mainly occurs in the tender phase.

In the second part of the research, success factors were identified that could enhance the implementation of biodiversity measures. Literature on innovation in the construction sector highlighted nine CSFs, with five focusing on the project's organisation from the client's perspective. The case studies identified 12 success factors, encompassing project organisation, measure characteristics, and the construction process. Expert interviews refined these findings, resulting in a comprehensive list of 18 success factors. These identified success factors influence three different aspects of an infrastructure project: 1) the characteristics of the measure, 2) the construction process, and 3) the organisation. Considering these three aspects potentially increases the integration of biodiversity-increasing measures in infrastructure projects.

In conclusion, the research regarding the actual implementation of biodiversity-increasing measures showed that measures are implemented in all considered phases. Furthermore, through the identification of success factors, three main aspects are identified that should be considered during the implementation to increase the integration of biodiversity-increasing measures.

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