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Assessing the IUCN global standard for nature-based solutions in riverine flood risk mitigation

Maikel Berg [a], Chris J. Spray [c], Astrid Blom [a], Jill H. Slinger [a], Laura M. Stancanelli [a], Yvo Snoek [b], Ralph M.J. Schielen [a,b,*]

[a] Delft University of Technology, Delft, the Netherlands
[b] The Netherlands Ministry of Infrastructure and Water Management, DG Rijkswaterstaat, Utrecht, the Netherlands
[c] Dundee University, Dundee, Scotland, United Kingdom

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ABSTRACT

The International Union for Conservation of Nature (IUCN) published their Global Standard for Nature-based Solutions (NbS) in an effort to further a common understanding and successful application of NbS. Our objective is to analyse the applicability of and considerations and advancements in using the IUCN Standard, as very few studies have examined and reflected on its actual application. As method, we applied the IUCN Standard to three case studies of river restoration projects with a focus on flood risk mitigation: (1) Eddleston Water Project, (2) "Room for the River" Deventer Project, and (3) Missouri River Levee Setback Project. Rather than evaluating the case studies itself, we evaluated the outcome to find the strong and weak points of the IUCN Standard. The gathered data (publicly accessible documents, conducted interviews with experts and stakeholders) was analysed and showed the role of the number of documents and interviews available. This determined the outcome of the IUCN assessment. The consultation of project experts has appeared to be an essential step in the data collection, while stakeholder interviews and field visits were less important, but did increase the degree of substantiation and the ease of data collection, respectively. Although restricted by a limited evaluation of flood risk mitigation studies, using the IUCN Standard for an ex-post assessment can provide credibility to project processes (e.g. stakeholder engagement and adaptive management), reveal project strengths and weaknesses, and provide opportunities for the comparison of projects. Hence, the IUCN Standard aptly evaluates process-based aspects of Nature-based Solutions for riverine flood risk mitigation.

1. Introduction

The past decades have seen unprecedented environmental and societal challenges, such as the exacerbation of floods (Najibi and Defineni, 2018; Whitfield, 2012), biodiversity loss (IPBES, 2019; Singh, 2012) and climate change (NOAA, 2023; IPCC, 2021). Nature-based Solutions (NbS) are actions that work with and enhance natural processes to help address some of these challenges, and there is increasing evidence of their effectiveness in a variety of environmental contexts, including urban (Monteiro et al., 2023; Augusto et al., 2020), rural (Woroniecki et al., 2023; Hou-Jones et al., 2021), riverine (Spray et al., 2022a; Turkelboom et al., 2021)

* Corresponding author. The Netherlands Ministry of Infrastructure and Water Management, DG Rijkswaterstaat, Utrecht, the Netherlands.
E-mail address: ralph.schielen@rws.nl (R.M.J. Schielen).

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and coastal environments (Mahmood et al., 2023; Perricone et al., 2023). The fast growing demand for and implementation of NbS has also resulted in misunderstanding and even misuse of the NbS concept. Examples include plantations of non-native species that replace existing ecosystems and NbS that are implemented without respecting local rights, leaving nature and human well-being worse off than before (Seddon et al., 2021). The International Union for Conservation of Nature (IUCN) published their Global Standard for NbS (IUCN, 2020a) in an effort to contribute to a common understanding and successful application of NbS. This framework is intended to help guide and assess NbS projects (IUCN, 2020b). There is a large number of studies available that use the IUCN Standard or other frameworks to assess and evaluate specific case studies, in urban or riverine environments albeit without explicit reflection on the applicability, and possible limitations of the Standard itself (e.g. Caroppi et al., 2023, Châles et al., 2023, Giordano et al., 2020, Le Gouvello et al., 2023, Mehta et al., 2023, Pugliese et al., 2020, Sharma et al., 2024; Wishart et al., 2021. Berg et al. (2024) compared the IUCN Standard to 22 other NbS frameworks and identified that the IUCN Standard has the greatest scope of application with regard to the variety of societal challenges, environmental contexts and project phases. Other studies by Pakeman et al. (2021), Sowińska-Świerkosz and García (2022) and Dumitru and Wendling (2021) acknowledge the foremost position of the IUCN Standard due to its comprehensiveness, structured guidance and support by an international organisation. The support by the IUCN guarantees regular updates of the standard (IUCN, 2020c) and increases the probability that a wide body of experience on its application will be developed. Since the launch of the IUCN Standard, various applications to case studies have been published. Most of these used preliminary (e.g. Shina and Bimson, 2021) or simplified (e.g. Risna et al., 2022; Telwala, 2023) versions of the Standard. Some case studies used the complete version of the Standard (e.g. Le Gouvello et al., 2022; Luo et al., 2023), but reflected on the case studies rather than the use of the Standard itself. Le Gouvello et al. (2023) and Châles et al. (2023) reflected on the use of the IUCN Standard by highlighting that the requirements for data input and adherence to the standard may be too high or inappropriate for aquaculture and Pacific Small Island Developing States, respectively. Furthermore, they emphasized that clarification on the added value of the assessment is required, along with further research on the application of the Standard to specific settings. As NbS have the potential to reduce flood risk, while playing a significant role in restoring biodiversity and many of the ecosystem services lost as result of human interventions and global warming (Albert et al., 2019), riverine environments are a particularly suitable setting for NBS implementations. Therefore, we focus our analysis on implementations of NbS in river restoration projects aiming at flood risk mitigation. Riverine NbS for flood risk mitigation include many measures as diverse as floodplain reconnection, creating room for the river, dam removal and bamboo-grass based embankments (Fig. 1). Accordingly, our research objective is to assess the applicability of the IUCN Standard and report on the considerations and advancements (rather than report on applying the Standard for the assessment of a specific case study). This is different from most studies that use the Standard for the evaluation of a case study, without reflecting on the applicability of the Standard itself. The case studies (aimed at river restoration with a focus on flood risk mitigation) differ regarding surface area, position in the catchment, and types of NbS to enable comparative analysis of the results. In addition, we varied the number and duration of stakeholder interviews and field visits in the data collection, enabling the analysis of their influence on the applicability of the IUCN Standard. Analysis of the challenges encountered during the case study assessment provides insight on the applicability of the IUCN Standard, while a reflection on the case study results (from the perspective of the assessment of the IUCN Standard) provides considerations and advancements in using the IUCN Standard.

2. IUCN global standard for NbS

The IUCN Standard was developed to ensure that NbS is based on a common understanding of its interpretation and a shared vision for a fair and sustainable world (IUCN, 2020a). The adoption of NbS in policy and projects underscores the necessity for clear guidelines to ensure consistent and effective implementation, preventing ad hoc applications that may undermine its impact. By establishing a standardized framework and fostering a global community, the NbS Standard facilitates informed decision-making, accelerates policy development, and maximizes the potential of NbS to address sustainability challenges. A series of publications and events on NbS followed after the first publication on the topic by the IUCN (IUCN, 2009). The IUCN definitional framework for NbS by Cohen-Shacham et al. (2016) recognized the concept of NbS as an umbrella concept that covers a whole range of ecosystem-related approaches and is the source for most of the framing of the IUCN Standard. The Standard was published in July 2020, following the integration of missing key concepts identified by Cohen-Shacham et al. (2019), such as temporal scales and the need for adaptive

Fig. 1. (a) Floodplain reconnection – Netherlands (Rijkswaterstaat, 2020); (b) Dam removal – United States of America (Bridges et al., 2021a); (c) Bamboo-grass based embankment – Bangladesh (Shina and Bimson, 2021).

management, and two rounds of public consultations (IUCN, 2019; IUCN, 2020b). The core of the IUCN Standard contains eight criteria that can be viewed as the essential principles to which a project or project design must adhere in order to be recognized as an NbS. The eight criteria and their interconnection are given in Fig. 2.

Each criterion consists of three to five indicators, adding up to 28 indicators in total. These indicators serve as guiding principles for process design, or as set qualitative parameters for assessment. Examples of indicators of the IUCN Standard are:

Indicator 2.2 (i.e. Criterion 2 – Indicator 2): *"The design of the NbS is integrated with other complementary interventions and seeks synergies across sectors"* (IUCN, 2020a, p. 8).

Indicator 8.1: *"The NbS design, implementation and lessons learnt are shared to trigger transformative change"* (IUCN, 2020a, p. 20).

The IUCN (2020a) provides a user-friendly framework with concise and straightforward guidance on the criteria and indicators and is supplemented with an in-depth guidance (IUCN, 2020b) and a self-assessment tool, which can be used to assist project design and assessment, respectively. With regard to ex-post assessments, the IUCN Standard states that *"past and ongoing NbS … can also be evaluated against the Standard's Criteria if the intention is for the intervention to be recognized as an NbS"* (IUCN, 2020b, p. 11). However, Berg et al. (2024) established that the IUCN Standard can only function as a process-oriented framework, to assess the processes (e.g. stakeholder engagement and adaptive management) of NbS projects. It cannot function as a results-oriented framework.

3. Case studies

3.1. Case study selection

To assess the applicability of the IUCN Standard and to study the considerations and advancements in its use, we selected case studies of river restoration projects that used NbS for flood risk mitigation, and for which a minimum of five project-related documents were publicly accessible. Relying on fewer documents provides too little information about a project to form the basis of an assessment. Additionally, the case studies needed to differ in the surface area, its position in the catchment and the type of riverine NbS measures to enable comparative analysis of the results. We used existing classifications of river restoration measures by Verdonschot et al. (2015), Speed et al. (2016) and Bridges et al. (2021b) to classify the five most common types of riverine NbS measures: floodplain reconnection, river planform adjustments, planting or removal of vegetation, in-channel interventions and interventions in the floodplain. This lead to three case studies: (1) Eddleston Water Project, Scotland (2) "Room for the River" (RftR) Deventer Project, the Netherlands, and (3) Missouri River Levee Setback (LS) Project, USA (see photos in Fig. 3). The case studies are briefly described below. We refer to Supplementary Material E for a more elaborate description of each case study.

3.2. Case study description

1 Eddleston Water Project

The Eddleston Water is a river draining a 69 km^2 basin in the upper catchment of the River Tweed in the Scottish Borders. Human interventions, such as the clearance of native woodland and river straightening, have significantly altered the catchment, resulting in increased downstream flood risk and habitat degradation (Spray et al., 2022a). In response, the Scottish Government initiated the Eddleston Water Project in 2009 as a research study to explore the effectiveness of NbS for flood risk mitigation. The project has three main objectives.

1. investigate the potential to reduce the risk of flooding to downstream communities through the utilisationof NbS for flood risk mitigation.
2. improve habitats for wildlife and raise the "ecological status" of the river.
3. work with landowners and farmers in the local community to maximise the benefits of the work.

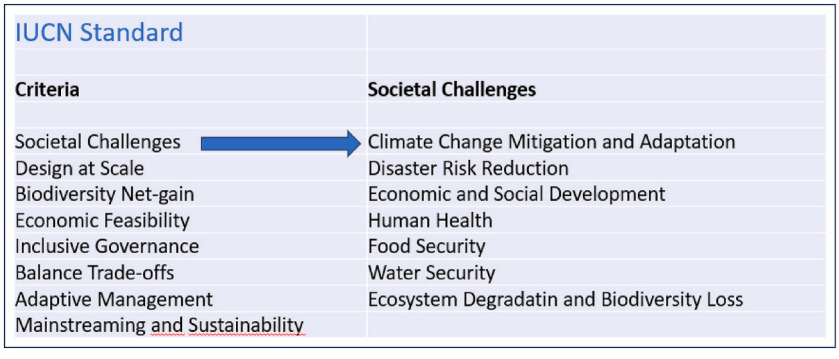


Fig. 2. The eight criteria of the IUCN Standard (IUCN, 2020a), and the major societal challenges addressed by NbS that are associated with the first criterion (based on Le Gouvello et al., 2022).

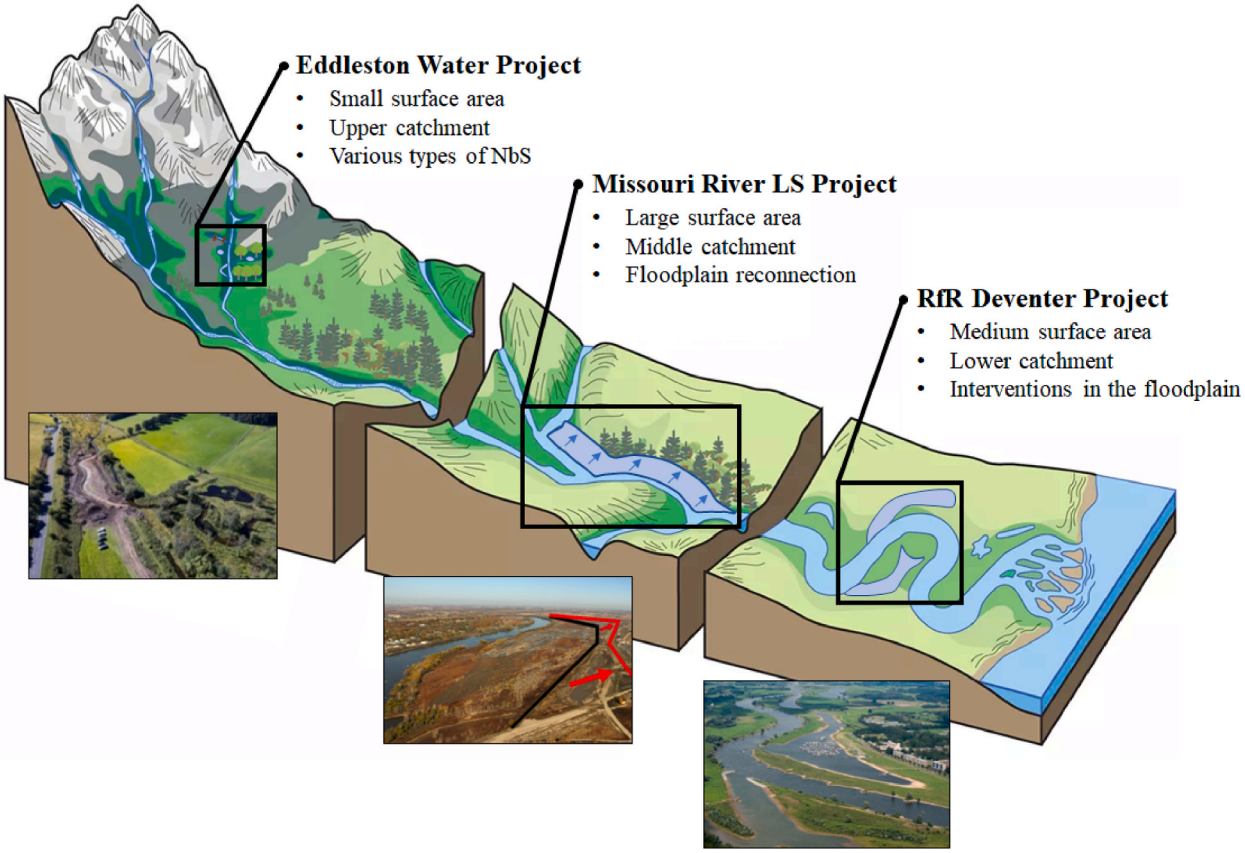


Fig. 3. Indication of the surface area, and the position of the three case studies in an idealised catchment(adapted from Thornberry-Ehrlich, n.d.). The three case studies: (left to right): Re-meandering - Eddleston Water Project (Spray et al., 2022a); Levee (L-575) Setback – Missouri River LS Project (Crane, 2012); Flood relief channels – RftR Deventer Project (van Gerner, 2015).

while sustaining farming livelihoods and practices.

The project is managed by the environmental charity Tweed Forum which, in voluntary collaboration with 21 farmers and landowners has implemented the following NbS measures.

a. 207 ha of native woodland planting (i.e. planting or removal of vegetation);
b. 116 engineered log jams (i.e. in-channel interventions);
c. 38 flood storage ponds (i.e. interventions in the floodplain, the largest having a capacity of 19.600 m^3);
d. 3.5 km of re-meandering (i.e. river planform adjustments, Fig. 3, left photo), .

These NbS measures have a combined surface area of approximately 2 km^2 (Spray et al., 2020b; Berg et al., 2024).

2 "Room for the River" Deventer Project

Rijkswaterstaat (executive agency of the Ministry of Infrastructure and Water management) implemented measures at 35 locations in the Room for the River programme, in order to (1) increase the river discharge conveyance capacity, and (2) improve the spatial quality of the riverine areas (Room for the River, 2012). Two of these locations, termed the "Bolwerksplas, Worp and Ossenwaard" (BWO) and the "Keizers- and Stobbenwaarden and Olsterwaarden" (KSO), are situated along the river IJssel in the lower catchment of the Rhine. The floodplain was excavated near the city of Deventer to create a combined 5.4 km^2 of flood relief channels (Fig. 3, right photo) which increased the discharge conveyance capacity and strongly improved spatial quality (Van De Laar et al., 2010a; Wolbers et al., 2018). The municipality of Deventer and the province of Overijssel were responsible for the planning phase of the project, while the water boards 'Groot Salland' and 'Vallei en Veluwe' were responsible for the implementation. After implementation in 2015, maintenance and monitoring of the project area were transferred to the landowners (Waterschap Groot Salland & Waterschap Vallei en Veluwe, 2015).

3 Missouri River Levee Setback Project

In 2011, heavy spring rains combined with significant meltwater runoff caused flooding along the Missouri River, United States of America. The Missouri River Levee Unit L-575, (Fremont County), sustained damage at 21 sites. The U.S. Army Corps of Engineers (USACE) assisted the levee sponsor, who operates and maintains the levee, with post-flood levee repair under the Public Law (PL) 84–99 Emergency Levee Rehabilitation Program (USACE, 2013a). During the in-line repairs, two large levee sections were determined to be damaged beyond repair (USACE, 2013b). Therefore, as a least-cost alternative, two large-scale levees were set back (about 800 m, over a length of 7.1 km (Fig. 4c), and about 1200 m over a length of 4.8 km), reconnecting the Missouri River to approximately 7 km^2 of its floodplains (Krause et al., 2015). The USACE mitigated the negative environmental consequences as much as possible (although habitat creation was formally not an objective of the project), for instance by creating mild slopes, irregular shapes and planting seeds in the borrow pits for wetland establishment (USACE, 2013a). The project has been recognized as Engineering with Nature by Bridges et al. (2018) and having Natural and Nature-based Features by Bridges et al. (2021b), because of its added ecological value.

4. Methods

We collected the data for assessment of the three case studies with the IUCN Standard following the three steps described in section 4.1. Subsequently, we used the self-assessment tool as described in section 4.2. Additionally, we analysed the results to determine the considerations (challenges), advancements (added value) and limitations of using the Standard. Fig. 4 provides an overview of the methodology of the case study assessments.

4.1. Data collection

Data collection was done in three steps: (1) analysis of publicly accessible documentation, (2) stakeholders interviews, and (3) project expert interviews. The order of these steps was a pragmatic choice, as collecting all of the required data from stakeholders and experts would have demanded a lot of their time. Therefore, we chose to start by selecting a minimum of five of the most informative project-related documents via search engines Google and Google Scholar (Table 1) and analysing each of these documents on key topics of interest for the case study assessments. Any choice of specific search engines could introduce biases, but we deliberatedly chose these as they are widely available and hence reproducible in other studies.

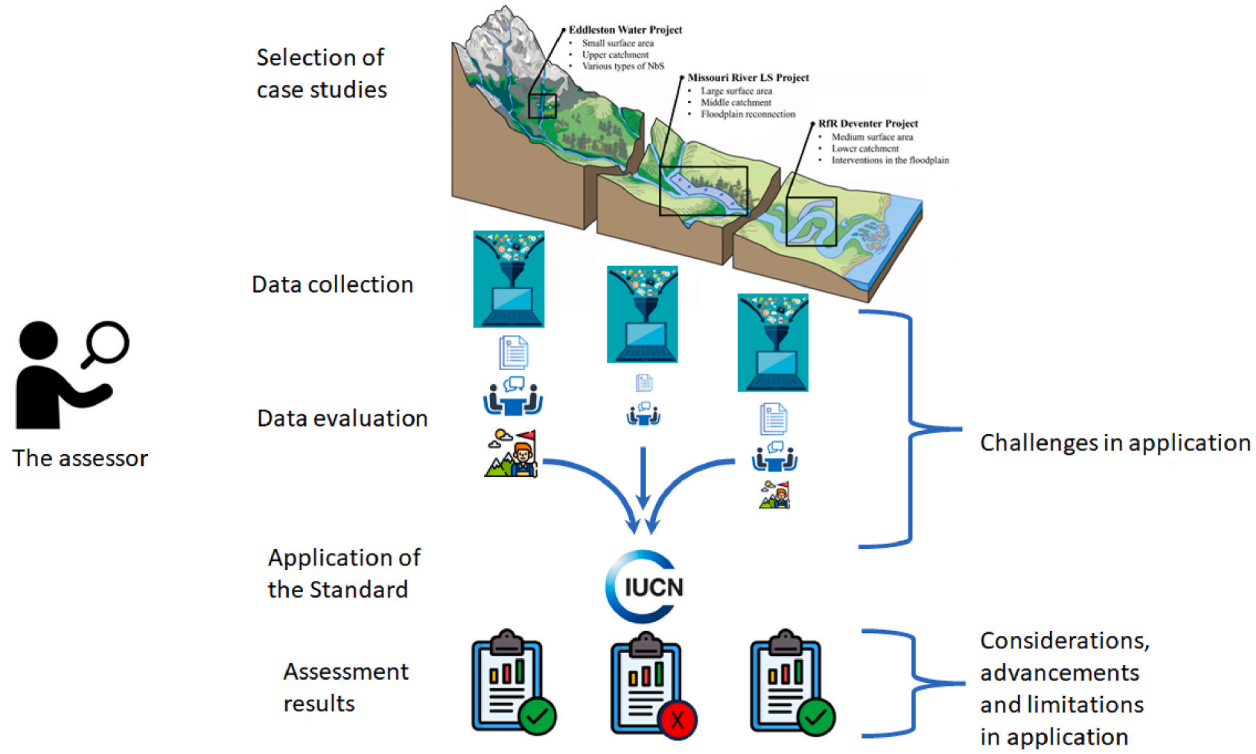


Fig. 4. Methodology of case study assessments (Eddleston Water in the upstream part of a catchment, Missouri River LS in the middle reach of a catchment and RftR Deventer in the downstream part of a catchment), visualizing the efforts of a single independent assessor on the left hand side. In the 'Data evaluation', the relative size of the icons indicate the availability of documents and interviews, and the duration of the field visit. Data evaluation and assessment of the results lead to challenges in application, and provides information on the added value and the limitations of the IUCN Standard when applied to case studies. Assessment of the Missouri case study shows that this project does not adhere to the IUCN Standard, indicated by the red cross.

The next step comprised interviews with stakeholders directly involved with the project. We conducted six stakeholder interviews for case study 1, one interview for case study 2, while no stakeholders were interviewed for case study 3. Rather than robustly studying the importance of the number of stakeholder interviews, this at least enabled us to reflect upon the role and potential impact of stakeholder interviews with respect to applying the Standard. We conducted additional interviews with project experts to collect the remaining data required for assessment completion. Someone who was closely and intensively (timewise) involved in planning, managing or researching the project was deemed a project expert. More details on the stakeholder and expert interviews can be found in Supplementary Material A. We also analyse how the different sources (stakeholders, experts, or documents) contribute to outcome of the self-assessment tool. The information obtained from stakeholders, experts, or documents might be conflicting on certain aspects. If that is the case, we assume that the data provided by the project expert, who was closely involved in the project, is more accurate than project-related documentation and stakeholder interviews. The data collection procedure included a field visit of three days for case study 1, half a day for case study 2, while no field visit was included for case study 3. This allowed us to analyse whether the duration of a field visit has an influence on the applicability of the IUCN Standard.

4.2. Assessment procedure

The IUCN Standard provides a Microsoft Excel spreadsheet self-assessment tool that can be used to assess whether a project adheres to the criteria and indicators. This tool provides three to eight guiding questions for each of the 28 indicators, enabling users to identify and score the extent (*strong, adequate, partial or insufficient*) to which a project adheres to the individual indicators. Examples of Guiding questions of Indicator 8.1 are:

> "Are NbS design, implementation and lessons learnt being systematically captured?"
>
> "Are they being shared, both on demand and with strategic audiences?"

Data from documents, stakeholders, and experts is compiled in the Excel spreadsheet. Initial scoring utilizes (in that order) project documents, stakeholder input for specific stakeholder related indicators, and expert interviews complete the assessment. Compliance to all guiding questions suggests that the project has a "strong" adherence to the indicator. In addition, we provided the corresponding rationale and means of verification in the self-assessment tool. All indicators need to be scored for a complete assessment. The scores are used by the tool to generate the percentage match of the case studies to each of the criteria, supplemented by a rating and traffic light colour as indicated in Table 2.

We then analysed the outcomes of the case study assessments (the percentage match to each of the criteria) through the following three features.

1. **Total percentage match and adherence to the IUCN Standard** – The percentage match of the case study to each criterion was normalized such that each criterion had an equal weight. The normalized percentage matches for the eight criteria were then averaged, resulting in a total percentage match to the IUCN Standard. The IUCN Standard states that a project is in adherence to the standard and may therefore be recognized as NbS by the IUCN if it has at least a 25 percent match to each criterion.
2. **Radar chart** – This is a chart that visually presents the percentage match of a case study to each of the eight criteria of the IUCN Standard.
3. **Strengths and weaknesses** – In contrast to the first two outcomes, which are direct outputs of the self-assessment tool, this feature follows from analysing the scores and rationale that the assessor provided for the individual indicators. The scores and rationale reveal with which components of the indicators the case studies are aligned, and which not, defined as their strengths and weaknesses, respectively. A "strong" adherence to an indicator implies that the case study is aligned with all components of an indicator, whereas a "partial" adherence to an indicator reveals both strengths and weaknesses. "Insufficient" suggests that the indicator does not apply to the case study.

Combining the findings of analysing the three case studies (rather than analysing the case study-specific results, which is not the aim of this paper) using the method of the IUCN Standard leads to considerations, advancements and limitations for using the Standard.

Table 1
Project-related documentation of the three case studies.

Case study	Documents
1 – Eddleston Water Project	(Harrison, 2012; Spray, 2017; Werritty et al., 2010; Spray et al., 2022a; Spray et al., 2022b; APEM, 2020; Tweed Forum, 2020; Mott Mott Macdonald, 2020)
2 – RftR Deventer Project	(Deventer and Overijssel, 2007), (Ruimtelijke plannen – Ruimtelijke plannen - Deventer, 2011; Platteeuw et al., 2004; Van de Laar et al., 2010a; Van de Laar et al., 2010b; Hartgers et al., 2015; DN Urbland, 2007; Ebregt et al., 2005)
3 – Missouri River LS Project	(Krause et al., 2015; USACE, 2013a; Smith et al., 2017; Farmer, 2013; USACE, 2013b; USACE, 2018)

Table 2
Output of self-assessment tool of the IUCN Standard for each of the eight criteria (IUCN, 2020b).

Percentage match (%)	Rating	Traffic light colour
≥ 75	Strong	
≥ 50 & < 75	Adequate	
≥ 25 & < 50	Partial	
< 25	Insufficient	

5. Results

Section 5.1 briefly provides the results of the three case study assessments with the IUCN Standard, including the accompanying radar charts (Fig. 5). In section 5.2, the considerations faced during the assessments are analysed to assess the applicability of the Standard, while section 5.3 discusses the provided advancements. Section 5.3 addresses the limitations. Considerations, advancements and limitation have been establishes from the combined analyses of the case studies.

5.1. Case study results

The case study assessments produced a percentage match to the eight criteria and a total percentage match to the IUCN Standard (Table 3). The complete self-assessment tools with the scores, rationale and means of verification for all indicators can be found in Supplementary Material B-D for the Eddleston Water Project, RftR Deventer Project and Missouri River LS Project, respectively.

5.1.1. Eddleston Water Project

Eddleston Water Project adheres to the IUCN Standard and is therefore recognized by the IUCN as an NbS. The assessment of the Eddleston Water Project highlights strengths and weaknesses. High matches to Criteria 5 and 8 indicate strong adherence to inclusive governance and sustainability guidelines, while Criterion 6 shows weaknesses in documenting and analysing trade-offs. Informal safeguards exist but are not formally documented or reviewed within the IUCN assessment process.

5.1.2. "Room for the river" Deventer Project

The RftR Deventer Project is in adherence to the IUCN Standard and is recognized by the IUCN as an NbS. The RftR Deventer project demonstrates strengths in prioritizing societal challenges, identifying drivers, and setting targets for human well-being (Criterion 1). Additionally, its design accounts for complexity and uncertainty both within and beyond the project area (Criterion 2). However, weaknesses are evident in the absence of a clearly stated project strategy and interconnected monitoring plan (Criterion 7). Furthermore, indicators for biodiversity effects and unintended consequences on nature have not been adequately assessed or monitored (Indicators 3.2 and 3.3), and the project's contributions to national and global targets have not been evaluated or reported, nor has it informed policy frameworks (Criterion 8).

5.1.3. Missouri River Levee Setback Project

The Missouri River LS Project is not in adherence to the IUCN Standard and is not recognized by the IUCN as an NbS. The project prioritized urgent societal challenges well but lacks targets and periodic evaluation for human well-being (Criterion 1). While integrating complementary interventions like habitat creation with borrow pits (Criterion 2), it inadequately addresses uncertainties, focusing mainly on hydraulic risk. Weaknesses include the absence of trade-off limits, safeguards, monitoring plans, adaptive

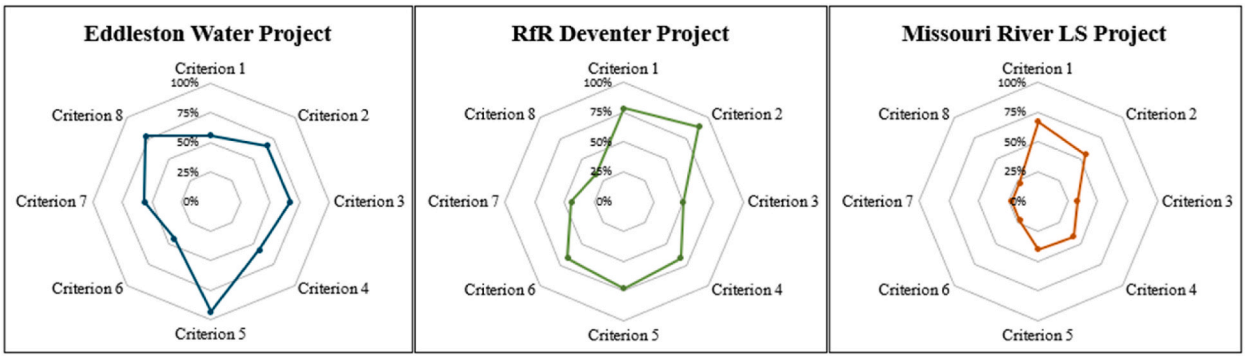


Fig. 5. Radar chart of percentage matches to the criteria of the IUCN Standard for case studies – (a) Eddleston Water Project; (b) RftR Deventer Project; (c) Missouri River LS Project.

Table 3
Results of the case study assessments with the IUCN Standard.

Criterion	Percentage match of adherence		
	Eddleston Water Project	RftR Deventer Project	Missouri River LS Project
1. Societal challenges	56%	78%	67%
2. Design at scale	67%	89%	56%
3. Biodiversity net-gain	67%	50%	33%
4. Economic feasibility	58%	67%	42%
5. Inclusive governance	93%	73%	40%
6. Balance trade-offs	44%	67%	22%
7. Adaptive management	56%	44%	22%
8. Sustainability and mainstreaming	78%	33%	22%
Total percentage match	**65%**	**63%**	**38%**

The percentage match can be related to the features listed in section 4.2. We briefly discuss them for the case studies.

management frameworks, and communication strategies for transformative change (Criteria 6, 7, 8). Additionally, it didn't inform policy frameworks or identify contributions to national/global targets.

5.2. *Considerations in application*

In the data collection, we have experienced (1) limited accessibility of data and (2) conflicting data. In addition, we analysed the effects of a lesser number, or absence of (3) stakeholder interviews and (4) field visits. These four considerations are described below.

5.2.1. *Consideration – 1. limited data accessibility & Implications for expert interviews*

Data availability and accessibility can be phrased as the "existence" and "possibility and ease of retrieval" of data (Dumitru and Wendling, 2021). We have experienced no difficulties in retrieving the required data for assessment of the case studies from publicly accessible documentation, stakeholder interviews and expert interviews. However, the amount of required accessible data by these means differed among the three case studies and, consequently we collected a different amount of remaining data from project experts. This is illustrated by the distribution of the means of verification for the indicators in Fig. 6. Despite the differences, at least 71 percent of the indicators was (partly) verified through expert interviews for all case studies. Since all indicators of the IUCN Standard need to be scored for a complete assessment, this implies that the case study assessments would have been incomplete without expert consultation and that, therefore, communication with project experts was essential.

We also experienced differences in the ease of data collection for the three case studies. Whereas the Eddleston Water Project

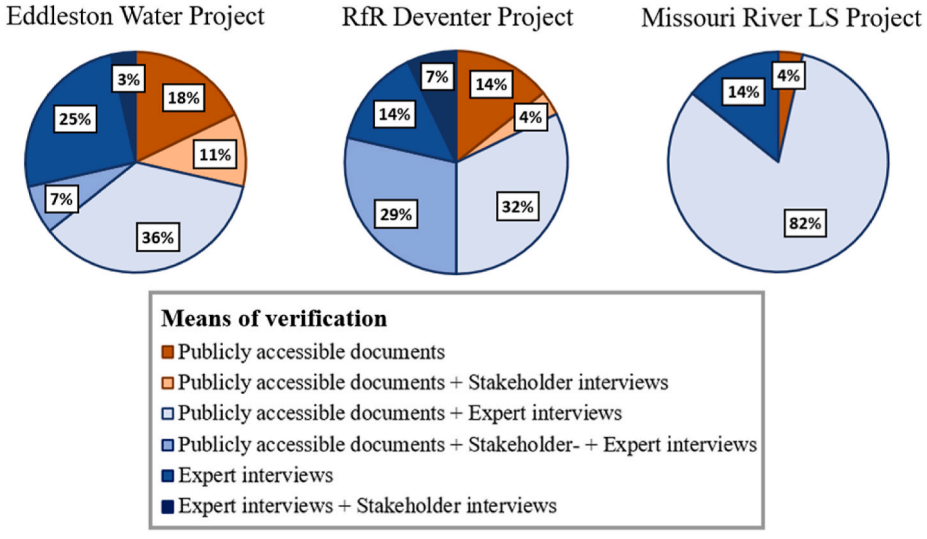
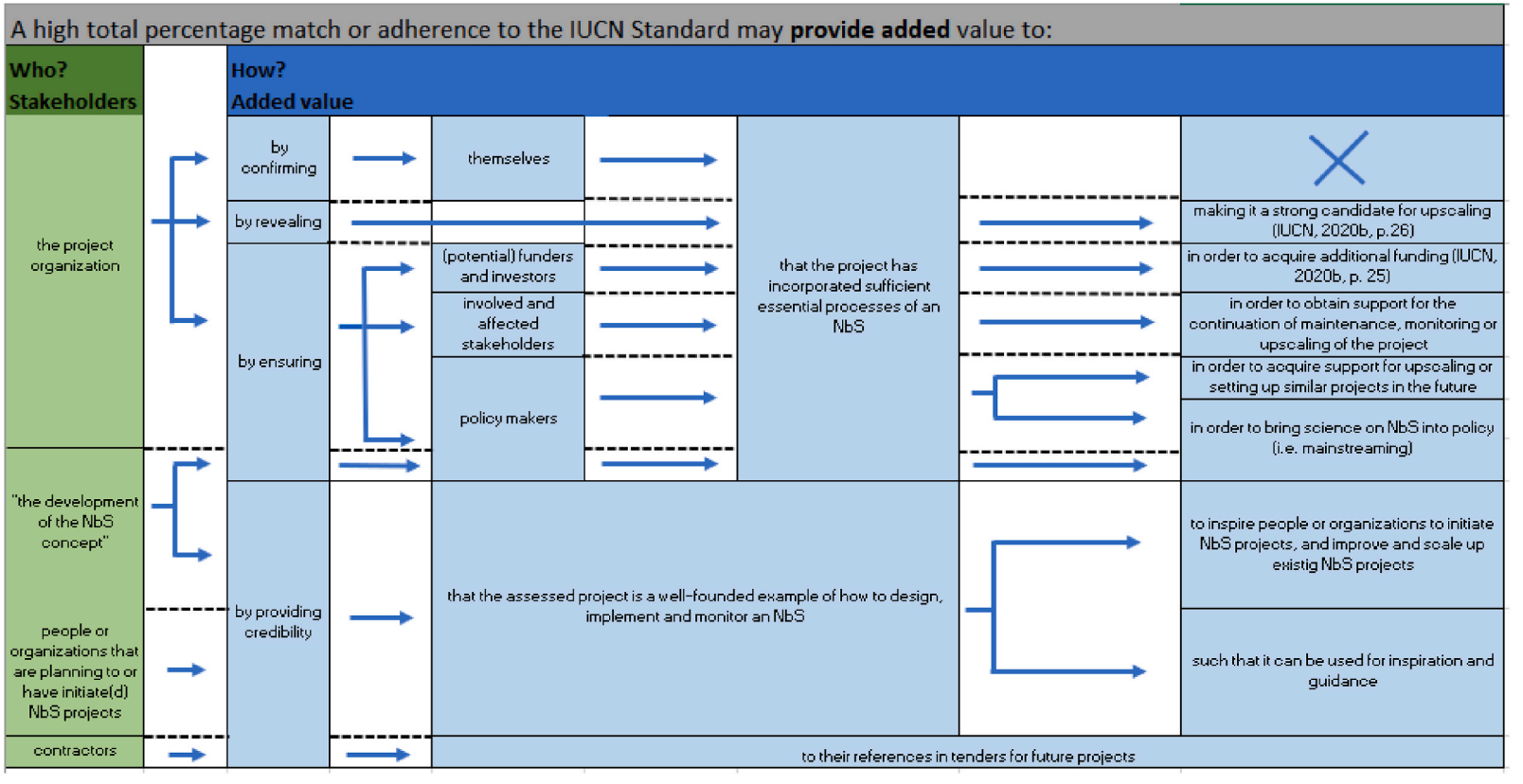


Fig. 6. Distribution of the means of verification for the indicators during the case study assessments with the IUCN Standard, where the blue and orange colour shades refer to verification with and without expert interviews, respectively.

Table 4
Various statements that provide added value of a high total percentage match or adherence to the IUCN Standard. The statements are build by following the blue arrows from left to right, where it is not allowed to cross the dashed lines. An example reads: "the added value of the project organization follows from ensuring policy makers that the project has incorporated sufficient essential processes of an NbS, making it a strong candidate for upscaling (IUCN, 2020b, p. 26)".



provides an elaborate publicly-available database of project-related documentation (https://tweedforum.org/eddleston-project-database/), data for the RftR Deventer Project and Missouri River LS Project was collected through a variety of websites and documents.

5.2.2. Consideration – 2. conflicting data

During data collection for the Missouri River LS Project, we were confronted with conflicting data. An example is the claim by Smith et al. (2017) that *"native flora and fauna have responded with increased growth and abundance after implementation of the levee setback"* (p. 42), which contradicts the statement by the project expert that these claims cannot be made due to limited monitoring. This observation introduces a potential bias. It also implies that the case study results would have been different and less accurate if no expert interviews were conducted.

5.2.3. Consideration – 3. stakeholder interviews

For the case of the Missouri River LS Project, we faced a challenge in answering and substantiating one or more guiding questions of Indicators 5.1, 5.3, 6.2 and 8.1, due to a lack of stakeholder interviews. An example is the guiding question of Indicator 5.1: *"Is the ownership and trust of the [feedback and grievance resolution] mechanism evident?"*. Based on the publicly accessible documentation and project expert interviews, we estimated that affected stakeholders have limited ownership of and trust in the possibilities to provide feedback. Because of the absence of stakeholder interviews, this conclusion is less accurate and lacks substantiation. We were able however, to adequately answer the remaining guiding questions based on publicly accessible documents and expert interviews, which suggests that stakeholder interviews were not always essential for a complete assessment. However, having these available would mean that less interpretation would have been necessary. Conducting six stakeholder interviews for the Eddleston Water Project with respect to one for the RftR Deventer Project has resulted in a better substantiation of the scores for the indicators that reflect on stakeholder opinions. In addition, undertaking a larger number of stakeholder interviews is likely to lead to a more accurate scoring of these indicators.

5.2.4. Consideration – 4. field visits

We were able to collect all of the required data for assessment of the Missouri River LS Project, for which no field visit was conducted, through publicly accessible documentation and digital communication with project experts. The field visits for the Eddleston Water Project and RftR Deventer project, however, did increase the ease of data collection, as it was easier to reach out to stakeholders and experts, and helped with a better understanding of the project context. These benefits were most significant for the Eddleston Water project due to the longer duration of the field visit (three days versus half a day for the RftR Deventer project).

5.3. Advancements of using the IUCN standard

Apart from the considerations, we also used the analysis of the case studies to derive three advancements of using the IUCN Standard in general.

5.3.1. Advancement – 1. total percentage match and adherence to the IUCN standard

Since the IUCN Standard is process-oriented, the total percentage match to the standard indicates the extent to which a project has incorporated the essential processes of an NbS, as established by the IUCN. If the total percentage increased 25 percent (set by IUCN), it adheres to the IUCN Standard and is recognized by the IUCN as NbS. Adherence does, however, not provide insight on the project results and effectiveness. Recognizing a project as NbS when it adheres to the IUCN Standard may, therefore, mislead people into thinking that the project is effective in providing the benefits associated with NbS, whereas this is not proven. To avoid misinterpretations, the result is framed as "adherence to the IUCN Standard" and not as "recognized as NbS" in the remainder of the paper. A non-exhaustive list of ways in which a high total percentage match or adherence to the IUCN Standard may provide added value is presented in Table 4. From that table (following the blue arrows in the table), it follows for instance that *"the added value of the project organization follows from ensuring policy makers that the project has incorporated sufficient essential processes of an NbS, making it a strong candidate for upscaling (IUCN, 2020b, p. 26)"*. Ultimately, adherence to the Standard can be interpreted as a potential quality indicator for a project having incorporated a sufficient amount of essential processes of an NbS that effectively and adaptively addresses societal challenges and simultaneously provides human well-being and biodiversity benefits. Reaching the standards set out by a widely-regarded international organization such as IUCN may be seen to provide independent quality assurance of the project. This may be compared to UNESCO recognition, the benefits of which include among others international exposure, promotional value and potential acquisition of funding.

A project scoring a low percentage match or not adhering to the IUCN Standard may indicate to the project organization that it is not in line with the IUCN guidelines for an effective NbS. This awareness may lead to efforts to strengthen the robustness of (i) the project itself, or (ii) future projects by learning from the identified weaknesses or using the IUCN Standard as ex-ante guidance, where studying other NbS projects with a high project score provide useful information.

5.3.2. Advancement – 2. strengths and weaknesses of the project

Assessment with the IUCN Standard reveals with which components of the indicators a project is aligned (i.e. strengths) or not (i.e. weaknesses). In general, the identification of project strengths may provide added value to.

i. the project organization by ensuring that certain project components are in line with the IUCNStandard, providing affirmation or help in the interaction with policy makers, funders, investors, and involved and affected stakeholders; and
ii. people or organizations that are setting up or upscaling a (NbS) project by disclosing the projectcomponents that are suitable for inspiration or guiding purposes.

Furthermore, the identification of project weaknesses may provide added value to.

i. the project organization by disclosing opportunities for improvement or alleviation, helping to strengthen therobustness of the (upscaled) project as a strong NbS;
ii. the project organization or clients by raising awareness about the learning opportunities within theirprevious project(s); and
iii. people or organizations that are upscaling or setting up a (NbS) project by disclosing the projectcomponents that require additional attention, such that these are incorporated in a more complete andeffective manner that is in line with the IUCN guidelines for an effective NbS.

5.3.3. Advancement – 3. radar chart

The radar chart (see Fig. 5) provides a clear overview of the percentage matches to the criteria of the IUCN Standard. In addition, the shape of the radar chart may be used to.

i. relate to projects with a similarly shaped radar chart (i.e. similar project characteristics) to learn from the barriers overcome and lessons learnt during these projects; and
ii. compare to projects with a higher percentage match to criteria, which may provide learning opportunities.

5.4. Limitations in using the IUCN standard

Finally, the analysis of the case studies revealed some limitations in using the IUCN Standard as assessing-application.

The IUCN Standard is set up for assessment of a general project. However, in practice every case study deviates to some degree from the general project considered by the IUCN. Case studies may receive a low score for a particular indicator as a result of choices that are made based on their objectives. An example is the Missouri River LS Project, which as an emergency rehabilitation project did not establish a formal feedback resolution mechanism, resulting in an insufficient score for Indicator 5.1. Hence, low scores can be the result of choices based on project objectives. Instead of solely considering the total percentage match and adherence to the IUCN Standard, assessors should also analyse the specific scores and rationale, which reveal valuable information on project choices and differences. Other implicitly made choices within the three case studies that resulted in low scores in the assessment with the IUCN Standard include those to do with being.

1. a research project, aiming to study the effectiveness of measures and not seeking return on investment;
2. a project with flood risk mitigation as its main objective;
3. a project with informal stakeholder engagement, based on trust;
4. a long-term project that initiates monitoring of certain elements at later project stages;
5. a project that is part of and contributes to the objectives of a (national) program; or
6. a project that aims to achieve maximum effect within a fixed budget.

Our analysis revealed that the IUCN Standard only explicitly includes indicators for human well-being (Indicator 1.3) and biodiversity (Criterion 3) to evaluate whether targets, benchmarks and monitoring are established but falls short in evaluating these processes for other societal challenges, such as flood risk mitigation. As a result, the IUCN Standard cannot be used to specifically identify strengths and weaknesses in the processes for flood risk mitigation. This lack of indicators hinders using NbS to promote upscaling for flood risk mitigation projects. This limitation can potentially be overcome with an additional criterion similar to Criterion 3 which evaluates whether targets, benchmarks and regular monitoring are established for the societal challenge(s) that the project aims to address.

Another limitation in using the Standard is that the requirement of a 25 percent match to each criterion to adhere to the Standard is relatively low. As a result, there can be a large difference in the quality of two projects that both adhere to the standard, posing a challenge in the comparison of projects. A suggestion to reduce this difference would be to always include the degree of adherence (*partial: 25 – 50%, adequate: 50 – 75%, or strong: 75 – 100%*) in the final result, rather than just 'adhere'.

A limitation to the use of Criterion 5 "Inclusive Governance" is that Indicator 5.5 "*Where the scale of the NbS extends beyond jurisdictional boundaries, mechanisms are established to enable joint-decision-making.*" suggests that a project that does not extend beyond jurisdictional boundaries should be provided with a "strong" score. As a result, projects with very limited inclusive governance, but an area that does not extend beyond jurisdictional boundaries, can still receive a higher than 25 percent match to Criterion 5. This is demonstrated by the assessment of the Missouri River LS Project. Unjustified adherence to the IUCN Standard could be avoided by providing a "neutral" scoring option at Indicator 5.5 for projects that do not extend beyond jurisdictional boundaries.

Lastly, a few indicators can be scored in multiple ways, as the corresponding guidance is not sufficiently clear. As a result, the scores that were provided for these indicators and consequently the case study results could have been slightly different if they were performed by another independent assessor, posing a limitation to the use of the IUCN Standard. The potential differences in results might

be reduced by increasing the level of detail in the indicator guidance. However, increasing the level of detail might in turn limit the scope of application of the IUCN Standard, as the room for interpretation might be essential in retaining the applicability to different contexts.

6. Discussion

6.1. Considerations

6.1.1. Consideration 1: limited data accessibility &implications for expert interviews

Our study identified the same challenge on data input requirements as Le Gouvello et al. (2030) and Chales et al. (2023) for river restoration projects, where consultation of project experts was essential to collect all required data. Our study also confirms that consultation of project experts was essential to collect all required data (Le Gouvelle et al. 2023), but makes a distinction between the consultation of project experts (essential for a complete assessment) and stakeholders (not essential, but does increase the degree of substantiation). We recognise however, the potential for bias if one only relies on project experts, as opposed to other (more independent) stakeholders being included as well.

6.1.2. Consideration 2: conflicting data

Le Gouvello et al. (2023) stressed that assessment with the IUCN Standard is subjective, corresponding to the individual conducting the assessment, and therefore that different stakeholders should work together as a group to discuss and agree on the most accurate assessment. This also minimises the possibility of collecting conflicting data. For our study, having a single assessor is admissible because we explicitly chose to research the use of the IUCN Standard and not the case studies themselves. Our study also confirms the finding of Le Gouvello et al. (2023) that the Standard tends to be subjective.

6.1.3. Consideration 3: stakeholder interviews

The first step in data collection was the analysis of publicly accessible project-related documents. It might have been more effective to directly start with stakeholder and expert interviews, as this likely yielded the relevant publicly accessible data. This may have influenced the means of verification (Fig. 6) and associated conclusions on data accessibility Data collection may be influenced by document selection (nature, type, scope), analysis effort, interview quantity/length, interviewee knowledge/biases, and communication contradictions).

6.1.4. Consideration 4: field visits

The desk study by Le Gouvello et al. (2022) strongly recommends that case study assessments with the IUCN Standard are conducted at location. However, assessing the Missouri River LS Project, our study found that a field visit is not required for a complete assessment, as long as digital communication with project experts and stakeholders is possible. While a field visit to the project location does increase the ease of data collection, we found that a complete assessment with the IUCN Standard can also be done remotely.

6.2. Advancements

6.2.1. Advancement 1: total percentage match and adherence to the IUCN standard

Our observation is that case studies received low scores for certain indicators as result of choices that were made based on the specific objectives of each case study or that some indicators (e.g. Indicator 5.5) are irrelevant and should be excluded. This corresponds with the finding of *Le Gouvello* et al. (2023) and Châles et al. (2023) in their application on aquaculture and the Pacific Small Island Developing States.

6.2.2. Advancement 2: strengths and weaknesses of the project

The added value of identifying weaknesses that was featured in this study corresponds with those found in Shina and Bimson (2021) and Risna et al. (2020). Our study suggests, unlike the findings of Luo et al. (2023) and Meyer and Hessenberger (2022) not to use the IUCN Standard for the sole purpose of determining whether a project fits within the NbS concept because the IUCN Standard cannot be used to evaluate the effectiveness of a project.

6.2.3. Advancement 3: radar chart

The shape of the radar chart can be used to compare projects, providing learning opportunities. This is only possible with a database of radar charts from assessments of other projects. Without such a database, or if it is difficult to access or contains few assessments, the radar chart loses its value for comparisons. Therefore, we suggest that the IUCN actively establish a database with radar chart assessments. Without this, the radar chart is not an advancement and might as well be removed from the IUCN Standard.

6.3. Relevance of research results to other scopes/fields

This study is confined to flood risk mitigation. Berg et al. (2024) shows that the IUCN Standard applies to a wide variety of environmental contexts and societal challenges, which means that our findings related to the considerations and advancements (Section 5.2 and 5.3) might be extended to coastal, urban or rural environments, or food or water security. The research results are

likely to be applicable in developing contexts, although there may be more challenges regarding data accessibility. A few indicators, however, seem to be more applicable in developing contexts, such as Indicator 5.2: "*Participation … upholds the right of Indigenous Peoples to Free Prior and Informed Consent*". We expect the IUCN Standard to be applicable to projects with less project-related documents, as long as sufficient data is accessible through stakeholders and experts. This implies that increasingly more detailed interviews with stakeholders and experts are necessary.

7. Conclusions

We have assessed the applicability and potential added value of using the IUCN Standard by applying it to three case studies to evaluate the utility of the Standard. We used the outcome of the analysis of the case studies to derive considerations of its limitations and potential for advancements in applying the Standard. We found that, in cases where there is limited data accessibility in project-related documentation or, where collection of data provides apparently conflicting perspectives the IUCN Standard can successfully be used for ex-post assessment of river restoration projects with a focus on flood risk mitigation. An essential step in collection of the data required for a complete assessment is the consultation of project experts, though this also raises challenges around potential bias. Interviews with stakeholders increase the degree of independent verification and substantiation, but may not be essential, provided that sufficient data can be collected from other sources. A visit to the project location increases the ease of data collection, but may not be essential as long as digital communication with interviewees is possible. The most notable advancements of the IUCN Standard manifest in the potential enhancements observed within the projects where the Standard is implemented.

1. providing credibility that a project has incorporated sufficient processes, considered essential by the IUCN(e.g. inclusive stakeholder engagement and continuous adaptive management), to effectively and adaptivelyaddress societal challenges and simultaneously provide human well-being and biodiversity benefits (i.e. to bean NbS),
2. revealing the strengths of a project, providing affirmation, and inspiring or guiding (NbS) projects,
3. revealing the weaknesses of a project, providing opportunities for improvement of the (upscaled) project or strengthening future (NbS) projects; and.
4. providing opportunities for the comparison of projects based on the shape of the radar charts.

This indicates that the IUCN Standard is a suitable framework to assess process based aspects of Nature based Solutions for riverine flood risk mitigation. These results may be transferred to the other societal challenges that the Standard is able to address (e.g. climate change mitigation and adaptation, and food security).

CRediT authorship contribution statement

Maikel Berg: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Conceptualization. **Chris J. Spray:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Astrid Blom:** Writing – review & editing, Supervision, Funding acquisition. **Jill H. Slinger:** Writing – review & editing, Conceptualization. **Laura M. Stancanelli:** Writing – review & editing. **Yvo Snoek:** Writing – review & editing. **Ralph M.J. Schielen:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data is provided in the supplementary Material

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Appendix A. Supplementary data

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