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A Framework to Evaluate the SDG Contribution of Fluvial Nature-Based Solutions

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Abstract: Nature-based solutions (NBSs) are measures reflecting the 'cooperation with nature' approach: mitigating fluvial flood risk while being cost-effective, resource-efficient, and providing numerous environmental, social, and economic benefits. Since 2015, the United Nations (UN) 2030 Agenda has provided UN member states with goals, targets, and indicators to facilitate an integrated approach focusing on economic, environmental, and social improvements simultaneously. The aim of this study is to evaluate the contribution of fluvial NBSs to the UN 2030 Agenda, using all its components: Sustainable Development Goals (SDGs), targets, and indicators. We propose a four-step framework with inputs from the UN 2030 Agenda, scientific literature, and case studies. The framework provides a set of fluvial flooding indicators that are linked to SDG indicators of the UN 2030 Agenda. Finally, the fluvial flooding indicators are tested by applying them to a case study, the Eddleston Water Project, aiming to examine its contribution to the UN 2030 Agenda. This reveals that the Eddleston Water Project contributes to 9 SDGs and 33 SDG targets from environmental, economic, societal, policy, and technical perspectives. Our framework aims to enhance the systematic considerations of the SDG indicators, adjust their notion to the system of interest, and thereby enhance the link between the sustainability performance of NBSs and the UN 2030 Agenda.

Keywords: nature-based solutions; river; flooding; sustainability; sustainable development goals; indicators

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1. Introduction

According to the United Nations (UN) 2015 report, 'The Human Cost of Weather-Related Disasters' [1], flooding has negatively affected 2.3 billion people over the last 20 years. This accounts for 56% of all those negatively affected by weather-related disasters such as droughts, storms, landslides, and extreme temperatures (64.4 million/year). Especially for fluvial floods, the number of affected people under the most extreme river flooding scenario and without further adaptation may rise from 39 million people per year to 134 million people per year by 2050. Approximately two-thirds of this increase can be attributed to increases in the severity and frequency of flooding due to climate change and the remainder due to population growth in flooding-prone areas [2].

Rapid development combined with the expansion of infrastructure, agricultural intensification, transport, and other linked socioeconomic systems has increased society's vulnerability to environmental disasters, especially in floodplain areas [3]. At the same time, climate change is an important driver for implementing sustainable practices in protecting and managing river ecosystems. In this context, the UN 2030 Agenda [4] has provided international and national governments with goals, targets, and indicators to facilitate an integrated approach focusing on economic, environmental, and social improvements simultaneously. Since 2015, all UN member states are expected to pursue these Sustainable Development Goals (SDGs), tailoring a path towards a peaceful and prosperous planet.

Nature-based solutions (NBSs) can help in addressing many of the SDGs as established in the UN 2030 Agenda. The inclusion of natural elements could create manifold benefits for all the three pillars – 'People', 'Planet', and 'Prosperity' which reflect the three sustainability principles (society, environment, economy) and are adopted by the UN 2030 Agenda. From a societal perspective, they could provide access to nature and recreation while adding cultural and heritage value to the landscape. From ecological and environmental perspectives, they could enhance biodiversity and contribute to water and air purification. From an economic viewpoint, they could promote sustainable and responsible resource management, resulting in cost-effective practices. In Europe, nature-based protection measures (green-blue-hybrid) have already gained increasing prominence in application [5–8]. Green/Blue infrastructure indicates a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in ter-restrial (including coastal) and ma-rine areas. Hybrid solutions mix hard infrastructure with ecosystem-based infrastructure (https://portals.iucn.org/library/sites/library/files/documents/2016-036.pdf, accessed on 10 October 2021). In global relevance, the effort to learn, implement and promote NBSs is worldwide and supported by many programs and data pools [9].

To date, several NBSs frameworks have been developed to comprehensively describe, analyze, and assess the planning, implementation, and operationalization of NBSs projects. Typically, they include indicators for benchmarking, assessing, or measuring the performance or (co-)benefits of NBSs under several hydro-meteorological hazards (HMHs). Kumar et al. [10], Ruangpan et al. [11], Shah et al. [12], and Albert et al. [13], for instance, developed a single NBS framework covering at least four HMHs. The type of environment under consideration typically differs; Kumar et al. [10], Ruangpan et al. [11], Calliari et al. [14], and Nesshöver et al. [15] do not focus on a single environment, in contrast to many other studies wherein a specific type of environment is the focus. The environments most studied are urban, large rivers (250–300 km), and coasts [11,13,16–21].

Sustainability is addressed in recent NBSs-related frameworks either with the inclusion of the three pillars in the assessment of the NBSs' performance or their (co-)benefits or by measuring the sustainability performance according to the components of the UN 2030 Agenda. Initially, studies such as those by ones of Artmann et al. [22], Pakzad et al. [23], Raymond et al. [20] showed that NBSs interact across and within society, economy, and environment. Building on that, subsequent studies (e.g., [18,21,24]) examined the potential contributions of NBSs to the UN 2030 Agenda by examining the SDGs and/or their targets. Schipper et al. [21] developed the Sustainability Impact Score (SIS) Assessment Framework, which uses a selection of SDGs and SDG targets to score the sustainability performance of coastal management projects. Whilst it is apparent that some of the recent frameworks address the SDGs and/or SDG targets from the UN 2030 Agenda, they omit consideration of the SDG indicators.

However, in scrutinizing the UN 2030 Agenda, it is noticeable that (i) often, SDG targets refer to multiple elements which are broken down into SDG indicators, and (ii) 12 SDG indicators are repeated (some with slight amendments) under different SDG targets. The SDG indicators (rather than the SDG targets) seem to have the right abstraction level to serve as a connection between the NBSs and the UN 2030 Agenda. Although reaching the SDGs in itself is a promising achievement in preserving our planet, as stated by the United Nations, using the SDG indicators could bring a new perspective to the effort of linking the NBSs to SDGs and hence to assessing the contribution of NBSs to the achievement of the SDGs.

To bridge the gap identified in the research to date, the aim of this study is to evaluate the sustainability performance of NBSs projects with respect to the UN 2030 Agenda, involving all its three components: SDGs, SDG targets, and SDG indicators. In other words, we seek the SDGs, SDG targets, and SDG indicators to which NBSs projects could contribute. We focus on NBSs projects for fluvial flood risk mitigation (FFRM) implemented in riverine ecosystems up to 100 km^2, which is a smaller scale than that examined in riverine environments to date. Specifically, we aim to evaluate the sustainability performance of NBSs projects for FFRM by:

a) Creating a set of fluvial flooding indicators that reflect the interactions of NBSs for FFRM projects with societal, environmental, economic, policy, and technical perspectives;
b) Establishing a link between the set of fluvial flooding indicators and the SDG indicators;
c) Testing the fluvial flooding indicators by selecting a specific case study with the necessary project metadata.

We consider case studies from countries with high-income economies only, as NBSs projects in countries with upper-middle, lower-middle, and low-income economies typically aim to cover more fundamental needs, such as water quality and scarcity, and flood mitigation is seldom the main driver for NBSs implementation. Interaction of the river ecosystem with the coastal environment is out of the scope of this research.

2. Methodology

The methodology of this study uses the SIS Assessment Framework in a way that looks to build on the systematic methodology introduced by Schipper et al. [21], but with focus on river ecosystems, recognizing and introducing new elements reflecting the scope of the research. With the UN 2030 Agenda as a starting point, four steps are considered that eventually lead to the formation of the framework. Subsequently, the framework is presented along with the four steps through which our aim is accomplished and, ultimately, a case study to test its applicability.

2.1. The Sustainability Performance Evaluation Framework

The Sustainability Performance Evaluation Framework presented here is derived from the SIS Assessment Framework with the necessary alterations. It encompasses a systematic methodology for creating a set of fluvial flooding indicators, linking them to the SDG indicators, and evaluating the sustainability performance of an FFRM NBSs project through four steps. Starting with the components of the UN 2030 Agenda as input (Figure 1), Step I defines the fluvial flooding indicators which relate to NBSs for FFRM. Subsequently (Step II), the SDGs relevant to NBSs for FFRM, along with the respective SDG targets and SDG indicators, are selected from the UN 2030 Agenda. In Step III, Step I and Step II are brought together, creating a set of NBSs fluvial flooding indicators that demonstrate the FFRM NBSs' contribution to the UN 2030 Agenda. The definition of fluvial flooding indicators and their subsequent connection to the SDG indicators (instead of directly using the SDG indicators) makes it possible to overcome an apparent lack of conceptual clarity inherent in some of the SDG indicators due to their universal nature. Finally, Step IV consists of the assessment of the fluvial flooding indicators based on their application to a case study with available project metadata, with the sustainability performance of the project as the main output.

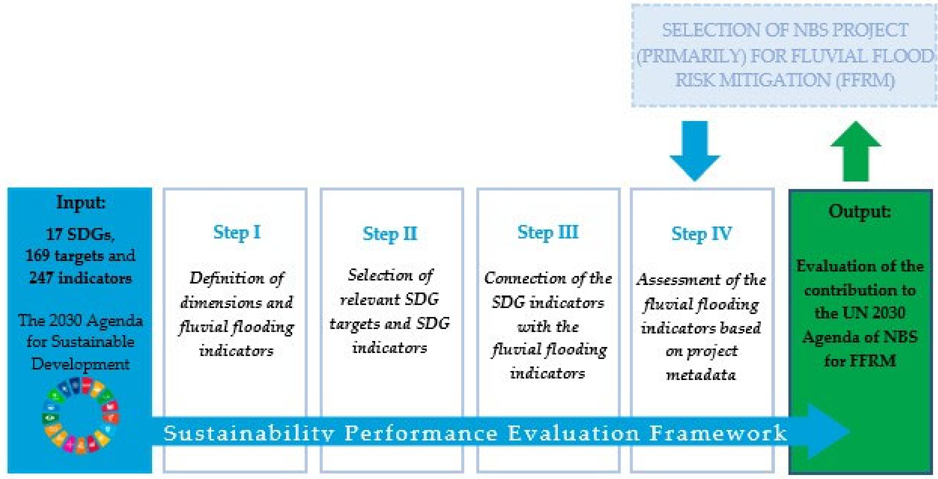

Figure 1. The Sustainability Performance Evaluation Framework, using a selection of SDGs, SDG targets, and SDG indicators published in the 2030 Agenda for Sustainable Development. The Sustainability Performance Evaluation Framework output shows the contribution of an NBSs project for FFRM (and the reason for it) to the UN 2030 Agenda (Figure adapted from [21]).

2.2. Step I—Definition of Dimensions and Fluvial Flooding Indicators

The scope of the sustainability evaluation is defined through the identification of the NBSs dimensions. The word 'dimension' is chosen above terminology such as 'property' or 'aspect' to emphasize the broadness of the NBSs (co-)benefits. The NBSs dimensions express sectors that are affected by FFRM NBSs projects in river ecosystems. For instance, floodplain ponds will, in addition to temporarily storing water during floods, provide habitats for wildlife and support biodiversity. Therefore, wildlife and biodiversity are two sectors that are affected by floodplain ponds and are expressed by the Environmental dimension in our study.

The identification of the dimensions is based upon an analysis of 7 existing NBSs frameworks or reviews ([14,15,20,22,25–27]), complemented by the examination of three case studies (Table 1). Case studies are used in order to validate that the framework/review findings are realistic and to add any relevant findings that might have been neglected in the literature. The selection of the case studies was based on the following five independent criteria. The criteria are not prioritized; the order is indicative.

1. The main objective of the NBSs should be fluvial flood risk mitigation;
2. Coverage of different geographical regions and scales;
3. Availability of documentation (language, type, and number);
4. Accessibility to relevant data, information, documentation;
5. Availability of grey literature relevant to the case studies, to be used as an additional source of information, including published articles and videos.

Table 1. The selected projects examined as case studies. They contribute to the definition of the dimensions and their fluvial flooding indicators (Step I).

Project	Location	Scale	References
Wave-attenuating willow forest	Noordwaard polder, The Netherlands	~ 44.50 km2 polder area	[28–33]
Colorado front range: recovery from 2013 floods	United States of America (USA)	~ 105 km river and floodplain improvements	[28,34,35]
Belford natural flood management scheme	Belford, Northumberland, United Kingdom (UK)	~ 6 km2 catchment size	[36–47]

Each dimension consists of fluvial flooding indicators, as shown in Figure 2, that act as a metric that condenses complexity and provides relevant information [48]. The aim of the fluvial flooding indicators is to list specific effects that might occur in a dimension when implementing an NBSs project for FFRM. For instance, biodiversity abundance is a fluvial flooding indicator that can be found under the Environmental dimension (Figure 2). A preliminary list of fluvial flooding indicators was created by:

(i) Collecting existing indicators from literature. The collection of indicators comes from the 7 frameworks reviewed for the dimensions. However, starting with the already identified frameworks and using snowballing techniques, three additional frameworks were identified that also revealed additional indicators [23,49,50].

(ii) Using the indicators derived from (i) in analyzing the three case studies (Table 1), chosen to reflect a reasonable geographical coverage, spread in surface and in geomorphological aspects and with enough information at hand to quantify the indicators. In this process, the case studies gave rise to several new indicators that were not included in Step (i).

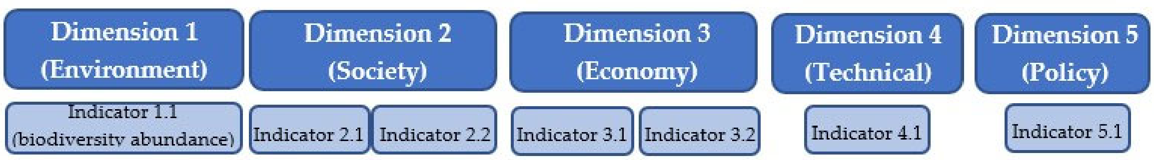

Figure 2. Within each of the five dimensions, the fluvial flooding indicators represent potential effects of NBSs projects for FFRM in the respective dimension. This figure aims to show the structure of the dimensions and their fluvial flooding indicators. The exact dimensions and their fluvial flooding indicators are fully explained in the Results section (Steps I and III).

2.3. Step II—Selection of Relevant SDG Targets and SDG Indicators

The Sustainable Development Goals, targets, and indicators constitute very broad but versatile milestones that users may need to adapt depending on the context and their precise area of interest. As the goals themselves are very broad, the starting point for examination in this study is the 169 targets, followed by the 247 indicators. In reviewing these, the aim is to establish what they address and then select those SDG targets and SDG indicators that are relevant to NBSs for FFRM. For this purpose, a screening process has been developed (Figure 3) to help select relevant SDG targets and SDG indicators according to (i) the boundary conditions (high-income economies, river ecosystem) and (ii) potential NBSs' contribution to them for FFRM. The latter, in particular, has been developed from insights gained from the literature review and case studies. The selection process is presented in Figure 3:

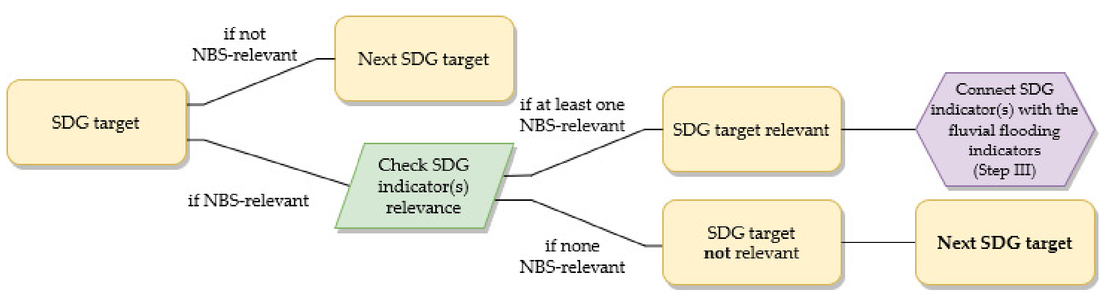

Figure 3. The screening process that selects SDG targets and SDG indicators relevant to NBSs for FFRM. Eventually, the relevant SDG indicators can be linked to the fluvial flooding indicators, as explained in Step III (hexagonal purple box).

2.4. Step III—Connection of the SDG Indicators With the Fluvial Flooding Indicators

Having selected the relevant SDG targets and SDG indicators from the UN 2030 Agenda (Step II), the SDG indicators were connected with the preliminary list of fluvial flooding indicators, as formed in Step I. The connection was made at a conceptual level: matching the description of the fluvial flooding indicator with the SDG indicators. For instance, the biodiversity abundance fluvial flooding indicator was connected to an SDG indicator that addresses the presence and diversity of species.

2.5. Step IV—Assessment of the Fluvial Flooding Indicators Based on Project Metadata

Finally, the connected fluvial flooding indicators (Step III) are applied to a selected case study using project metadata as input to them. Through examination of the fluvial flooding indicators, the sustainability performance of a selected FFRM NBSs project with respect to the UN 2030 Agenda is evaluated.

3. Results

3.1. Step I—Definition of Dimensions and Fluvial Flooding Indicators

Five dimensions are defined: Environment, Economy, Society, Policy—Procedural, and Technical. The Environment, Economy, and Society dimensions represent the three pillars of sustainability. These three pillars, along with the Policy—Procedural dimension, can all be found as broad divisions within the UN 2030 Agenda [51]. The Environment, Economy, and Society dimensions are also used by other frameworks addressing either NBSs sustainability or the additional benefits that NBSs bring [17,19–21,52]. The Technical dimension is a new addition that is considered highly relevant because it refers to the fulfillment of the objective of the intervention (flood protection) and to characteristics that the intervention should comply with, including structural integrity, reliability, ease of implementation, adaptability, and resilience. The Technical dimension has recently been introduced in the literature. The study of Pugliese et al. [19] uses the framework introduced by PHUSICOS [53], where the Technical dimension is used as an ambit to examine the NBSs' technical and economic feasibility aspects. The Policy—Procedural dimension is usually found in the Society dimension. This is the case both in the EC Handbook for Practitioners [52], which places the 'Participatory Planning and Governance' under the People pillar of Sustainable Development, and in the PHUSICOS framework [53] that includes the 'Community Involvement and Governance', in the Society ambit. In the Sustainability Performance Evaluation Framework, we distinguished the Policy—Procedural dimension from the Society one, aligning with the UN 2030 Agenda [4], which devotes entire goals to partnerships (Goal 17) and inclusive collaboration (Goal 16).

A preliminary list of 32 fluvial flooding indicators was identified spread across the five dimensions (Environment 8, Society 5, Economy 5, Technical 6, Policy—Procedural 8) to describe the effects of NBSs for FFRM. Overall, 24 of the fluvial flooding indicators were collected from the NBSs frameworks and reviews examined; three emerged from the case studies, and five technical fluvial flooding indicators were introduced by the authors adjusted after Slinger, J.H. [54]. A detailed table with all the dimensions, their fluvial flooding indicators, and their use is presented in the description of Step III to avoid repetition.

3.2. Step II—Selection of Relevant SDG Targets and SDG Indicators

Table 2 shows the selection of 10 SDGs, 42 SDG targets, and 51 SDG indicators as relevant to NBSs for FFRM, as derived from the screening process. The selection starts by examining, one by one, all the SDG targets following the screening process (Figure 3). For each SDG target that was considered relevant to the FFRM NBSs, at least one of its SDG indicators also had to be FFRM-NBSs-relevant. The explanation as to which SDG indicator is considered relevant is shown in the fourth column of Table 2 and is derived from our examination of the literature and case studies.

Table 2. In total, 10 SDGs, 42 SDG targets, and 51 SDG indicators are considered relevant to NBSs projects for fluvial flood risk mitigation. These 51 relevant SDG indicators will be connected with the fluvial flooding indicators in Step III. For a full description of the SDG targets and SDG indicators, reference should be made to the UN 2030 Agenda.

SDGs Identified	Relevant SDG Targets	Relevant SDG Indicators	Explanation
GOAL 1 End poverty in all its forms everywhere	Target 1.5 Disaster Resilience	1.5.1 Casualties due to disasters	Protect from/reduce exposure of people to flooding
		1.5.2 GDP economic losses due to disasters	Prevent or minimize economic losses due to flooding
		1.5.3 Strategies in line with Sendai	Introduce to/become part of the national flood risk reduction strategies
		1.5.4 Alignment of local and national strategies	Make the alignment with national flood risk reduction strategies feasible
GOAL 3 Ensure healthy lives and promote well-being for all at all ages	Target 3.9 Pollutions and Contaminations	3.9.1 Air pollution mortality	Can contribute to air purification due to the natural elements used/enhanced
		3.9.2 Unsafe water mortality	Protect from/reduce exposure of people to poor quality water
GOAL 6 Ensure availability and sustainable management of water and sanitation for all	Target 6.3 Water Pollution	6.3.2 Water quality	Can contribute to water purification due to the natural elements used/enhanced
	Target 6.5 Management and Cooperation	6.5.1 Integrated water resources management	Require integrated water resources management
		6.5.2 Transboundary water cooperation	Can potentially achieve it
	Target 6.6 Water Quantity and Quality	6.6.1 Extent of water-related ecosystems	By enhancing the natural processes, the ecosystem expands
	Target 6.b Community Participation	6.b.1 Community engagement	They require inclusive processes and stakeholder participation in the management of water resources
GOAL 8 Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all	Target 8.1 Economic Growth	8.1.1 Economic growth per capita	Overall economic growth shared over the local population due to new jobs, increased income, or production due to intervention
	Target 8.2 Economic Productivity	8.2.1 Economic growth per employed person	Potential increase of the income per employed person due to jobs created or enhanced by the intervention
	Target 8.3 Development-Oriented Policies	8.3.1 Employment	Ameliorate existing jobs by providing opportunities and better prevailing conditions
	Target 8.4 Resource Efficiency	8.4.2 Domestic material consumption per GDP	Use of locally available materials and limited cost compared to grey materials

SDGs Identified	Relevant SDG Targets	Relevant SDG Indicators	Explanation
	Target 8.5 Employment	8.5.2 Unemployment rates	New job opportunities
	Target 8.9 Tourism-Oriented Policies	8.9.1 Economic growth due to tourists	Money and jobs due to the touristic attractiveness of the area
GOAL 9 Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation	Target 9.4 CO2 Emissions Reduction	9.4.1 CO2 emissions	C02 sequestration through use of the natural material chosen
	Target 9.5 Research and Development Expenditure	9.5.1 Research and development expenditure	Research and pilot projects needed for the implementation of the NBSs
GOAL 11 Make cities and human settlements inclusive, safe, resilient, and sustainable	Target 11.3 Participation and Management	11.3.2 Public engagement strategies	Stakeholder involvement in NBSs design and implementation
	Target 11.4 Expenditure on Preserving Heritage	11.4.1 Expenditure on culture and heritage	Protection of cultural heritage is an additional aspect to the NBSs' main function in flood risk mitigation
	Target 11.5 Economic Losses Due to Disasters	11.5.1 Casualties due to disasters	Protect from/reduce exposure of people to flooding
		11.5.2 Damages to infrastructures and services	Prevent or minimize economic losses due to flooding
	Target 11.7 Green and Public Spaces	11.7.1 Use of public areas	Accessibility, recreation, and leisure space are additional aspects to the NBSs' main function in flood-risk mitigation
	Target 11.A Economic, Social, and Environmental Links	11.a.1 Development plans accounting for future projections	Part of the NBSs design
	Target 11.B Holistic Disaster Risk Management	11.b.1 Strategies to protect development gains from the risk of disaster (Sendai framework)	NBSs are part of flood-risk-reduction strategies which align with Sendai FDRR
		11.b.2 Alignment of local and national strategies	Make the alignment with national flood risk reduction strategies feasible
GOAL 12 Ensure sustainable consumption and production patterns	Target 12.1 Consumption and Production	12.1.1 Sustainable production and consumption plans	NBSs include sustainable use/consumption of naturally available materials
	Target 12.2 Domestic Material Consumption	12.2.2 Domestic material consumption	Use of locally available materials
	Target 12.6 Sustainability in Companies	12.6.1 Sustainability reports by companies	NBSs involve the three sustainability pillars and thus could evoke sustainable activities in the companies
	Target 12.7 Procurement Practices	12.7.1 Sustainable action plans	NBSs involve inclusive strategies, actions, and the three sustainability pillars

SDGs Identified	Relevant SDG Targets	Relevant SDG Indicators	Explanation
	Target 12.8 Education and Awareness	12.8.1 Education for sustainability	Offer education through the enrichment of the area and close contact with nature
GOAL 13 Take urgent action to combat climate change and its impacts	Target 13.1 Resilience and Adaptive Capacity	13.1.1 Casualties due to disasters	Protect from/reduce exposure of people to flooding
		13.1.2 Strategies in line with Sendai	NBSs are part of flood-risk-reduction strategies that align with Sendai FDRR
		13.1.3 Alignment of local and national strategies	Make the alignment with national flood risk reduction strategies feasible
	Target 13.2 Operationalization of Climate-Related Policies	13.2.1 Climate adaptation plans and strategies	Offer multi-benefit approach that applies at NBSs design and implementation
	Target 13.3 Development Action	13.3.2 Technology knowledge, transfer, and development in countries	NBSs result from and contribute to development
	Target 13.B Capacity for Planning and Management	13.b.1 Support for climate-related actions	Strengthening the evidence and experience in NBSs would spread their application for climate resilience
GOAL 15 Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Target 15.1 Protected Areas	15.1.2 Protected areas	Protection and conservation of designated sites (including Natura 2000) are considered during NBSs design and implementation
	Target 15.3 Land Degradation	15.3.1 Degraded areas	NBSs can contribute to halting erosion
	Target 15.5 Threatened Species	15.5.1 Red List Index	Generation of wildlife habitat and population viability are addressed by NBSs
	Target 15.6 Access to and Sharing of Benefits	15.6.1 Policies for sharing of benefits	NBSs are designed in order to provide as many benefits as possible to multiple stakeholders
	Target 15.8 Prevention of Invasive Alien Species	15.8.1 Policies for control of invasive non-native species	Contribute to awareness and prevention of spread of non-native invasive species in riverine ecosystems
	Target 15.9 Ecosystem and Biodiversity into Policies	15.9.1 Aichi biodiversity target 2	Enhance biodiversity as part of the NBSs goals
	Target 15.A Assistance and Expenditure on Biodiversity and Ecosystems	15.a.1 Use and conservation of biodiversity and ecosystems	Part of the NBSs project goals
GOAL 17 Strengthen the means of implementation and revitalize	Target 17.6 Cooperation between Countries	17.6.1 Cooperation between countries	NBSs could enhance science and technology cooperation between countries

SDGs Identified	Relevant SDG Targets	Relevant SDG Indicators	Explanation
the Global Partnership for Sustainable Development	Target 17.14 Policy Coherence	17.14.1 Mechanisms for sustainable development	The broad involvement needed in NBSs projects could lead to policy coherence for sustainable development
	Target 17.15 Use of Domestic Development Tools	17.15.1 Use country-owned resources	NBSs intervention aligned with national policies and development plans
	Target 17.16 Partnerships and Stakeholder Engagement	17.16.1 Reporting progress in SDG	NBSs can contribute to SDG progress through the multi-benefit approach, which includes society, environment, and economy
	Target 17.17 Money to Partnerships	17.17.1 Partnerships	Partnerships and coalitions formed/enhanced through NBSs
	Targets 17.18 Data and Indicators	17.18.1 Production of SD indicators per country	NBSs can create trackable indicators

3.3. Step III—Connection of the SDG Indicators With the Fluvial Flooding Indicators

The preliminary list of fluvial flooding indicators was coupled with the relevant SDG indicators, resulting in 21 out of 32 fluvial flooding indicators being linked to various of the 51 SDG indicators. It was expected that not all the fluvial flooding indicators would be linked to the relevant SDG indicators since the intention was to match a targeted—to fluvial flooding—list specifically derived from the authors' examination of literature and practice to a universal solid agenda. However, since the UN 2030 Agenda is a universally recognized policy framework and the aim of this study is to examine the FFRM NBSs's contribution to it, the preliminary list was extended to cover all the relevant SDG indicators. A total of 12 fluvial flooding indicators were added in the Policy—Procedural dimension, which can be seen in Table 3, rows #29–34 and #39–44. Therefore, the final list comprises 33 fluvial flooding indicators coupled with all the 51 relevant SDG indicators.

Table 3 presents the five dimensions with their respective fluvial flooding indicators (first four columns) and their connection with the SDG indicators (last two columns).

Table 3. All the 44 fluvial flooding indicators. The first 32 fluvial flooding indicators that belong to the preliminary list come from (i) literature review [14,15,20,22,25–27,54] and (ii) case study examination [28–47]. From these, 21 link to SDG indicators whilst the 11 remaining do not (-). In rows #29–34 and #39–44, there are 12 new fluvial flooding indicators. On this base and with project metadata, the final list of 33 fluvial flooding indicators will show the contribution of an NBSs project for FFRM to the UN 2030 Agenda (Step IV).

#	Fluvial Flooding Indicator	(Fluvial Flooding Indicator) General Description	Ref.	Dimension	Relevant SDG Indicator	(SDG Indicator) Short Description
1	Biodiversity abundance	Animals using the site, vegetation cover, designation as a protected site (e.g., inclusion in the EU 'Natura 2000' network)	[14,15,20, 22,25–27]	Environment	15.1.2	Protected areas
2	Wildlife habitat	Creation of habitat for flora and fauna	[14,15,20, 22,25–27]		15.5.1	Red List Index
3	Population viability	Expresses either lifetime of a species in time or	[14,15,20, 22,25–27]		15.5.1	Red List Index

#	Fluvial Flooding Indicator	(Fluvial Flooding Indicator) General Description	Ref.	Dimension	Relevant SDG Indicator	(SDG Indicator) Short Description
		natural elements that enhance fauna abundance				
4	Endogeneity	Presence of non-native invasive species	[14,15,20, 22,25–27]		-	-
5	Continuity of water and sediment flux	Erosion, sediment traps, amount of sediment captured	[14,15,20, 22,25–27]		15.3.1	Degraded areas
6	Water quality	Nitrates, phosphorus, and suspended sediments, water discharge	[14,15,20, 22,25–27]		6.3.2	Water quality
7	CO2 emissions	CO2 captured by the vegetation/natural elements used	[14,15,20, 22,25–27]		9.4.1	CO2 emissions
8	Extent of water-related ecosystems	Spatial extent of the water-related ecosystem since the NBSs' implementation	[14,15,20, 22,25–27]		6.6.1	Extent of water-related ecosystems
9	Well-being	Mortality rate, numbers of people affected by water pollution, air pollution, flooding	[14,15,20, 22,25–27]	Society	1.5.1/ 13.1.1/ 11.5.1 3.9.1 3.9.2	Casualties due to disasters Air pollution mortality Unsafe water mortality
10	Physical and mental health	People frequently using the NBSs area	[14,15,20, 22,25–27]		-	-
11	Cultural heritage/educational value	Protected or (newly) created value by the intervention	[14,15,20, 22,25–27]		12.8.1	Education for sustainability
12	Recreation/leisure value	(New) walking/running/biking paths, activities	[14,15,20, 22,25–27]		11.7.1	Use of public areas
13	Enhance attractiveness	Improvement of 'spatial quality', accessibility of the area, number of tourists (tourist accommodation)	[14,15,20, 22,25–27]		11.7.1	Use of public areas
14	Exploitation	A measure of Net Present Value from the stakeholders' perspective, e.g., income per exploitation activity (irrigation, recreation, cattle farming, agriculture, tourists)	[14,15,20, 22,25–27]	Economy	8.1.1 8.2.1 8.9.1	Economic growth per capita Economic growth per employed person Economic growth due to tourists
15	Investment	A measure of Net Present Value from the intervention's perspective,	[14,15,20, 22,25–27]	Economy	8.4.2/ 12.2.2	Domestic material consumption per GDP

#	Fluvial Flooding Indicator	(Fluvial Flooding Indicator) General Description	Ref.	Dimension	Relevant SDG Indicator	(SDG Indicator) Short Description
		e.g., less money spent compared to a traditional measure			9.5.1 11.4.1	Research and development expenditure Expenditure on culture and heritage
16	Employment	Additional jobs created (pruning of trees, mowing, renting canoes, selling local growing products)	[14,15,20, 22,25–27]		8.3.1 8.5.2	Employment/ Unemployment rates
17	Value of flood damage avoided	Value of assets that would have been destroyed in case of flood avoided relocation	[14,15,20, 22,25–27]		1.5.2 11.5.2	GDP economic losses due to flooding disasters Damages to infrastructure and services
18	Maintenance	Money spent for maintenance	[28–47]		-	-
19	Flood protection	Attenuation of the flood due to the natural components of the intervention, delay of the travel time of the peak flow	[14,15,20, 22,25–27]		-	-
20	Structural integrity	Proof of structural stability whilst using natural materials	[54]		-	-
21	Reliability	Repairs or replacements needed since construction	[54]		-	-
22	Ease of implementation	Availability (and use) of resources and materials available on site	[54]	Technical	8.4.2/ 12.2.2 12.1.1	Domestic material consumption Sustainable production and consumption plans
23	Adaptability	Future changes in function	[54]		11.a.1 13.2.1	Development plans accounting for future projections Climate adaptation plans and strategies
24	Resilience	Whether another major intervention will be needed in due course (long-term perspective with respect to safety)	[54]		-	-

#	Fluvial Flooding Indicator	(Fluvial Flooding Indicator) General Description	Ref.	Dimension	Relevant SDG Indicator	(SDG Indicator) Short Description
25	Different stakeholders/disciplines involved	Different stakeholders/disciplines involved	[14,15,20,22,25–27]	Policy—Procedural	11.3.2	Public engagement strategies
					12.7.1	Sustainable action plans
26	Planning/participatory processes	Types of participatory/planning process used: top-down/bottom-up, formal/informal rule-oriented, trust-based, consultation processes, collaborative learning, learning by performing, workshops, meetings	[14,15,20,22,25–27]	Policy—Procedural	6.b.1	Community engagement
					12.7.1	Sustainable action plans
27	Hierarchy relations (e.g., communication, transparency)	Gap between local stakeholders and projects managers/central bosses (committed and accessible project managers)	[28–47]	Policy—Procedural	-	-
28	Environmental agendas, frameworks, directives	Different legislations that need to be considered: assessments, (water, floods, birds) directives, Natura 2000	[14,15,20,22,25–27]	Policy—Procedural	1.5.3/ 11.b.1/ 13.1.2	Strategies in line with Sendai
					1.5.4/ 11.b.2/ 13.1.3	Alignment of local and national strategies
					15.8.1	Policies for invasive alien species
29	Integrated water resources management	Newly added dimension indicator to cover the relevant SDG indicator	[4]	Policy—Procedural	6.5.1	Integrated water resources management
30	Transboundary water cooperation	Newly added dimension indicator to cover the relevant SDG indicator	[4]	Policy—Procedural	6.5.2	Transboundary water cooperation
31	Capacity-building for development actions	Newly added dimension indicator to cover the relevant SDG indicator	[4]	Policy—Procedural	13.3.2	Technology knowledge, transfer, and development in countries
32	Sharing of benefits	Newly added dimension indicator to cover the relevant SDG indicator	[4]	Policy—Procedural	15.6.1	Policies for sharing of benefits
33	Aichi biodiversity target 2	Newly added dimension indicator to cover the relevant SDG indicator	[4]	Policy—Procedural	15.9.1	Aichi Biodiversity target 2
34	Conservation of biodiversity and ecosystems	Newly added dimension indicator to cover the relevant SDG indicator	[4]	Policy—Procedural	15.a.1	Use and conservation of biodiversity and ecosystems
35	Expectations-outcomes alignment	Alignment of project aims with the expectations of stakeholders and	[28–47]	Policy—Procedural	-	-

#	Fluvial Flooding Indicator	(Fluvial Flooding Indicator) General Description	Ref.	Dimension	Relevant SDG Indicator	(SDG Indicator) Short Description
		with the outputs and outcomes delivered				
36	Long-term data consistency	Existence and/or maintenance of databases relevant to the project info	[14,15,20,22,25–27]		-	-
37	Raising and sharing nbss awareness	Virtual visits on respective sites/forums, publications in social media, citations/newspapers, public consultations about how the people feel after the completion of the intervention (public engagement meeting)	[14,15,20,22,25–27]		-	-
38	Promoting collaboration	Coalition and partnerships formed and sustained	[14,15,20,22,25–27]		17.14.1 17.17.1	Mechanisms for sustainable development Partnerships
39	Sustainability reporting	Newly added dimension indicator to cover the relevant SDG indicator	[4]		12.6.1	Sustainability reports by companies
40	Climate-related support	Newly added dimension indicator to cover the relevant SDG indicator	[4]		13.b.1	Support for climate-related actions
41	(Types of) cooperation between countries	Newly added dimension indicator to cover the relevant SDG indicator	[4]		17.6.1	Cooperation between countries
42	Country-owned resources	Newly added dimension indicator to cover the relevant SDG indicator	[4]		17.15.1	Use country-owned resources
43	Progress in SDGs	Newly added dimension indicator to cover the relevant SDG indicator	[4]		17.16.1	Reporting progress in SDG
44	Production of national indicators	Newly added dimension indicator to cover the relevant SDG indicator	[4]		17.18.1	Production of SD indicators per country

3.4. Case Study: The Eddleston Water Project

The Eddleston Water Project was selected as a representative case study to test the use of the fluvial flooding indicators. Importantly for our assessment, the Eddleston Water Project adopts a multi-benefit approach to the use of NBSs aiming at (i) exploring whether flood risk can be reduced by means of NBSs, (ii) the use of NBSs for improving the ecological condition of the river, and (iii) working with landowners and communities to maintain and enhance sustainable land management practices and farm businesses. Furthermore, since the measures were implemented in 2013, preliminary outcomes from the monitoring campaigns are already available. Finally, it is also part of the EU North Sea Region (NSR) Interreg Building with Nature (BwN) program (https://northsearegion.eu/building-with-nature/), providing good links with experts if further consultation was needed.

The details of the Eddleston Water Project are summarized in the first column of Figure 4. A full description is available on the project website (https://tweedforum.org/our-work/projects/the-eddleston-water-project/). The Eddleston Water Project started as a learning-by-doing project, which is successfully evolving and revealing valuable insights as to how a catchment approach reduces flood risk, involving both structural measures and natural flood management (NFM), and may help improve resilience to climate change. A key element throughout the project has been close stakeholder consultation because uptake of NBSs measures is voluntary, and all the locations for NBSs measures within the project catchment are privately owned. Local land managers and the wider community had been engaged from the very beginning of the project, and these and other stakeholders are still actively involved through regular meetings and surveys, ensuring productive continuation and uptake of the project.

The present year (2021) was the end of the 5 years of matched funding for the Eddleston Water Project from the EU NSR Interreg BwN program. The Interreg program focused on assessing the costs and benefits of implementing NFM through improved monitoring and modeling. With ongoing support for the current phase (2021–2024) from the Scottish Government, and the participation of local farmers and landowners, the study continues with the implementation of different types of NFM measures across the catchment, alongside detailed hydrological and ecological monitoring. Some of the headline outcomes from the Eddleston Water Project so far are summarized in the second column of Figure 4. For a more extended description of the project, reference is made to the Eddleston Water Project Report [55]; to the paper on flood risk reduction [56]; and to the Tweed Forum website (see above) where all the reports, including those from the Building with Nature program, are made publicly available.

Eddleston Water

Location: Scottish Borders

River Characteristics: tributary of the River Tweed, about 18km long, flowing south and joining the main river at Peebles town

Catchment Characteristics: c. 70 km², small size that favors an integrated hillslope to floodplain natural flood risk management approach

Examined period of the project: 2010-2021, from the production of the Scoping Study (2010) up to the end of the Building with Nature phase

Current project state: More measures implemented, monitoring and evaluation carried out with the support from the EU NSR Interreg program and now by Scottish Government.

Measures:
- 207 ha of native tree planting in the headwaters
- 116 features of large woody in-stream structures
- 29 off-line ponds (wetlands)
- 2.9 km reach re-meandering

Outcomes of the measures implemented to date
- The installation of woody debris dams, ponds and riparian tree planting in the headwaters has a significant effect on delaying flood peaks by some 3-7 hours, and the flood peak in the upper catchment has reduced by c.30% post-implementation of these measures
- Soil infiltration rates are 6-8 times more effective underneath old native woodland compared to adjacent pasture, and also much greater than under conifer plantations
- The morphological diversity (pool, riffles, etc.) of the river channel has increased markedly since the historically straightened and channelized river was re-meandered
- The assemblage of aquatic invertebrates has increased in number and diversity since restoration, reflecting the increase in habitat variety and extent in the channel
- The numbers of fish have increased in line with the increase in channel length (average 30% increase)
- A cost benefits analysis showed that the Net Present Value of flood damages avoided in downstream communities was just under £1 million, whilst the complementary wider benefits of these NFM measures from improvements to carbon management, biodiversity, water quality and recreation amounted to another £4.2 million
- Working with local farmers and the community was essential to achieving sustainable benefits for all

Figure 4. Eddleston Water Project key information. Photos of the Lake Wood site, Eddleston Water Project: the previously straightened reach (top photo), the site immediately after the completion of the re-meandering works (middle photo), and the site one year after the completion of the re-meandering works with small consecutive floodplain ponds and the new re-meandered reach (bottom photo). All were retrieved from the Tweed Forum website.

3.5. Step IV—Assessment of the Fluvial Flooding Indicators Based on Project Metadata

To assess the utility and effectiveness of the fluvial flooding indicators, they were applied to the Eddleston Water Project to examine its sustainability performance in terms of:

- Whether the Eddleston Water Project contributes to the attainment of the SDGs, and, if so;
- To which SDGs;
- How and why.

The application was performed with input metadata from the Eddleston Water Project to the fluvial flooding indicators. The metadata for the Eddleston Water Project in Table 4 were collected from the Project Reports and [56–59]. The output of the evaluation is presented in Table 4, with three columns and the following format: each fluvial flooding indicator (Column I) contributes to none/one/or more SDGs and SDG targets (Columns II and III) as justified by the Eddleston Water Project metadata (Column IV). The contribution of the Eddleston Water Project to the UN 2030 Agenda is presented in Table 4 in terms of SDGs because this is more practical and easier to remember as a take-home message. However, by referring back to Table 3, it is possible to see the derivation and connection between the relevant SDG targets and respective SDG indicators. For instance, in Table 4, it can be seen that the Eddleston Water Project contributes to SDG 15 and SDG target 15.1, as assessed by the biodiversity abundance (fluvial flooding) indicator according to available project metadata. By referring back to Table 3 and the biodiversity abundance indicator (#1), it can be seen that the Eddleston Water Project contributes to SDG indicator 15.1.2. Therefore, the Eddleston Water Project contributes to the SDG indicator 15.1.2, SDG target 15.1, and SDG 15 of the UN 2030 Agenda in terms of biodiversity abundance.

Table 4. Contribution of the Eddleston Water Project to the relevant SDGs and SDG targets (second, third column), examined per fluvial flooding indicator (first column) according to Eddleston Water Project's metadata (fourth column). Divisions are according to the dimensions, as in Table 3.

#	Fluvial Flooding Indicator	Contribution to SDGs	SDG Targets	Eddleston Project Metadata
1	Biodiversity abundance	15	15.1	EU Special Area of Conservation (SAC) for its salmon, lampreys, otters, and aquatic plants Macroinvertebrate: a rapid recolonization of re-meandered channels by aquatic macroinvertebrates. Species richness and diversity increased post-restoration Salmonids: Eddleston is important for breeding salmon and as a nursery habitat. Improved salmonid habitat due to restorations in terms of the provision of suitable micro habitat and overall physical diversity. Total available habitat area increased due to the increased channel length and width
2	Wildlife habitat	15	15.5	An increase in overall physical diversity of habitats within re-meandered sections and an increase in habitat area, both greater where there has been a greater degree of re-meandering
3	Population viability	15	15.5	Potential increase in the number and extent of spawning habitats for salmon, as indicated by changes in the spatial distribution of favored micro-habitats for salmonids
4	Continuity of water and sediment	15	15.3	Morphological units: generally, there is much greater morphological diversity through the reach because of restoration, with the most significant change happening at the Lakewood reach with the biggest increase in length (re-meandering). Generally, restoration has resulted in much more diverse channel morphology, with all morphological unit types present in 2015/2016 compared to only three in 2009 Grain size per geomorphic unit: following restoration, the overall grain size and variation was seen to decrease, with units post-restoration being better sorted and grain sizes more distinctive and specific per geomorphic unit
5	Water quality	-	-	Water quality is generally good in Eddleston, apart from some isolated incidents of diffuse organic pollution and increased nitrate levels in recent decades. Generally, it was not an objective, aim, or constraint of the project (Spray et al., 2017)
6	CO2 emissions	9	9.4	Tree planting reduces carbon; however, no specific measurements were taken because it is not a key project issue. However, more research is currently being completed in this direction
7	Extent of water-related ecosystems	6	6.6	Re-meandering (approximately 3 km): the new courses increase the existing individual lengths of channel by between 8% and 56%, reducing the gradient and adding some 300 m (approximately 3000 m^2) of new in-channel habitat
8	Well-being	1, 11, 13	1.5, 11.5, 13.1	Modeling from SEPA (SEPA's flood risk assessments) shows 521 properties in Peebles, 61 in Eddleston, and 7 rural dwellings are at risk from a 1:200 year flood event. To date, catchment communities escaped the 2015/2016 and late 2016 winter floods
9	Cultural heritage/educational value	12	12.8	The project works as a living laboratory, open to public and to schools for raising awareness of flooding in the area and encouraging pupils and teachers to take an active part in the project and learn about their catchment. Additionally, interpretation boards enhance the commercial use of the area. Finally, as a publicly funded Research Platform, the river is the location

#	Fluvial Flooding Indicator	Contribution to SDGs	SDG Targets	Eddleston Project Metadata
				for many research projects from universities and academic institutions
10	Recreation/leisure value	11	11.7	Soon, a multi-use track (biking, walking) will be constructed on the old railway line, which will attract even more people for recreation
11	Enhance attractiveness	11	11.7	Interpretation boards to be produced along this new path will improve the recreational side of the Eddleston
12	Exploitation	8	8.1, 8.2, 8.9	Full details of the economic costs and benefits of the implementation of NBSs measures have been analyzed as they impact farm income and profitability in the case study area based on land use data, agricultural and environmental support subsidies, and foregone farm income The salmon fishery of the Tweed is worth a total of over 24 million GBP a year to the local economy and supports over 500 jobs, so any improvement to fish habitat is important. Although salmon fishing is predominantly on the main Tweed River, Eddleston Water and similar tributaries are vital as breeding and nursery locations for salmon
13	Investment	8, 9,11,12	8.4, 9.5, 11.4, 12.2	Modeling for a range of climate change scenarios shows a positive net present value from NFM tree planting, indicating that the riparian woodland is worth implementing. Annual benefits of c. 80 k GBP per year were estimated, with a high average benefit–cost ratio for the riparian woodland, though full benefits will not be realized for some 15 years after implementation Direct measurements on the ground of the value of a range of ecosystem services/multiple benefits already delivered as part of the NFM measures is an additional GBP 4.2 million Net Present Value (NPV) over and above the NPV from flood damages avoided (GBP 950 k) from the implementation of the same measures. The total cost of physical works amounts to GBP 1.3 million across 20 different landholdings, with the majority of that attributed to river and pond excavations, fencing, and planting. Monitoring and evaluation have cost some GBP 925 k on top of that
14	Employment	-	-	No additional jobs created yet. Maybe some slight vegetation management, but nothing bigger. If the track is realized, then it is possible that there will be more additional jobs (such as renting bicycles)
15	Value of reduced flood damage	1, 11	1.5, 11.5	The value of flood damages avoided by the current NFM features is GBP 950 k Net Present Value (100 years) The value of other ecosystem services/multiple benefits delivered as part of the NFM measures is an additional GBP 4.2 million NPV over and above the NPV from flood damages avoided (GBP 950 k) from the implementation of the same measures
16	Implementability	8, 12	8.4, 12.1, 12.2	Where possible, interventions are made of local timber from recently felled trees in the forest. An exception was for the rocks protecting the meander where it approaches the road, which were imported Large woody structures: on the Middle Burn, nearby conifers were felled and pinned across the channel Woodland and riparian woodland planting with native trees: species included oak, ash, willow, birch, aspen, and hazel
17	Adaptability	11, 13	11.a, 13.2	Although measures put in are seen as permanent, they are all subject to natural ecological and hydrological processes, and thus they will eventually need replacement. Potential change in the land of the area must be feasible, and project managers must be willing to facilitate and work with the landowners for land-use changes
18	Different stakeholders/disciplines involved	11, 12	11.3, 12.7	Landowners are key, and to date, 25 farmers and landowners have been involved, and 19 have hosted measures on their

#	Fluvial Flooding Indicator	Contribution to SDGs	SDG Targets	Eddleston Project Metadata
				land. The Tweed Forum acts as project managers with Scottish Government, SEPA, Scottish Borders Council, Dundee University, and British Geological Survey. Others include Peebles Community Council, Forest Commission Scotland, Environment Agency, Scottish Natural Heritage, and National Farmers Union (Scotland)
19	Planning/participatory processes	6, 12	6.b, 12.7	Shared policy development and implementation: as a 'Trusted Intermediary', Tweed Forum spent significant time and effort informing and engaging with the local community and landowners in framing the project prior to implementation; regular meetings and presentations with the Peebles Community Council; interviews with landowners; leaflet to locals outlining and explaining aims of the project before the start of it; hands-on participatory engagement at local shows; questionnaire survey for the implemented measures
20	Environmental agendas, frameworks, directives	1, 11, 13	1.5, 11.b, 13.1	Tweed EU Special Area of Conservation (SAC); Water Environment and Water Services (Scotland) Act 2003; Flood Risk Management (Scotland) Act 2009; Eddleston Water forms part of the River Tweed, which has been designated as a HELP basin following the UNESCO program; Scottish Rural Development Programme (SRDP) scheme
21	Integrated water resources management	6	6.5	The Eddleston Project adopted an integrated catchment approach across all aspects of water resource management since this underpins the project approach to address the 'sources—pathways and receptors' contributing to flood risks
22	Transboundary water cooperation	-	-	Not a transboundary water project
23	Capacity-building for development actions	13	13.3	Eddleston is a small catchment where a specialized focus and strengthening of locals' interest and involvement was needed for the realization of the project. This was achieved through participatory processes and engagement strategies
24	Sharing of benefits	15	15.6	Participatory processes and engagement strategies were a way of ensuring equitable share of benefits over the sectors considered in the project, including recognition of potential impacts of NBSs on farm businesses
25	Aichi biodiversity target 2	15	15.9	Monitoring campaigns are running, aiming at evaluating the effect of the measures on biodiversity and hydro-morphology, creating evidence for strengthening biodiversity strategies
26	Conservation of biodiversity and ecosystems	15	15.a	Monitoring campaigns are running, aiming at evaluating the outputs of the measures on biodiversity and ecosystems
27	Promoting collaboration	17	17.14, 17.17	Generally, a partnership approach has been followed, and Tweed Forum has brought together the landowners, the community, and the project experts
28	Sustainability reporting	-	-	No sustainability reports by companies
29	Climate-related support	-	-	No climate-related support. Currently, more research is being carried out to examine the effects of the interventions on climate change projections
30	(Types of) cooperation between countries	-	-	No cooperation between countries in the beginning. Many countries were involved when the project became part of the Interreg North Sea Region Program
31	Country-owned resources	17	17.15	The Eddleston Project Managers are Tweed Forum, and they, along with Scottish Government and SEPA and the main science provider, Dundee University, are all based in Scotland, and thus the project was generated and developed by country-owned institutions before attracting wider interest
,32	Progress in SDGs	17	17.16	Very detailed and wide-ranging monitoring campaigns are running, aiming at evaluating the outcomes of the measures on multiple sectors and thus progress on SDGs
33	Production of national indicators	-	-	No production of SDG indicators

Overall, the Eddleston Water Project contributes to 9 SDGs: 1, 6, 8, 9, 11, 12, 13, 15, and 17, and to 33 SDG targets, as can be seen graphically in Figure 5. Figure 5 complements Table 4 since it shows all the relevant SDGs and SDG targets (as established from Step II). The SDG targets in bold black color are the ones that the Eddleston Water Project contributes to, while in red, the ones that it does not. We showed that the Sustainability Performance Evaluation Framework follows a systematic methodology that allows to identify the interactions of the Eddleston Water Project within the five dimensions and define fluvial flooding indicators, which showed the Eddleston Water Project's contribution to the UN 2030 Agenda. Table 5 presents the Eddleston Water Project's SDGs under their respective dimensions. As expected, most of the Eddleston Water Project's SDGs contribute to multiple dimensions at the same time due to the repetition of some of the SDG indicators under several SDG targets.

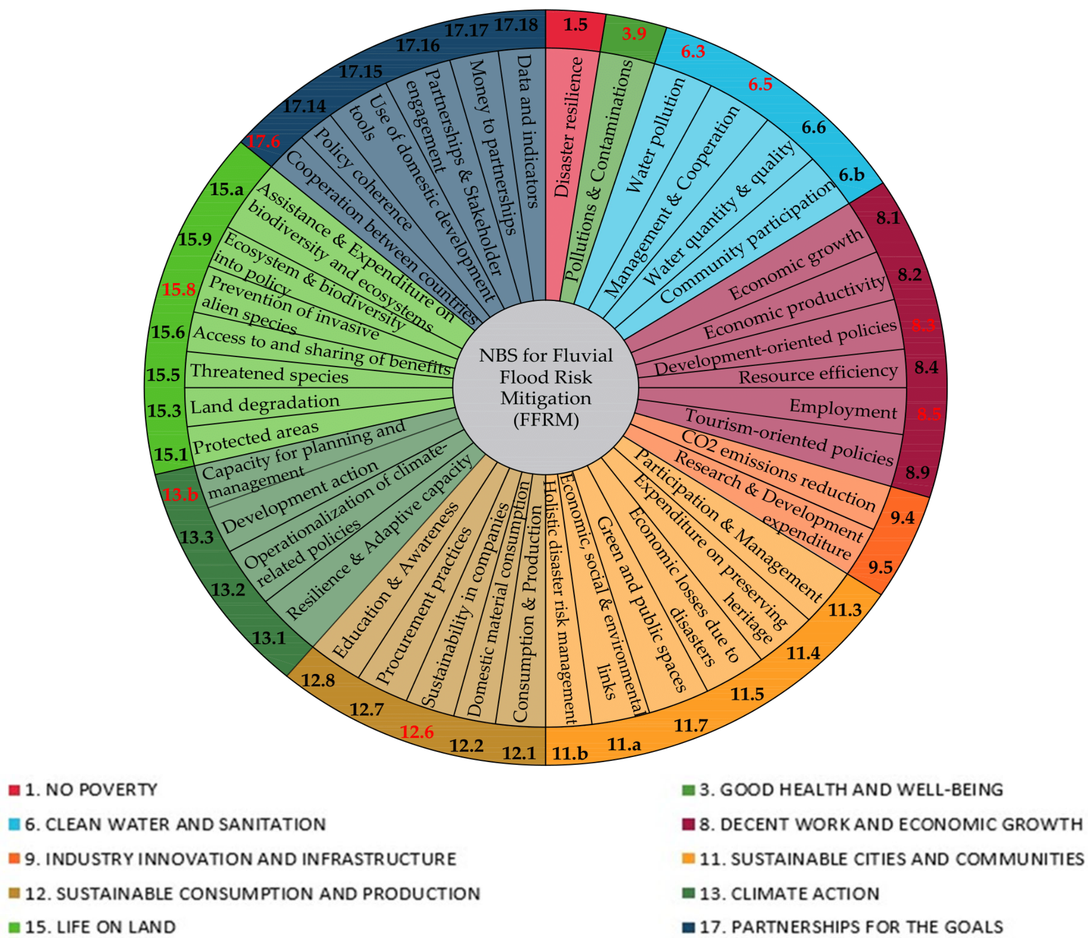

Figure 5. NBSs for FFRM could address 10 SDGs (legend) and 42 SDG targets (circle), as set by the UN 2030 Agenda. The framework application to the Eddleston Water Project revealed that the Eddleston contributes to 9 out of these 10 SDGs (not to the third) and to 33 SDG targets (not to the ones in bold red color in the outer circle).

Table 5. The Eddleston Water Project's SDGs under their respective dimension.

Dimension	Policy—Procedural	Economy	Society	Environment	Technical
Sustainable Development Goals	SDG 1	SDG 1	SDG 1	SDG 6	SDG 8
	SDG 11	SDG 11	SDG 11	SDG 9	SDG 12
	SDG 13	SDG 8	SDG 13	SDG 15	SDG 13
	SDG 6	SDG 9	SDG 12		SDG 11
	SDG 12				
	SDG 17				

4. Discussion

4.1. Regarding the Framework Itself: From Structure To Output

The Sustainability Performance Evaluation Framework was developed from literature review, insights from three case studies, and then applied to one independent case study. On the one hand, this enabled us to assess the performance of the fluvial flooding indicators in depth, as we tried to find and access metadata for each fluvial flooding indicator. On the other hand, application to more case studies would have provided more insights that could extend or alter the NBSs–SDG coupling. For instance, the research showed that SDG seven, which assesses energy resources, could potentially be linked to the fluvial flooding indicators. More specifically, the Noordwaard polder project provided some clues about energy production from biomass, but the other case studies did not (https://www.ecoshape.org/en/cases/wave-attenuating-willow-forest-noordwaard-nl/), and thus SDG seven was not included in the link between NBSs and SDGs. A broader case study examination will provide further insights regarding the potential of energy production in NBSs for FFRM interventions.

For data-dependant frameworks, such as the Sustainability Performance Evaluation Framework, data accessibility and/or method availability are key factors. Literature indicators such as 'population viability', although meaningful in the context of NBSs, are difficult to measure in practice. Similarly, within the Tier Classification for the Global SDG Indicators [60], Tier three includes the need for new or re-examination of existing measuring methods. Shah et al. [12] recognize the need for making the level of information even more local and specific alongside primary data collection for local NBSs or their indicators. From a more general point of view, Kumar et al. [10] state that the challenge of inadequate or insufficient data hinders the acceptance, assessment, and potentially successful operationalization of NBSs. Recent studies have addressed this challenge; Schröter et al. [9] provide extensive lists of online data pools on NBSs, and the EC's Handbook for Practitioners [52] devotes a chapter to types of data, data sources, and data generation techniques for NBSs monitoring and impact assessment. Therefore, current sources seem to allow for the effective use of such data-based frameworks while acknowledging the need for new or enhanced measuring methodologies.

The output of the Sustainability Performance Evaluation Framework is qualitative. We acknowledge, however, the potential to extend it to a quantitative one. Quantitative outputs, such as scored evaluation against pre-defined targets, enhance the evidence base of NBSs effectiveness [13]. To date, several studies provide quantitative results regarding effectiveness, co-benefits, and NBSs' sustainability contribution. Schipper et al. [21] provide a methodology for scoring the sustainability performance of coastal management projects using numeric data. Pugliese et al. [19] apply a multi-criteria tool to assess the effectiveness of NBSs for a specific case study compared to a grey alternative. Martín et al. [18] use qualitative analysis of Fuzzy Cognitive Maps (FCM) alongside semi-quantitative analysis of the co-benefits to examine the effectiveness of different NBSs and their co-benefits. Liquete et al. [17] perform an ex-post assessment of the environmental, social, and economic benefits of multi-purpose NBSs for water pollution control based on Multi-

Criteria Analysis (MCA). The proposed framework is used to couple to the SDGs but can (with minor changes) also be used as an independent framework for the ex-post evaluation of individual NBSs projects, as a tool to compare grey–green alternatives for an NBSs project, or even as a tool to compare different NBSs projects. Andrikopoulou [61] describes the development of such a framework. We speculate that application of such a framework to a 'Room for the River' project, where pre-defined targets for the Rhine's conveyance capacity were set (https://www.tandfonline.com/doi/abs/10.1080/02508060508691839), would have resulted in a better understanding regarding the potentials of the Sustainability Performance Evaluation Framework to derive a scored evaluation. A Multi-Criteria Analysis would both bring the framework output closer to reality and better assist decision makers in prioritizing river management options. In this research, flood safety was the primary river function under consideration, while ecosystem development, water quality, and recreation issues were also examined. However, rivers typically have a larger number of functions (e.g., water supply, navigation, water quality, nature development), the importance of which may have greater or lesser weighting at any one time and location, and to different stakeholders, depending on the focus of the project. Therefore, prioritization of the fluvial indicators based on the primary river functions of a specific case would greatly benefit the framework output.

4.2. How Do the Outcomes of Our Framework Relate to Other Relevant Studies?

We have set up a framework to create a set of fluvial flooding indicators to evaluate the ex-post contribution of the Eddleston Water Project to the UN 2030 Agenda. Ligtvoet [2] and Ge et al. [62] have also explored the relationship between rivers and the SDGs. Ge et al. [62] have defined SDGs for river basin scale in terms of water, ecosystems, and socioeconomic capabilities. Ligtvoet [2] has identified those SDGs related to people and the economy that are negatively affected by river flooding.

Framework application to the Eddleston Water Project shows that it contributes to six out of the nine SDGs mentioned in Ligtvoet [2]. In the study of Ligtvoet [2], Ward and Winsemius have identified the negative effects of fluvial flood risk on SDGs 1, 2, 3, 6, 8, 9, 10, 13, and 16 for people and the economy (specifically on agriculture). Although Ward and Winsemius established a broader link (river flood risk and SDGs) than ours (NBSs for FFRM and SDGs), the outcomes of our framework application show that the Eddleston Water Project can ameliorate most of the negatively affected SDGs by river flooding. Exceptions constitute SDGs 2, 10, and 16. SDG two addresses food security issues and agricultural practices, which were considered out of scope for the functions of fluvial flood risk mitigation NBSs considered in this research. SDG 10 refers to the reduction of inequalities between countries in terms of providing the same means of coping with flood risk between high-income, upper-middle, lower-middle and low-income economies. NBSs could address such an aspect; however, it needs examination in a broader context combined with geopolitical considerations. Similarly, SDG 16 talks about justice and inclusivity in societies, which can be promoted as part of the general NBSs conceptual framing but are out of scope for this study. Leaving these aside then, it is apparent that the Eddleston Project positively affects the following 6 SDGs: 1, 3, 6, 8, 9, 13.

The SDGs to which the Eddleston Water Project contributes align with seven out of eight SDGs proposed by Ge et al. [62]. Ge et al. [62] link river basins (e.g., Amazon, Nile, and Heihe river basins) to SDGs in terms of water, ecosystem, socioeconomic, and ability-related issues, and they find all SDGs relevant apart from SDG seven. The water-related SDGs (6, 11, 12, 14) and the ecosystem-related SDGs (14, 15) coincide with the SDGs derived from the present Eddleston Water study, apart from SDG 14 (which was out of scope for the current research context because it focuses on the coastal environment). The socioeconomic-related SDGs were omitted because they focus mostly on food security, justice, and inequalities which, whilst they might be added in other situations, were not within the scope of the impacts of the fluvial NBSs examined for the present research. However, although they were not specifically considered, it could be argued that by including and elaborating on the third aim in the Eddleston Water Project's objectives (working with landowners and communities to maintain and enhance sustainable land management practices and farm businesses), the project contributes to an element of this SDG. The ability-related SDGs (9, 11, 13, 17) coincide with the ones derived from our research because they refer to structural actions and strategies for conserving and protecting the rivers. Hence, SDGs 6, 9, 11, 12, 13, 15, 17 are shared between Ge et al. [62] and the Eddleston Water Project with respect to water, ecosystem, and ability-related issues.

4.3. Standardization and Scale of Sustainability Assessments

As mentioned by Pohle et al. [63], standards, in general, have a twofold role: they can serve as a source of information and enabler for the development and transfer of technology. The EU Research and Innovation program Horizon 2020 has recognized standardization as a measure that underpins innovation since it bridges the gap between research and the market but also facilitates the propagation of research outcomes to the European and international markets [64]. That said, standardization of sustainability assessments could provide harmonization in indicators, reliability and transparency in calculation methods, and comparability of results [65]. To date, standardization for sustainability assessments has already been discussed in the literature [66–68]. Although most of the studies recognize the aforementioned benefits of standardization, they also recognize the risk of compromising agendas, contexts, and needs when treating larger scales. Similarly, in the present study, although the aim was to derive indicators as widely applicable as possible, given the scope of the study, we acknowledge that most of the indicators would need further consideration when used in projects of different scales and contexts. Some of the indicators, e.g., the environmental and technical indicators, could relatively easily be standardized – some with slight amendments—for larger scales. For others, such as the Social, Policy—Procedural, and Economic indicators, this is more difficult because they are geopolitically dependent. For instance, in a transboundary water body apart from the international legislation, the in-between the country-member treaties and arrangements should also be considered. Such a view was out of scope in our research and thus requires further research.

Sustainability assessments should be able to be carried out at any scale. However, the necessary data are not always available or accessible at any scale. For instance, it is likely that the Sustainability Performance Evaluation Framework cannot be applied globally to any NBSs project due to the lack of data. Most of the data collected for such projects either suit national aims, which do not always align with the global SDG indicators, or come from private sources. Therefore, it seems that currently, the main challenge lies in finding adequate, available, and accessible data to upscale the sustainability assessments, and although there is still a lot to accomplish in this direction, the EC's Handbook for Practitioners [52] and Schröter et al. [9] have made promising steps (as discussed in paragraph 4.1).

5. Conclusions

The aim of this study is to propose a ready-to-use methodology to evaluate the sustainability performance of Nature-Based Solutions (NBSs) with respect to the United Nations (UN) 2030 Agenda, involving all its components (i.e., Sustainable Development Goals (SDGs), targets and indicators). This was achieved by building on the Schipper et al. [21] systematic framework and adjusting it to fit our needs. The focus is on NBSs for Fluvial Flood Risk Mitigation (FFRM) in river basins of sizes up to 100 km^2. The derived framework is called the Sustainability Performance Evaluation Framework. It encompasses four steps through which the end-user creates a set of fluvial flooding indicators that can then be linked to the SDG indicators, and by applying the fluvial flooding indicators to a specific FFRM NBSs project, it is possible to ascertain the project's contribution to the UN 2030 Agenda. The Eddleston Water Project was used as a case study to test the effectiveness of the fluvial flooding indicators. Application to the Eddleston Water Project has shown that it contributes to 9 SDGs and 33 SDG targets. In developing the

Sustainability Performance Evaluation Framework and testing its fluvial flooding indicators, the findings are:

1. The Sustainability Performance Evaluation Framework can systematically consider SDG indicators by exploring potential interactions of NBSs for FFRM projects within five chosen dimensions: economy, environment, society, policy, and technical.
2. Through the Sustainability Performance Evaluation Framework, it is possible to adjust the SDG concept to the system of interest and qualitatively measure its alignment with and progress towards the SDGs.
3. Data availability and accessibility play a crucial role in the Sustainability Performance Evaluation Framework. Although potentially challenging in some situations, many NBSs programs and projects have been funded by the European Union (EU) or national governments and agencies, and data are typically available either publicly or upon request.

To further develop the Sustainability Performance Evaluation Framework, a key recommendation is its trial application in other areas and by different end-users. This should focus on three aspects:

- Application to projects where quantified targets pre-exist would help enable the derivation of some form of scored evaluation.
- Application to different case studies in terms of scale, location, and type of measures (e.g., projects in upland rivers and transboundary projects) is suggested.
- Application to case studies in countries with upper-middle, lower-middle, and low-income economies, with different cultural contexts, legal frameworks, governance structures, challenges of environmental justice, and data scarcity would add value. This recommendation, combined with the previous one, would also shed light on the potentials of the proposed indicators to be standardized.
- Application with end-users, stakeholders, or even people unfamiliar with NBSs and SDGs, to examine whether the framework would yield the same indicators and/or the same result regarding the evaluation of the NBSs project (regarding its contribution to the SDGs).

We recognize that the more the framework is reviewed and applied, the more insights will be gained with respect to its biases, limitations, and gaps, including opportunities that could extend or alter the NBSs–SDG coupling.

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Appendix A. Data Availability and Accessibility for the Eddleston Water Project

One of the main reasons for choosing the Eddleston Water Project was the data availability and accessibility. Indeed, most of the fluvial flooding indicators (85%) were filled in with data publicly available online, while only 15% of the indicators needed a project specialist —either to verify data found online or to provide additional information. Expert consultation was needed for the following five fluvial flooding indicators: CO2 emissions, recreation/leisure value, enhance attractiveness, employment, and adaptability. Both qualitative and quantitative data were gathered since not all indicators required a numerical value – for example, those covering the Policy—Procedural dimension. On the contrary, fluvial flooding indicators such as 'well-being' or 'extent of water-related ecosystems' could be filled in with quantitative data.

During the framework application, a few overlaps of the project metadata per fluvial flooding indicator were observed. For example, in looking at the 'recreation/leisure value' and 'enhance attractiveness', similar data were used for both fluvial flooding indicators. Although the attractiveness of the area has been enhanced and it is being used by the public, new plans for a cycleway will further increase its recreational value. To this end, there is a limited extent of data for these two indicators, leading to their current overlap. However, for a case study where all the interventions had been finalized, these two indicators might provide different information.

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