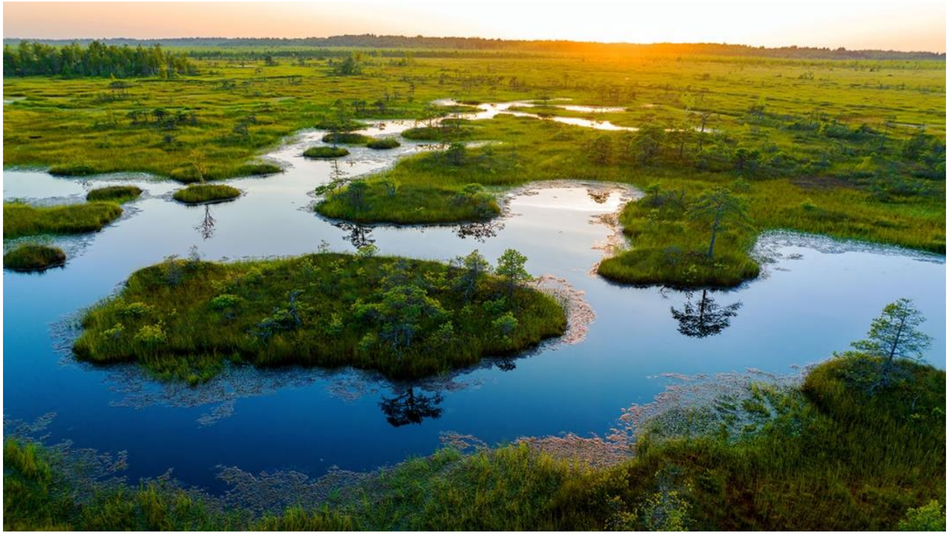
Incorporating Social Learning-oriented Monitoring in Nature-based Solutions Planning

Applying QCA to understand the effect of conditions in the Nature-based Solutions planning environment on social-learning oriented monitoring in plans



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Incorporating Social Learning in Nature-based Solutions Planning: Applying Qualitative Comparative analysis to understand the effect of conditions in the Nature-based Solutions planning environment on social learning-oriented monitoring.

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Abstract

The transformative potential of Nature-based Solutions (NBS) has led to numerous projects being centered around applying NBS principles. However, planning for NBS remains a significantly neglected topic, despite its undeniable impact on implementation. Specifically, the understanding of the relationship between social learning and planning in the context of NBS is limited. In this thesis, the effect of conditions within the NBS planning environment on monitoring—serving as a proxy for social learning—when embedded in plans was analyzed. To achieve this, a Qualitative Comparative Analysis (QCA) was applied, examining 24 NBS and 14 non-NBS case studies. Although the results suggest that monitoring is more frequently embedded in NBS cases than in non-NBS cases, the QCA reveals that the analyzed conditions do not serve as explanatory factors for monitoring inclusion in plans. Consequently, future research should explore different conditions conducive to social learning-oriented monitoring in NBS planning and employ more qualitative analyses to deepen our understanding of this relationship.

Acknowledgments

The success of this research has largely depended on the unwavering support of my supervisor, Raffaele Vignola. The ideas that emerged during our meetings significantly influenced the development of this thesis. His ability to connect my work to his own was a profoundly meaningful experience.

I would also like to extend my heartfelt gratitude to Lotte van Roosmalen. Our shared experiences and her insightful comments were invaluable throughout this journey. Lastly, I express my deep appreciation to the authors of *Qualitative Comparative Analysis Using R*. Their book played a pivotal role in enabling me to conduct this research effectively.

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Introduction

Planning for Nature-based Solutions (NBS) is riddled with uncertainties (Pahl-Wostl & Knieper, 2014; Pelling & High, 2005). The context in which NBS planning takes place is highly dependent on the complex interplay between human and physical systems (Palomo et al., 2021; Seddon et al., 2020). The interactions between these systems are innately complex and unpredictable, which results in there always being some form of uncertainty when planning for and implementing NBS.

To overcome these inherent uncertainties, NBS projects try to incorporate different planning approaches (Cilliers et al., 2022). What they have in common is that they all aim to follow the principles of adaptive planning (Albert et al., 2021). Central to this approach is the ambition to plan "efficiently, cost-effectively, and sustainably" (Cilliers et al., 2022, pg. 2). To tackle the uncertainties of the NBS planning environment, projects need to be flexible and adaptable, to prevent lock-ins and path dependencies in the planning phase (Hermans et al., 2017). Creating this flexibility and adaptability is fostered by social learning (Pahl-Wostl & Knieper, 2014). Social learning is often referred to as "a process of social change in which people learn from each other in ways that can benefit wider social-ecological systems" (Reed et al., 2010, pg. 2). This form of learning promotes a constant (re)assessment of the planning process, decisions, risks, and concrete plans (Kato & Ahern, 2008).

Social learning should primarily focus on receiving and implementing feedback (Giordano et al., 2011). In this sense, monitoring is the most important learning device (Hermans et al., 2017). To handle and be responsive to the uncertainties in NBS planning, a constant process of feedback and experimenting is required (Albert et al., 2022; Kato & Ahern, 2008; Pahl-Wostl & Knieper, 2014). According to various authors, therefore, social learning-oriented monitoring can be regarded as a powerful learning tool to make NBS planning more adaptive (Kato & Ahern, 2008; Malekpour & Newig, 2020).

Even though theoretically the importance of incorporating social learning-oriented monitoring as a tool to overcome uncertainties is recognized, monitoring is merely erratically embedded in NBS plans. This is the case because monitoring is considered a costly and time-consuming effort which deters decision-makers from including it in their projects (Hermans et al., 2017; Kato & Ahern, 2008). Therefore, the potential of monitoring as a social learning device in NBS planning is highly underutilized (Kato & Ahern, 2008).

The problem is that we do not know what the factors are in NBS planning that determine whether monitoring is embedded in plans or not, in particular, the role that conditions in the NBS planning environment could play. It is important to know these conditions because they will give more control over the incorporation of social learning devices - in particular, monitoring - in NBS project plans.

Therefore, the purpose of this research is to understand how certain conditions in the NBS planning environment may affect social learning-oriented monitoring being embedded in NBS plans. To do so, a Qualitative Comparative Analysis (QCA) was applied to 38 European case studies to understand the extent to which social learning-oriented monitoring is incorporated in NBS plans and under what conditions.

This study is structured as follows: first, the concepts and the relationships between them are defined and visually presented. This is followed by an explanation of the methodology including an in-depth description of the way QCA was applied. Then the results are presented after which the results are discussed and placed into the academic context. The research ends with recommendations and a conclusion.

Theoretical Framework

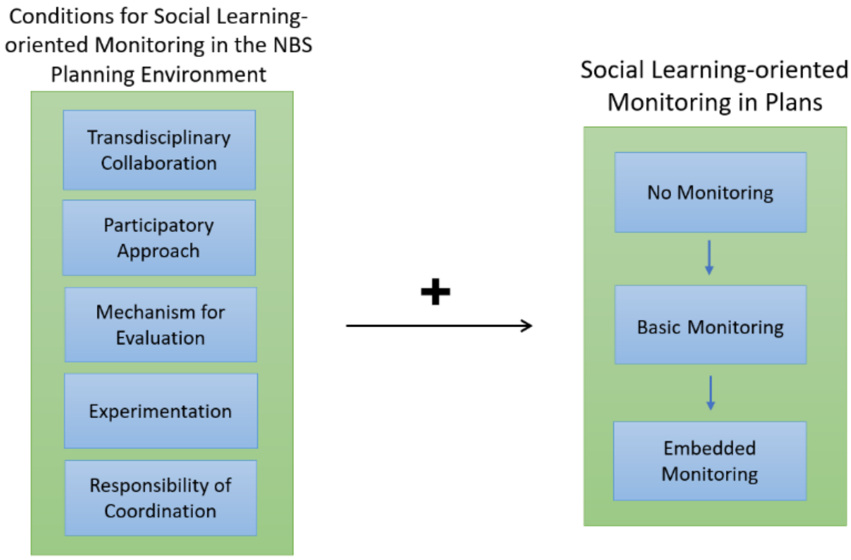

Figure 1: Conceptual Framework describing how Conditions for Social Learning-oriented Monitoring in the Planning Environment positively relates to Monitoring being embedded in Plans

Nature-based Solutions and their Planning Environment

Nature-based Solutions (NBS) are actions designed to tackle climate adaptation and mitigation challenges through the use of nature (Seddon et al., 2020). They do so by maintaining, restoring, and/or transforming natural ecosystems (Cohen-Shacham et al., 2016). The most applied definitions of NBS have been made by the International Union for Conservation of Nature (IUCN) in 2012 and the European Commission in 2015 (EPRS, 2017). Whereas the IUCN definition puts more emphasis on restoring and managing ecosystems as the core of NBS, the European Commission takes a broader view in which projects that do not use, but are inspired or supported by nature, can also be considered NBS (Cohen-Shacham et al., 2016). Although contention about the NBS definition exists, there is widespread consensus that NBS have the potential to provide benefits for both natural and human systems, thereby contributing to the achievement of the Sustainable Development Goals (Albert et al., 2021; Faivre et al., 2017).

NBS are praised for their transformative potential to create sustainability compared to grey infrastructure (Frantzeskaki, 2019). To achieve this potential, NBS requires a planning environment that is supported by various disciplines, where there are opportunities for co-creation, and where there is a widespread awareness of NBS' transformative potential. Furthermore, successful planning for NBS entails solutions to be embedded in the local context where relevant stakeholders are integrated into the planning process (Gottwald et al., 2021; Nesshöver et al., 2017). However, due to the variety of backgrounds, power relations, interests, and multiple understandings of the issue, it is challenging to come to a common vision of what the issue is and subsequently devise appropriate solutions (Gottwald et al., 2021). These complexities are exacerbated by the unpredictability of climate change and result in uncertainty in NBS planning (Pelling & High, 2005).

From her analysis of various NBS case studies, Frantzeskaki (2019, pg. 108) concluded that to overcome uncertainties, "nature-based solutions need to be designed in such a way and scale that lessons for their effectiveness can be easily harvested and thus, easily replicated into other locations." One of how lessons can be collected is by incorporating a continuous process of social learning in NBS project plans, with monitoring as one of the most important learning devices (Kumar et al., 2021).

Social Learning-oriented Monitoring

Social learning-oriented monitoring is "a process of measuring, recording and comparing the achievements against a set of predefined targets, and thereby informing the project outcomes to the managers and policymakers to assist them in decision-making" (Kumar et al., 2021, pg. 2). Furthermore, when monitored over longer periods, cause-effect relationships in complex systems can be discerned. Therefore, by continuously enabling a process of social learning the understanding of the system is improved, objectives and plans can be revised and eventually, uncertainty is reduced (Hermans et al., 2017).

Based on previous notions, the gathering and evaluating of NBS monitoring data may assist decision-making, as this data can empirically underpin the need to change NBS projects' implementation. Perhaps more importantly, evaluations of the effectiveness of NBS projects can influence/alter plans in other NBS projects (Frantzeskaki, 2019). All things considered, embedded monitoring can be utilized to create opportunities for social learning in which stakeholders use feedback from monitoring to improve planning and implementation practices (Schönfeld et al., 2020).

Hermans et al. (2017) have devised an approach for designing monitoring for adaptation pathways. They have argued that certain monitoring "building blocks" will ultimately help stakeholders deal with the uncertainties and complexities of adaptation (Hermans et al., 2017, pg. 32). Furthermore, the more of these building blocks are included in projects, the more likely that a long-term social learning process is ensured. Inspired by this research, we can distinguish three levels of monitoring in plans (see Figure 1).

Firstly, plans may include nothing about monitoring (No Monitoring). This may either be due to monitoring efforts not being institutionalized or written down on paper or stakeholders do not regard monitoring as a valuable part of their projects. Secondly, Hermans et al. (2017) argue that minor inclusion of monitoring revolves around only having Basic Monitoring. This entails that monitoring in itself is mentioned on paper, but detailed information on the operationalization of monitoring is not included in NBS plans. The last level revolves around the idea that monitoring is not merely mentioned, but that, responsibilities are divided, resources are allocated towards monitoring, etc., which will be referred to as Embedded Monitoring (Kumar et al., 2021).

Conditions for Social Learning-oriented Monitoring

There are an infinite number of conditions in the NBS planning environment that, when met, may enable the embedding of social learning-oriented monitoring in NBS plans. Inspired by Bos et al. (2013), Malekpour & Newig (2020), and Rauws & de Roo (2016), and conceptually supported by Nesshöver et al. (2017), there are five of these conditions highlighted in this research (see Figure 1).

Firstly, *Transdisciplinary Collaboration* refers to the idea that, in the planning environment, there are frequent interactions between science and practitioners and other stakeholders in the field to guide and give feedback to experimental processes (Nesshöver et al., 2017). Science-practice interactions allow stakeholders to become more aware of uncertainties thereby acknowledging the importance of embedded monitoring.

Secondly, a *Participatory Approach* is a condition for embedded monitoring. When stakeholders are involved in the planning process in a meaningful way, likely, they would also like to track the progress during the implementation phase. Therefore, monitoring is more likely to be embedded in plans. Malekpour & Newig (2020) assert that the participation of the local community is vital to create the previously mentioned benefits. A community can be understood as a “social group of any size whose members reside in a specific locality or share a common heritage or set of values” (Lachapelle & Austin, 2014, pg. 1073). In this research community participation is referred to as: “Those who are affected by a decision have a right to be involved or have some degree of influence over any process and outcome related to its legislation, execution & adjudication” (Lachapelle & Austin, 2014, pg. 1073). Whereas in Transdisciplinary Collaboration, the emphasis lies on interactions between practitioners and science, in Participatory Approach, the focus is on the interactions between practitioners and the affected community.

Thirdly, in the NBS planning environment, there should be room for *Experimentation* for stakeholders to explore which plans will be most suitable (Nesshöver et al., 2017). In reality, experimentation often manifests itself through the use of pilots. When you experiment, you need to monitor the progress to see if the experiment was successful or not (Frantzeskaki, 2019). When monitoring is then already embedded in the planning environment is it likely that experimentation in the planning environment indirectly promotes the likelihood of social learning-oriented monitoring being embedded in plans.

Related is a *Mechanism for Evaluation* which is a way to incorporate feedback from experimentation to enhance the flexibility and adaptability of the planning process. There is a need to monitor the planning process to be able to evaluate it. Therefore, having a mechanism for evaluation increases the likelihood of embedded monitoring. Lastly, an important condition is *Responsibility of Coordination*. This refers to the idea that in the NBS planning environment, there should be some form of governance structure that organizes and regulates the planning process. In particular, this coordinating body should acknowledge the uncertainties of the system and aim to unite relevant stakeholders to participate in a co-creative learning process (Nesshöver et al., 2017). It is more likely to set up an organized structure to embed monitoring when there already is an organization responsible for creating structure in a planning environment.

Hypothesis and Research Question

Based on the previous notions, I hypothesize that the more of the five conditions are met in the NBS planning environment, the more likely monitoring will be embedded in NBS plans as visualized in Figure 1. Based on this hypothesis, the research question is as follows:

What are the necessary and sufficient conditions in the NBS planning environment for social learning-oriented monitoring to be embedded in NBS plans?

Methodology

This chapter is dedicated to a detailed description of the methodology. The parts of the methodology are described in the order in which they were implemented. To be able to compare and contrast, the next Nature-based Solutions (NBS) case studies I have also collected and analyzed non-NBS case studies as well. First, I decided on which database and case studies to use. Then, I coded the information based on the operationalization using Atlas.ti after which a non-NBS and NBS calibrated dataset was created. Finally, a Qualitative Comparative Analysis (QCA) was conducted for both datasets through a test of necessity and sufficiency.

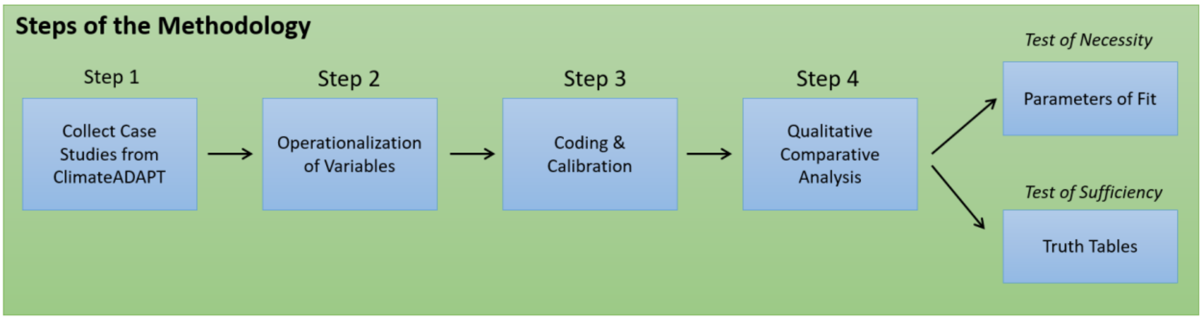

Figure 2: Description of the Methodological Steps around which the Research is focused.

Step 1: Collecting Case Studies from ClimateADAPT

To be able to find cases that would fit the criteria of this study, I have looked at the GeoIKP, Oppla, and ClimateADAPT online databases. These three online portals present elaborate information on NBS projects in Europe. I checked whether the databases included NBS plans and information about the planning process as this information most closely represents the planning environment.

Contrary to GeoIKP and Oppla, only the ClimateADAPT database included information about the planning process of different cases. Furthermore, ClimateADAPT contained data about non-NBS cases. Therefore, I decided to only use information from the ClimateADAPT database. The European Climate Adaptation Platform (ClimateADAPT) is maintained by the European Environment Agency (EEA). Its primary goal is to help EU member states adapt to climate change through the dissemination of information about expected climate change, vulnerability of regions, adaptation strategies, etc. (Climate ADAPT, 2023). Relevant for this research, is that they have a database in which they provide easily accessible information about (non-)NBS projects in Europe.

To apply the QCA, cases were chosen from ClimateADAPT. I wanted to make a distinction between NBS and non-NBS cases, to be able to see whether the QCA would render similar or different results regarding what (set of) conditions in the planning environment would lead to monitoring in plans. Therefore, 27 NBS cases and 15 non-NBS cases were selected. They were chosen based on the following criteria: The case studies were in Europe, operated at a sub-national or local level, included information about the planning process, and presented plans.

The distinction between an NBS and a non-NBS case was made using the definition that the ClimateADAPT database presents for NBS (Climate ADAPT, 2023). They argue that any case that falls under the European Commission's and/or United Nation's definition of NBS, will be recognized as a NBS in their database. For the clarity and structure of this research, the practical distinction of cases by ClimateADAPT is adopted in this research as well as it aligns with the NBS definitions of this research (see pg. 6).

Step 2: Operationalization of the Variables

Table 2 explains the indicators for monitoring. They are defined in the conceptual scale order so that No monitoring = 0, Basic Monitoring (BM) = 0.5, and Embedded Monitoring (EM)= 1. The indicators that were used to operationalize the five conditions can be found in Table 2. All the indicators are based on existing literature and help to identify whether a case meets a condition or not. A condition can be met (1) or not met (0).

To be able to make a distinction between 0 and 1 for *Transdisciplinary Collaboration* and *Participatory Approach*, the Ladder of Participation was used. The Ladder is a metaphorical representation of the levels at which citizens have agency and power (Figure 3). The higher on the Ladder, the more citizens participate (Arnstein, 1969). For this research, I will consider every interaction in the planning process below informing as not meeting the condition and above informing as met. Informing is used as a threshold as it is the last step on the ladder where there merely is a one-way flow of information rather than an active interaction (Stout, 2010). For the conditions to be met, there must be a form of repeated two-way interactions between science and practice (Transdisciplinary Collaboration) or stakeholders who are directly affected (Participatory Approach) (Nesshöver et al., 2017).

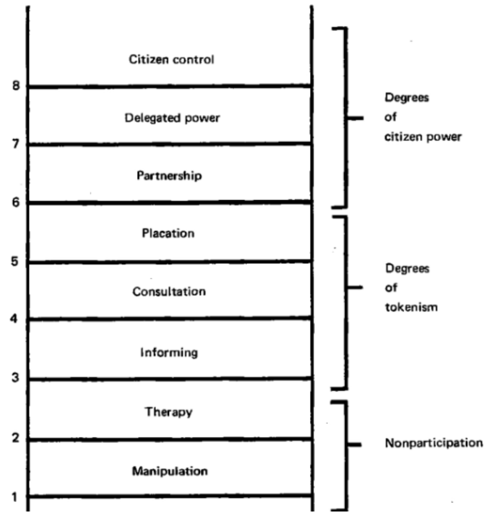

Figure 3: Ladder of Participation as devised by Arnstein (1969)

Table 1: Operationalization of the five conditions for social learning-oriented monitoring

Condition	**Value = 0**	**Value = 1**	**Literature**
Transdisciplinary Collaboration (TrCo)	Science-practice interactions are not mentioned, or some interactions are informing or below on the Ladder of Participation.	Science-practice interactions are mentioned and exist on or above the consultation step on the Ladder of Participation	Bos et al. (2013) Malekpour & Newig (2020) Stout (2010)
Participatory Approach (PaAp)	Stakeholders directly affected by a project are not included in the planning process or stakeholders are merely informed or below on the Ladder of Participation	Stakeholders who are directly affected by a project are included in the planning process on or above the consultation step on the Ladder of Participation	Malekpour & Newig (2020) Stout (2010)
Mechanism for Evaluation (MfE)	There is no mention of a peer review of the planning process	A peer review of the planning process is mentioned	Malekpour & Newig (2020)
Experimentation (Exp)	Within the planning environment, experiments such as pilots are not conducted by stakeholders.	Within the planning environment, experiments such as pilots are conducted by stakeholders.	Bos et al. (2013) Malekpour & Newig (2020) Rauws & de Roo (2016)

Table 1 Continued

Responsibility of Coordination (RoC)	There is not an organization that takes on the role of coordination in the planning environment.	There is an organization that takes the role of coordination in the planning environment. There is an organization that takes charge of the planning process.	Malekpour & Newig (2020)

Table 2: Operationalization of Social Learning-oriented Monitoring as the outcome

Outcome	**Value**	**Indicator**
No Monitoring	0	Monitoring is not mentioned in the plans & therefore not applied systematically.
Basic Monitoring	0.5	Monitoring is mentioned on paper
Embedded Monitoring	1	Monitoring is mentioned on paper and/or responsibilities are assigned and/or resources are allocated towards monitoring and/or there are learning conditions defined.

Step 3: Coding & Calibration

After the case studies had been selected and the variables operationalized, I proceeded with coding the data. The case descriptions in the ClimateADAPT database were coded as well as additional information that the case descriptions would refer to, such as project plans and project descriptions on different websites. The data was coded in ATLAS.ti using a deductive coding method as I had already defined the codes based on the operationalization and looked for quotes that would fit the codes (Babbie, 2016). After coding all case studies, the data was independently cross-checked by the supervisor.

Then I proceeded to create a calibrated dataset that would meet the requirements of QCA. For each case study, I looked at which conditions were present or not present and what level of monitoring was present. For that, I assigned the values from the Tables 1 & 2. The full calibrated datasets for both NBS and non-NBS can be found in Appendix B.

Step 4: Qualitative Comparative Analysis

To test the hypothesis and answer the research question, this study used Qualitative Comparative Analysis (QCA). The main quality of this method is "to develop explanatory models based on a systematic comparison of a small number of cases" (Marx, 2005, pg. 2). QCA is an appropriate tool for analyzing whether a set of conditions will lead to a certain outcome (Pahl-Wostl & Knieper, 2014). In particular, QCA can help to discern causal relationships in those cases where there is more than one set of conditions generating a certain outcome, also known as multiple conjunctural causation (Marx, 2005). I have used the QCA and SetMethods packages in Rstudio to carry out the QCA.

Within QCA, Ragan & Pennings (2005) differentiate between crisp and fuzzy set QCA. Whereas in crisp sets, conditions are either FALSE (0) or TRUE (1), in fuzzy sets, conditions can fall between 0 and 1. Even though the conditions in this study can either be present or not present (0, 1), monitoring will be measured using a scale (0, 0.5, 1), and therefore a fuzzy set QCA (fsQCA) is most appropriate to use.

QCA can be divided into two sets of tests, the test of necessity and the test of sufficiency (Oana et al., 2021). The former investigates which individual conditions are necessary for the outcome to be present. The latter focuses on which sets of conditions are sufficient for the outcome to be present. The test of necessity results in a table consisting of the parameters of fit in which each condition is attributed a consistency value. Whereas the literature does not point to a strict coverage threshold, if a condition has a consistency > 0.9, then it is considered a necessary condition (Oana et al., 2021).

The test of sufficiency is used to create so-called truth tables in which the different configurations of sufficient conditions are presented (Oana et al., 2021). The columns include the different conditions and each row presents a different configuration where a condition may be absent (0) or present (1), depending on the set of sufficient conditions. Each configuration of conditions that leads to the outcome may also be referred to as a 'solution formula'. For such a formula to be considered significant, the consistency must be above 0.75 and a Proportional Reduction in Inconsistency (PRI) greater than 0.5 (Oana et al., 2021).

When the scale range of the outcome is very small and the conditions are crisp (either 0 or 1), it is advised to conduct separate csQCAs for each of the scale levels (Oana et al., 2021). This is to determine the reliability of the fsQCA that is conducted. When the separate csQCAs provide similar parameters of fit and truth tables, it is more likely that the overall fsQCA is reliable. Since the monitoring scale in this study consists of three levels, I have conducted two csQCAs. The first one focuses on BM so that either it is present (1) or absent (0). The second csQCA focuses on EM where EM can either be present (1) or absent (0). These extra csQCAs have been conducted for both the NBS and non-NBS datasets.

Results

General Results

After coding the information, four cases were removed from the analysis because there was insufficient information about the planning process in the case descriptions. This left the final dataset to consist of 24 Nature-based Solutions (NBS) and 14 non-NBS cases. A more detailed overview of the ClimateADAPT case studies can be found in Appendix A.

The preliminary analysis indicates that there are more NBS cases with Embedded Monitoring (EM) compared to the non-NBS dataset (see Table 3). For the NBS dataset, 18 out of 24 case studies had Basic Monitoring (BM). Ten of those 18 cases included information about Embedded Monitoring (EM). For the non-NBS dataset, seven out of 14 case studies were found to have BM. In five of the seven cases, EM was also present. These results align with the initial assumption that NBS projects are more likely to embed monitoring as a social learning device in their project plans.

Table 3: The number of cases with each outcome in the NBS and non-NBS datasets

	NBS N = 24	**Percentage of cases within the NBS dataset**	**non-NBS** N = 14	**Percentage of cases within the non-NBS dataset**
No Monitoring	6	25%	7	50%
Basic Monitoring (BM)	18	75%	7	50%
Embedded Monitoring (EM)	10	42%	5	35%

Table 4 summarizes the number of cases with the presence of each separate condition for both datasets. The non-NBS cases score lower than NBS in relative terms, except for Responsibility of Coordination and Mechanism for Evaluation. However, the difference is negligible. Furthermore, it is worthwhile noting that, in both datasets, Mechanism for Evaluation scores considerably lower in the number of cases than in the other conditions. Responsibility of Coordination and Participatory Approach, on the other hand, score relatively higher than the rest of the conditions.

Table 4: The number of cases with each condition in the NBS and non-NBS datasets

	NBS N = 24	**Percentage of cases within the NBS dataset**	**non-NBS** N = 14	**Percentage of cases within the non-NBS dataset**
Transdisciplinary Collaboration (TrCo)	13	54%	4	28.5%
Participatory Approach (PaAp)	18	75%	9	64.5%
Mechanism for Evaluation (MfE)	2	8.5%	2	14.5%
Experimentation (Exp)	9	37.5%	3	21.5%
Responsibility of Coordination (RoC)	18	75%	11	78.5%

Analysis of the Effect of the Five conditions on Social Learning-oriented Monitoring

The fuzzy set QCA (fsQCA) and the BM and EM crisp set QCAs (csQCA) provided very similar results for both the NBS and non-NBS datasets. The BM csQCA rendered broader results with more solution formulas in the truth tables and the EM csQCA provided more conservative results with fewer solution formulas in the truth tables. This is logical given the fact that in both datasets there were more cases with BM and fewer with EM. For the sake of clarity, I will present the results of the fsQCA. The complete csQCA results for BM and EM can be found in Appendix C.

In both the NBS and non-NBS QCA, the necessity analysis did not render any significant results. When obtaining the parameters of fit, none of the conditions met the threshold (consistency > 0.9). This means that none of the conditions are individually necessary for EM in both the NBS and non-NBS datasets. For the sufficiency analysis, there were significant results for both datasets. There was a consistency above 0.75 and a Proportional Reduction in Inconsistency (PRI) greater than 0.5 in both datasets.

The most significant and interesting findings of the sufficiency analysis in the NBS and non-NBS datasets respectively are presented in Tables 5 & 6 in the form of truth tables. Here, the values for consistency and PRI are also given. For the NBS dataset, there are four sets of conditions that lead to monitoring, namely,

1) Participatory Approach + Mechanism for Evaluation + Responsibility of Coordination;
2) Transdisciplinary Collaboration;
3) Transdisciplinary Collaboration + Participatory Approach + Mechanism for Evaluation + Responsibility of Coordination;
4) Experimentation + Responsibility of Coordination.

For the non-NBS dataset, the sets of conditions leading to monitoring are as follows:

5) Mechanism for Evaluation + Responsibility of Coordination;
6) Participatory Approach;
7) Transdisciplinary Collaboration + Participatory Approach;
8) Transdisciplinary Collaboration + Participatory Approach + Responsibility of Coordination.

Table 5: Truth Table with the Results of NBS

	TrCo	PaAp	MfE	Exp	RoC	No. Cases	OUT	Consistency	PRI
1	0	1	1	0	1	1	1	1.00	1.00
2	1	0	0	0	0	1	1	1.00	1.00
3	1	1	1	0	1	1	1	1.00	1.00
4	0	0	0	1	1	2	1	0.75	0.667

Note: TrCo, PaAP, MfE, Exp, & RoC are abbreviations of the five conditions. Full names can be found in Table 4. No. Cases are the number of cases and OUT refers to whether or not the outcome (monitoring) is present (1) or absent (0). Consistency should be > 0.75 and Proportional Reduction in Inconsistency > 0.5 for the result to be significant.

Table 6: Truth Table with the Results of non-NBS

	TrCo	PaAp	MfE	Exp	RoC	No. Cases	OUT	Consistency	PRI
5	0	0	1	0	1	1	1	1.00	1.00
6	0	1	0	0	0	1	1	1.00	1.00
7	1	1	0	0	0	1	1	1.00	1.00
8	1	1	0	0	1	1	1	1.00	1.00

Note: TrCo, PaAP, MfE, Exp, & RoC are abbreviations of the five conditions. Full names can be found in Table 4. No. Cases are the number of cases and OUT refers to whether or not the outcome (monitoring) is present (1) or absent (0). Consistency should be > 0.75 for the result to be significant.

The tests of sufficiency have provided very ambiguous results. Even though there are four solution formulas for each of the datasets, the sets of conditions are only present in one or two cases per formula (No. Cases in Tables 5 &6). Since most sufficiency solutions can be found in either one or two cases of the total amount of cases, the coverage of each solution formula is very low. The low coverage has negative implications for the validity of each solution formula. There are no results that strongly point to a set of conditions in the planning environment that are sufficient for monitoring to be embedded in plans.

Therefore, Embedded Monitoring in plans is not well represented by a clearcut sufficiency solution formula based on the predefined planning environment conditions. For the different sets of conditions, different configurations of conditions have an influence. Even though Responsibility of Coordination is present three out of four times in the NBS dataset (Table 5), it does not imply that this condition will automatically lead to monitoring in plans, because it is not a necessary condition. Moreover, due to the low coverage of each solution formula, they must not be over-analyzed, as they are all very case-specific. Since both truth tables present these case-specific formulas, the comparison between the NBS and non-NBS QCA outcomes becomes trivial and insignificant.

Based on the aforementioned results, the hypothesis stating that the more of the five conditions for social learning-oriented monitoring in the planning environment, the more likely monitoring is embedded in project plans, cannot be accepted. There are no necessary conditions for embedded monitoring. Furthermore, the coverage of the sets of sufficient conditions is too low to determine which sets of conditions lead to monitoring being embedded in plans. Therefore, the results point in the direction that, based on the five conditions in this research, there are no necessary or sufficient conditions that lead to social learning-oriented monitoring to be embedded in NBS plans.

Discussion

In this chapter, the results of the previous will be compared and contrasted with insights from the literature. This is followed by a discussion of the limitations of this research and recommendations for future research.

This research started with the hypothesis that the more of the five conditions for social learning-oriented monitoring in the planning environment are met, the more likely that monitoring is embedded in Nature-based Solutions (NBS) plans. This is supported by Frantzeskaki (2019) who underpinned the importance of incorporating learning in NBS planning to overcome the inherent uncertainties ingrained in NBS planning. She continues this line of thought by arguing that monitoring can be one of the learning devices incorporated in planning. Through monitoring, the effectiveness of a project can be measured against certain pre-determined targets. The purpose of social learning-oriented monitoring is then to improve the planning and implementation of the NBS project being monitored and to inform future NBS projects about best practices (Kumar et al., 2021).

Inspiration from Bos et al. (2013), Malekpour & Newig (2020), and Rauws & de Roo (2016) formed the basis for the identification of five conditions for social learning-oriented monitoring in the NBS planning environment which may positively affect the degree to which monitoring to be embedded in NBS plans. They are Transdisciplinary Collaboration, Participatory Approach, Mechanism for Evaluation, Experimentation, and Responsibility of Coordination. Each of the conditions theoretically has a unique relation with how they impact the embedding of monitoring in plans.

The results from the Qualitative Comparative Analysis (QCA) are in contrast with the theoretical links mentioned above. This study has not proved a clear and undisputable link between the five conditions and Embedded Monitoring. None of the separate conditions were necessary for monitoring to be embedded in plans and the coverage for the significant sets of conditions from the test of sufficiency were too low to be considered meaningful.

It is interesting to note that due to the inconclusive results, it is worthwhile to understand why this might be the case. I have looked at five conditions in the planning environment, but since the NBS planning environment is complex and contextual many different conditions could have been at play (Gottwald et al., 2021; Pelling & High, 2005). They may include creating a shared learning agenda or stakeholders' intrinsic motivation. This research has looked at a limited number of conditions for social learning-oriented monitoring. However, due to the complex system that is the NBS planning environment, there may be many more factors at play.

An example of a non-included factor is inspired by Gómez Martín et al. (2020), who have made an operationalized classification of NBS where they distinguish between type 1, 2, & 3 NBS. Type 1 is those NBS projects where there is little interference with the ecosystem and the focus lies on maintaining it. With type 2, there is a focus on restoring ecosystems with more management interventions, and in type 3, new ecosystems are created or radically altered. Interestingly, within the ten cases with Embedded Monitoring in the NBS dataset, nine of them fit the requirements of the type 2 classification and one case was a type 1 NBS.

It could be the case that monitoring is found more in type 2 NBS projects because this type requires more management interventions than type 1 (Gómez Martín et al., 2020). In that line of thought, it can be argued that the more intensive management required with type 2, the more (social learning-oriented) monitoring is being incorporated into NBS project plans. Monitoring is used as a learning device to track the process of different interventions (Kato & Ahern, 2008). Type 2 NBS highlights the transformative potential of NBS as traditional paradigms of conservation and restoration are changed

(Palomo et al., 2021). In turn, the transformative approach could lead the way for an increase in social learning practices (Wickenberg et al., 2022).

The results of this study may also be better understood in the face of the structure-agency debate. Looking at conditions in the NBS planning environment, it is safe to say that they belong to the structure debate, because the conditions focus more on the structure of the institutions rather than on the agency of planners (Binder, 2012; Klotz et al., 2006). The focus on structure is largely a result of the requirements of a QCA. The QCA can only be done with three to seven conditions and one outcome. Furthermore, the conditions have to be calibrated on a numerical scale (Oana et al., 2021). As a result, the nuances that exist in the agency cannot be measured using a QCA and I therefore opted to focus on structure conditions.

Limitations

Despite shedding some preliminary light on the NBS planning environment, this research is not without fault and some limitations should be highlighted. First of all, QCA is limited in analyzing complexity (Oana et al, 2021). The analysis only has room for three to seven conditions. However, with a complex system such as a planning environment, there are many conditions for monitoring that can affect the outcome, such as creating a shared learning agenda or stakeholders' intrinsic motivation (Malekpour & Newig, 2020; Rauws & de Roo, 2016). Therefore, it could be the case that different or more conditions could pass the necessity and sufficiency tests.

Secondly, the bias of the researcher during coding must not be overlooked as it is difficult to fully separate the researcher from the data. To control this bias, I decided to use a pre-defined codebook based on the conceptualization and operationalization of the concepts. However, due to this way of coding, some of the quotes could have been miscoded based on the original intention of the text passage. To overcome these barriers, the quotation report was cross-checked by the supervisor of this thesis.

Thirdly, whereas the cases had somewhat equal information in ClimateADAPT, I also opted to use additional documents such as project plans to gain a deeper understanding of the planning environment and plans. In some cases, these documents were publicly accessible and others were translated so the message could have been lost in translation. Therefore, not all cases had an equal amount of information which may have resulted in bias.

Recommendations

This study has aimed to shed light on the Nature-based Solutions planning environment and its effect on social learning incorporated in plans. Even though some contextual outcomes were provided, the one thing that this research has shown is that much more research has to be conducted to fully comprehend the NBS planning environment. Especially when considering the contextual factors, in particular type 1 and type 2 NBS, there is much more behind the NBS planning environment that we currently cannot see. This understanding is vital as it helps improve the success of NBS projects.

Firstly, it would be interesting to use different or more conditions to perform a different QCA. Perhaps this will lead to more significant results. Complementary, data mining could be an interesting method to incorporate to find trends among the data more readily. Perhaps this research could even be done in reverse. Where there is monitoring, what conditions are behind it?

Furthermore, besides conditions highlighting the structure of the planning environment, it is important to shift the focus to the agency of the planners. Here, a QCA would be inappropriate because it will not capture the complexity. Rather, a qualitative study with in-depth interviews and focus groups might be better suited.

Conclusion

The purpose of this research was to understand the causal relationship between the Nature-based Solutions (NBS) planning environment and monitoring, as a proxy for social learning, being incorporated into project plans. The main research question related to the purpose is what conditions in the NBS planning environment are necessary and sufficient for social learning-oriented monitoring to be incorporated in NBS plans? To answer this question, a Qualitative Comparative Analysis (QCA) was conducted. The causal relationship is important to understand because relatively little is known about the influence of the planning environment on social learning, especially in NBS projects.

The analyzed conditions included Transdisciplinary Collaboration, Participatory Approach, Mechanism for Evaluation, Experimentation, and Responsibility of Coordination. Furthermore, monitoring was used as a proxy for social learning and operationalized along a three-point scale. The cases for the calibrated datasets were derived from the ClimateADAPT. Besides creating an NBS dataset, non-NBS cases were collected to compare both datasets. For the final QCA analysis, there were 24 NBS and 14 non-NBS cases. The data confirms that monitoring is relatively more often embedded in the NBS cases compared to the non-NBS case studies.

The analyses could neither confirm nor deny the hypothesis that the more conditions are met, the higher monitoring will be on the scale. The QCA indicated that there is not one condition necessary for there to be Embedded or Basic Policy Monitoring for both the NBS and non-NBS datasets. There were significant results following the sufficiency analysis, as the QCA analysis illustrated that there were four sufficiency configurations for both the NBS and non-NBS datasets that led to Embedded Monitoring as the outcome. However, it must be noted that the sufficiency solution formulas turned out to be case-specific and therefore not significant to either confidently adopt or reject the hypothesis. Furthermore, due to the trivial results from both datasets, the NBS and non-NBS results could not be compared. In short, there is no conclusive answer to the research question regarding what NBS planning environment conditions are necessary and sufficient for monitoring to be embedded in NBS plans.

Several factors may explain the lack of significant results. First, other unexamined conditions could be at play. For instance, the operationalized types of NBS (Type 1 vs. Type 2) may influence outcomes. Second, the QCA's limitation of accommodating only seven conditions might hinder capturing the complexity of NBS planning. Lastly, agency conditions, overlooked in this study, could interact with structural conditions. Based on these insights, a qualitative approach would be more appropriate as it would better shed light on these dynamics that are difficult to grasp in a quantitative setting.

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Appendix A: Case Study Overview

Table A-1: Overview of the cases in the Nature-based Solutions dataset

Case Study	Title from ClimateADAPT	Country
1	The integrated system of Nature-based Solutions to mitigate floods and drought risks in the Serchio River Basin	Italy
2	Building fire resilience using recycled water in Riba-Roja de Túria	Spain
3 *(removed)*	Natural Water Retention Measures in the Altovicentino area	Italy
4	Adaptive restoration of the former saltworks in Camargue	France
5	Sand Motor – building with nature solution to improve coastal protection along Delfland coast	The Netherlands
6 *(removed)*	Nature-based measures against rockfalls over forests in the Engadin Region	Switzerland
7	Environment-friendly urban street design for decentralized ecological rainwater management in Ober-Grafendorf	Austria
8	Mainstreaming adaptation in water management for flood protection in Isola Vicentina	Italy
9	The Watermachine: a multifunctional area for flood protection and improved water quality - Kristalbad, Enschede	The Netherlands
10	Vrijburcht: a privately funded climate–proof collective garden in Amsterdam	The Netherlands
11	Multifunctional water management and green infrastructure development in an eco-district in Rouen	France
12	Climate adapted management of the Kis-Sárrét area in the Körös-Maros National Park	Hungary
13	Landscape and watershed Recovery Programme for the Košice Region of Slovakia	Slovakia
14	Urban river restoration: a sustainable strategy for storm-water management in Lodz	Poland
15	Adapting agriculture to wetter and drier climates: the Tullstorp stream Project	Sweden
16 *(removed)*	Saltmarsh recreation by managed realignment, Hesketh Out Marsh	United Kingdom
17	Berlin Biotope Area Factor – Implementation of guidelines helping to control temperature and runoff	Germany
18	Fluvial Restoration of the Manzanares River in the surroundings of the Real Sitio de El Pardo (Madrid)	Spain
19	Moor protection in the Allgäu region through a stakeholder-based approach	Germany
20	Bosco Limite - A participatory strategy of water saving and aquifer artificial recharge	Italy
21	Autonomous adaptation to droughts in an agro-silvo-pastoral system in Alentejo	Portugal
22	GAIA - Green Area Inner-city Agreement to finance tree planting in Bologna	Italy
23	Kruibeke Bazel Rupelmonde (Belgium): a controlled flood area for flood safety and nature protection	Belgium
24	Isar-Plan – Water management plan and restoration of the Isar River, Munich	Germany
25	Habitat restoration and integrated management in the Ebro delta to improve biodiversity protection and climate resilience	Spain
26	Urban stormwater management in Augustenborg, Malmö	Sweden
27	The economics of managing heavy rains and stormwater in Copenhagen – The Cloudburst Management Plan	Denmark

Table A-2: Overview of the cases in the non-Nature-based Solutions dataset

Case Study	**Title**	**Country**
1	Adapting to climate change by improving irrigation practice in Vipava Valley	Slovenia
2	Temporary flood water storage in agricultural areas in the Middle Tisza river basin	Hungary
3	Adapting to heat stress in Antwerp based on detailed thermal mapping	Belgium
4	Flood risk management for hydropower plants	France
5	Climate adaptation strategy for the Grimsel area in the Swiss Alps	Switzerland
6	Rainwater saving and use in households, Bremen	Germany
7	Relocation as adaptation to flooding in the Eferdinger Becken	Austria
8	Public-private partnership for a new flood proof district in Bilbao	Spain
9 *(removed)*	Berlin Biotope Area Factor – Implementation of guidelines helping to control temperature and runoff	Germany
10	Wetland adaptation in Attica Region	Greece
11	New locks in the Albert canal in Flanders	Belgium
12	Adapting to the impacts of heatwaves in a changing climate in Botkyrka	Sweden
13	Improving soil structure of an arable crop farm in the district of Heilbronn	Germany
14	Realisation of flood protection measures for the city of Prague	Czechia
15	Amphibious housing in Maasbommel	The Netherlands

Appendix B: Calibrated Datasets

Case Study	Transdisciplinary Collaboration	Participatory Approach	Mechanism for Evaluation	Experimentation	Responsibility of Coordination	Basic Policy Monitoring	Embedded Monitoring
1	0	1	1	0	1	0.5	1
2	1	0	0	0	1	0.5	1
4	1	1	0	0	1	0.5	1
5	1	1	0	1	1	0.5	1
7	0	0	0	1	1	0.5	0
8	1	1	0	1	1	0	0
9	1	0	0	0	1	0	0
10	1	1	0	0	1	0	0
11	0	0	0	0	1	0.5	0
12	1	1	0	0	0	0.5	0
13	0	1	0	1	0	0.5	0
14	1	1	0	1	0	0	0
15	0	0	0	1	1	0.5	1
17	0	1	0	0	1	0	0
18	1	0	0	0	0	0.5	1
19	0	1	0	0	1	0.5	1
20	1	1	0	0	1	0.5	0
21	1	1	0	1	0	0.5	1
22	1	1	0	1	1	0.5	1
23	1	1	1	0	1	0.5	1
24	0	1	0	0	1	0.5	1
25	0	1	0	0	0	0.5	0
26	0	1	0	1	1	0.5	0
27	0	1	0	0	1	0	0

Table B-1: Calibrated Dataset for Nature-based Solutions conditions and outcome

Case Study	Transdisciplinary Collaboration	Participatory Approach	Mechanism for Evaluation	Experimentation	Responsibility of Coordination	Basic Policy Monitoring	Embedded Monitoring
1	1	1	0	0	0	0.5	1
2	0	0	1	0	1	0.5	1
3	1	1	0	1	0	0.5	0
4	0	0	0	0	1	0	0
5	0	1	0	0	1	0.5	0
6	0	0	0	0	1	0	0
7	0	0	0	1	1	0	0
8	0	1	1	0	1	0	0
10	1	1	0	0	1	0.5	1
11	0	1	0	1	1	0	0
12	1	0	0	0	1	0	0
13	0	1	0	0	0	0.5	1
14	0	1	0	0	1	0.5	1
15	0	1	0	0	1	0	0

Table B-2: Calibrated Dataset for non-Nature-based Solutions Conditions and Outcome

Appendix C: Truth Tables

Below I will present the truth tables from the Qualitative Comparative Analysis. I have divided the presentation of these tables into the combined analysis, Basic Policy Monitoring, and Embedded Monitoring. First, the Nature-based Solutions truth table is presented, and then the non-Nature-based Solutions truth table for each section respectively. The explanation of the abbreviations can be found in the Methodology and Results section.

Combined Truth Tables

Table C-1: Truth Table for the Nature-based Solutions combined dataset.

TrCo	PaAp	MfE	Exp	RoC	OUT	n	incl	PRI	Case study
0	1	1	0	1	1	1	1.000	1.000	1
1	0	0	0	0	1	1	1.000	1.000	18
1	1	2	0	1	1	1	1.000	1.000	23
0	0	0	1	1	1	2	0.750	0.667	7, 15
1	1	0	1	1	0	3	0.667	0.667	5, 8, 22
0	0	0	0		0	1	0.500	0.000	11
0	1	0	0	0	0	1	0.500	0.000	25
0	1	0	0	1	0	4	0.500	0.500	17, 19, 24, 27
0	1	0	1	0	0	1	0.500	0.000	13
0	1	0	1	1	0	1	0.500	0.000	26
1	0	0	0	1	0	2	0.500	0.500	2, 9
1	1	0	0	0	0	1	0.500	0.000	12
1	1	0	0	1	0	3	0.500	0.400	4, 10, 20
1	1	0	1	0	0	2	0.500	0.500	14, 21

Table C-2: Truth Table for the non-Nature-based Solutions combined dataset.

TrCo	PaAp	MfE	Exp	RoC	OUT	n	incl	PRI	Case study
0	0	1	0	1	1	1	1.000	1.000	2
0	1	0	0	0	1	1	1.000	1.000	13
1	1	0	0	0	1	1	1.000	1.000	1
1	1	0	0	1	1	1	1.000	1.000	10
0	1	0	0	1	0	1	0.500	0.000	5
1	1	0	1	0	0	1	0.500	0.000	3
0	0	0	0	1	0	2	0.000	0.000	4, 6
0	0	0	1	1	0	1	0.000	0.000	7
0	1	0	1	1	0	1	0.000	0.000	11
0	1	1	0	1	0	1	0.000	0.000	8
1	0	0	0	1	0	1	0.000	0.000	12

Basic Policy Monitoring Truth Tables

Table C-3: Truth Table for the Nature-based Solutions BPM dataset

TrCo	PaAp	MfE	Exp	RoC	OUT	n	incl	PRI	Case study
0	0	0	0	1	1	1	1.000	1.000	11
0	0	0	1	1	1	2	1.000	1.000	7, 15
0	1	0	0	0	1	1	1.000	1.000	25
0	1	0	1	0	1	1	1.000	1.000	13
0	1	0	1	1	1	1	1.000	1.000	26
0	1	1	0	1	1	1	1.000	1.000	1
1	0	0	0	0	1	1	1.000	1.000	18
1	1	0	0	0	1	1	1.000	1.000	18
1	1	0	0	0	1	1	1.000	1.000	12
1	1	2	0	1	1	1	1.000	1.000	23
1	1	0	0	1	0	3	0.667	0.667	4, 10, 20
1	1	0	1	1	0	3	0.667	0.667	5, 8, 22
0	1	0	0	1	0	4	0.500	0.500	17, 19, 24, 27
1	1	0	1	0	0	2	0.500	0.500	14, 21

Table C-4: Truth Table for the non-Nature-based Solutions BPM dataset

TrCo	PaAp	MfE	Exp	RoC	OUT	n	incl	PRI	Case study
0	0	1	0	1	1	1	1.000	1.000	2
0	1	0	0	0	1	1	1.000	1.000	13
1	1	0	0	0	1	1	1.000	1.000	1
1	1	0	0	1	1	1	1.000	1.000	10
1	1	0	1	0	1	1	1.000	1.000	3
0	1	0	0	1	0	3	0.667	0.667	5, 14, 15
0	0	0	0	1	0	2	0.000	0.000	4, 6
0	0	0	1	1	0	1	0.000	0.000	7
0	1	0	1	1	0	1	0.000	0.000	11
0	1	1	0	1	0	1	0.000	0.000	8
1	0	0	0	1	0	1	0.000	0.000	12

Embedded Monitoring Truth Tables

Table C-5: Truth Table for the Nature-based Solutions EM dataset

TrCo	PaAp	MfE	Exp	RoC	OUT	n	incl	PRI	Case study
0	1	1	0	1	1	1	1.000	1.000	1
1	0	0	0	0	1	1	1.000	1.000	18
1	1	2	0	1	1	1	1.000	1.000	23
1	1	0	1	1	0	3	0.667	0.667	5, 8, 22
0	0	0	1	1	0	2	0.500	0.500	7, 15
0	1	0	0	1	0	4	0.500	0.500	17, 19, 21, 27
1	0	0	0	1	0	2	0.500	0.500	2, 9
1	1	0	1	0	0	2	0.500	0.500	14, 21
1	1	0	0	1	0	3	0.333	0.333	4, 10, 20
0	0	0	0	1	0	1	0.000	0.000	11
0	1	0	0	0	0	1	0.000	0.000	25
0	1	0	1	0	0	1	0.000	0.000	13
0	1	0	1	1	0	1	0.000	0.000	26
1	1	0	0	0	0	1	0.000	0.000	12

Table C-6: Truth Table for the non-Nature-based Solutions EM dataset

TrCo	PaAp	MfE	Exp	RoC	OUT	n	incl	PRI	Case study
0	0	1	0	1	1	1	1.000	1.000	2
0	1	0	0	0	1	1	1.000	1.000	13
1	1	0	0	0	1	1	1.000	1.000	1
1	1	0	0	1	1	1	1.000	1.000	10
0	1	0	0	1	0	3	0.333	0.333	5, 14, 15
0	0	0	0	1	0	2	0.000	0.000	4, 6
0	0	0	1	1	0	1	0.000	0.000	7
0	1	0	1	1	0	1	0.000	0.000	11
0	1	1	0	1	0	1	0.000	0.000	8
1	0	0	0	1	0	1	0.000	0.000	12
1	1	0	1	0	0	1	0.000	0.000	3

Appendix D: Use of Artificial Intelligence

During the thesis process, I have used Artificial Intelligence for the use of improving spelling, grammar, and sentence structure in the thesis. I have used Grammar.ly and CoPilot to do so. Grammar.ly automatically spotted the grammar and punctuality mistakes in my thesis Word documents. For CoPilot, I used the following prompts and questions:

- What is another word for x?
- Can you rewrite this sentence to make it more formal?
- Does this paragraph have any grammar mistakes?
- How can I best structure the Abstract?