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Using standards for coastal nature-based solutions in climate commitments: Applying the IUCN Global Standard to the case of Pacific Small Island Developing States

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ABSTRACT

Coastal nature-based solutions (NbS) are increasingly recognized for their multiple benefits to socio-ecological systems, including climate mitigation and adaptation (e.g. conservation, restoration and sustainable management of coastal ecosystems for climate). National climate plans, such as the Nationally Determined Contributions (NDCs) developed under the Paris Agreement, include coastal NbS as a practical and effective action to help countries achieve their climate and biodiversity targets. However, the absence of a standardized NDC structure and the lack of guidance about how NbS should be included in NDCs can hinder access to external funding for developing countries and prevent transparent reporting on progress at the international level. In this context, our aim is to understand how coastal NbS are currently included in NDCs by evaluating their alignment with the IUCN Global Standard for NbS. Our analysis focuses on the description of coastal NbS in the NDCs of Pacific Small Island Developing States (PSIDS), as they are among the most vulnerable countries to the impacts of climate change. Overall, we find that, for the 22 coastal NbS examined in the NDCs of PSIDS, the degree of alignment with the eight criteria of the IUCN Global Standard is insufficient or partial, with slightly better alignment with the standard in revised NDCs than in original NDCs. We discuss opportunities provided by the standardization of the description of coastal NbS in NDCs, in terms of access to funding and stock taking to monitor the effectiveness of implementation and progress towards long-term goals. We also discuss the relevance of using the IUCN Global Standard for reporting on NbS in NDCs for PSIDS.

1. Introduction

Climate change and environmental degradation are two main challenges of our time, threatening human health and exacerbating development inequalities [35]. In the face of dual climate and biodiversity emergencies, the scientific and policy communities recognize and stress the need for urgent measures and for addressing these dual crises in an integrated manner in order to reduce their causes and avoid maladaptation [9,23,24,35,37].

Nature-based solutions (NbS) have been recognized as a valuable tool to jointly tackle these challenges [23]. NbS are defined by the International Union for Conservation of Nature (IUCN) as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" [7]. Well-designed NbS help to reinforce synergies between the 17 Sustainable Development Goals of the United Nations [6], while being in many contexts low-cost options compared to engineered solutions (Gattuso et al., [22,27,39]). In particular, coastal NbS (i.e., solutions based on coastal ecosystems, such as mangrove restoration) can help reduce climate change impacts, such as coastal erosion and flooding, while mitigating its causes [23]. For example, carbon sequestration rates

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in the sediments of coastal ecosystems such as mangroves and seagrasses can be up to ten times higher than those of terrestrial ecosystems [10].

Today, more than 90 countries worldwide have signed the Leaders Pledge for Nature, a commitment to take urgent action to address biodiversity loss, and in doing so have committed to scaling up the adoption of NbS. Even more countries have committed to use NbS in their revised Nationally Determined Contributions (NDCs) – the national climate plans developed under the Paris Agreement to limit global temperature rise to 1.5 °C by 2100 and enhance adaptation [28,40,41,47].

However, the growing use of the NbS concept by scientists and practitioners raises concerns about its potential misuses and implementation constraints [5,39]. For instance, Gann et al. [14] pointed out that many restoration projects and programs for climate and nature have underperformed. In particular, the effectiveness of NbS in delivering climate change mitigation and adaptation outcomes, while sustaining natural ecosystems and other ecosystem services, can be hampered by difficulties in measuring their effectiveness, mobilizing funding for their implementation, and overcoming governance challenges [39]. The Global Standard for NbS was developed by IUCN to address these difficulties, and to ensure that the NbS concept is clearly described, understood, implemented and communicated so that NbS deliver their intended outcomes [25]. The standard was developed based on research and public consultations. It is composed of eight criteria and accompanying indicators to guide practitioners in designing effective NbS [25].

As a global standard, it is important to ensure that coastal NbS are appropriately considered in climate commitments such as NDCs [13]. However, there is currently no NDC[1] standards or templates about their format or substance, indicating which elements should be included into NDCs and how. The lack of NDC standardization and clear guidelines on how actions (including NbS) can be incorporated in NDCs results in a wide variety of NDC formats and contents, which makes it difficult to aggregate, compare and monitor commitments. This compromises the success of the global stocktake mandated by the Paris Agreement to take stock of progress at the global scale [19]. Previous studies have also focused on assessing the presence of ocean-related issues in climate plans through quantitative analysis (e.g., [13]), but none, to our knowledge, have assessed how coastal NbS have been included in climate plans with regards to standards and best practice principles.

Our work aims to understand how coastal NbS are included in the NDCs of Pacific Small Island Developing States (PSIDS) relative to the IUCN Global Standard for NbS. We focus on solutions that aim to protect, restore and sustainably manage coastal ecosystems (i.e. coastal NbS) in PSIDS, for the following reasons. First, coastal zones are among the most vulnerable areas to climate change [4]. Second, the potential of coastal NbS is still largely under-exploited in national climate strategies [15]. Lastly, PSIDS are among the most vulnerable countries to the impacts of climate change [4], and highly dependent on coastal ecosystems for livelihoods and income [2,18,20,42,43,49].

In what follows, we first present the methods and results to assess the alignment of coastal NbS with the IUCN Global Standard for NbS based on information available in NDCs, and identify gaps in adherence. We then discuss two areas where a standardized description of NbS in NDCs might support action: mobilizing funds and tracking progress. These are two of the main challenges identified by Seddon et al. [40] for increasing the potential of NbS. Finally, we discuss the applicability of the IUCN Global Standard for NbS, and the relevance of standardization more generally, for NbS in PSIDS NDCs.

[1] Note that, in this paper, the term NDC often refers to the official written document describing the nationally determined contribution of a country (rather than the commitments themselves).

2. Materials and method

2.1. Scope of the analysis

There are several standards for protecting nature, such as the Open Standards for the Practice of Conservation developed by the Conservation Measures Partnership, or the Green List of Protected and Conserved Areas (GLPCA) developed by IUCN. A number of studies have also proposed evaluation frameworks for NbS [3] (e.g., in [31]), but robust frameworks that assess NbS multifunctionality are lacking [11]. To analyse how coastal NbS are currently included in NDCs, we chose to focus on the IUCN Global Standard for NbS because it aims to provide an holistic framework to assess NbS, building on previous published standards that focused more on specific management methods (e.g., conservation, in the case of the Open Standards and the GLPCA) or specific societal challenges (e.g., flood reduction in the case of [31]).

In the NDCs of PSIDS, coastal NbS mostly refer to the protection, restoration and sustainable management of mangroves, seagrasses and coral reefs, which are emblematic ecosystems in PSIDS providing valuable site-specific services and products [17,21], as well as to the community-based sustainable management of coastal fisheries. Our study covers all the PSIDS, across Melanesia, Micronesia and Polynesia (Fig. 1). PSIDS correspond to the fifteen independent countries of the Pacific Ocean that are members of the Alliance of Small Island States, an intergovernmental organization of coastal and small island countries established in 1990. While NbS for climate are typically addressed by PSIDS in a wide range of national policy instruments (e.g., national ocean policies, national biodiversity plans, national communications under the UNFCCC), we chose to focus on NDCs because these plans represent an umbrella policy for countries to account for their climate action on the international stage. Another motivation for focusing on NDCs specifically was the opportunity provided by the upcoming global stocktake mandated under the Paris Agreement to track global progress towards achieving its long-term goals. The first cycle of NDC submissions by countries occurred between 2015 and 2017 (original NDCs). The Paris Agreement mandates that NDCs must be revised regularly in a five-year cycle with increased ambition [33]. The 31st of October 2021 was the deadline for countries to submit their revised[2] NDCs to the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), corresponding to the beginning of the 26th Conference of Parties on climate change in Glasgow. Our analyses considered all the PSIDS NDCs released by the UNFCCC secretariat as of 31st of October 2021 (15 original NDCs and 9 revised NDCs).

2.2. Method description

The methodology is composed of three related steps (Fig. 2): 1) the identification of coastal nature-based solutions, 2) the development of a semi-quantitative assessment of indicators' alignment with the IUCN Standard, and 3) the calculation of an overall match score. Each step is described in detail in the following sub-sections.

2.2.1. Step 1: identification of coastal nature-based solutions

The first step consisted of identifying and categorizing the coastal NbS in the NDCs of PSIDS. We used the typology created by Gattuso et al. [16], which allows the definition and classification of solutions based on the ocean to address climate change issues. To adapt Gattuso's classification to our study context, we focused on four categories that are relevant to coastal NbS (Table 1). Category A refers to the conservation, restoration, and sustainable management of coastal vegetation for mitigation, with coastal vegetation referring to seagrasses and

[2] In this paper, we will use the term « revised » to refer to both new and updated NDCs. Original NDCs were submitted in 2015-2017 whereas revised NDCs were submitted in 2018-2021.

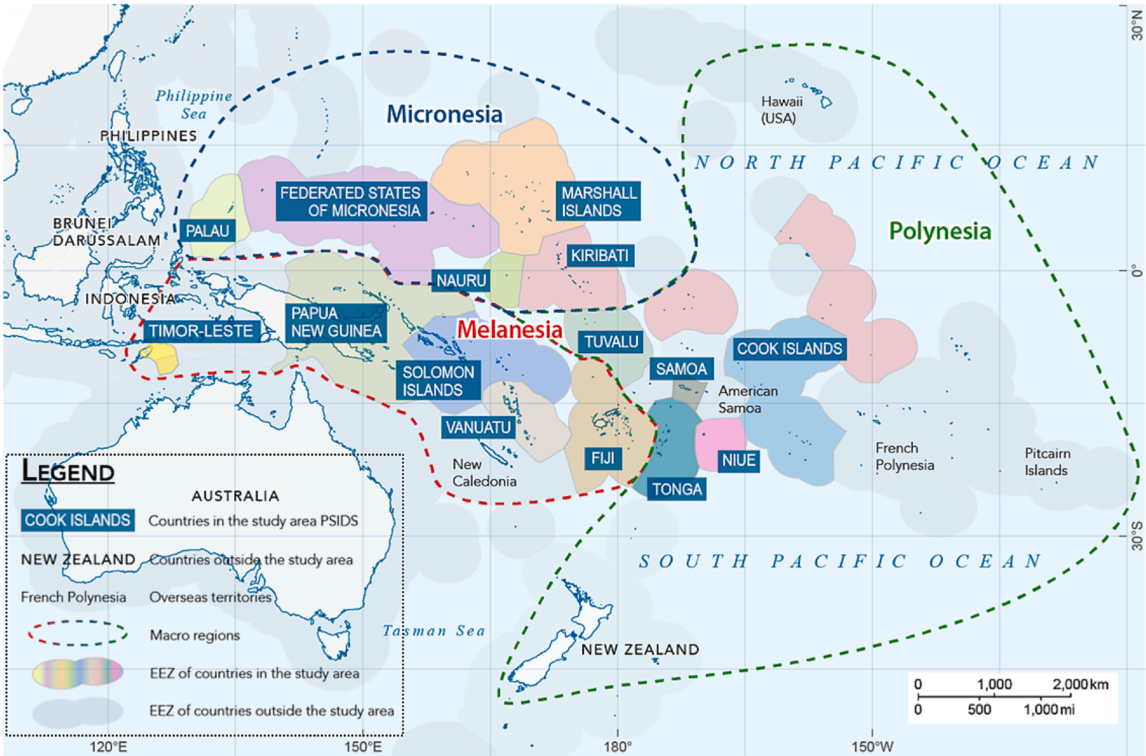

Fig. 1. The fifteen Pacific Small Island Developing States, their exclusive economic zones and the macro-regions.

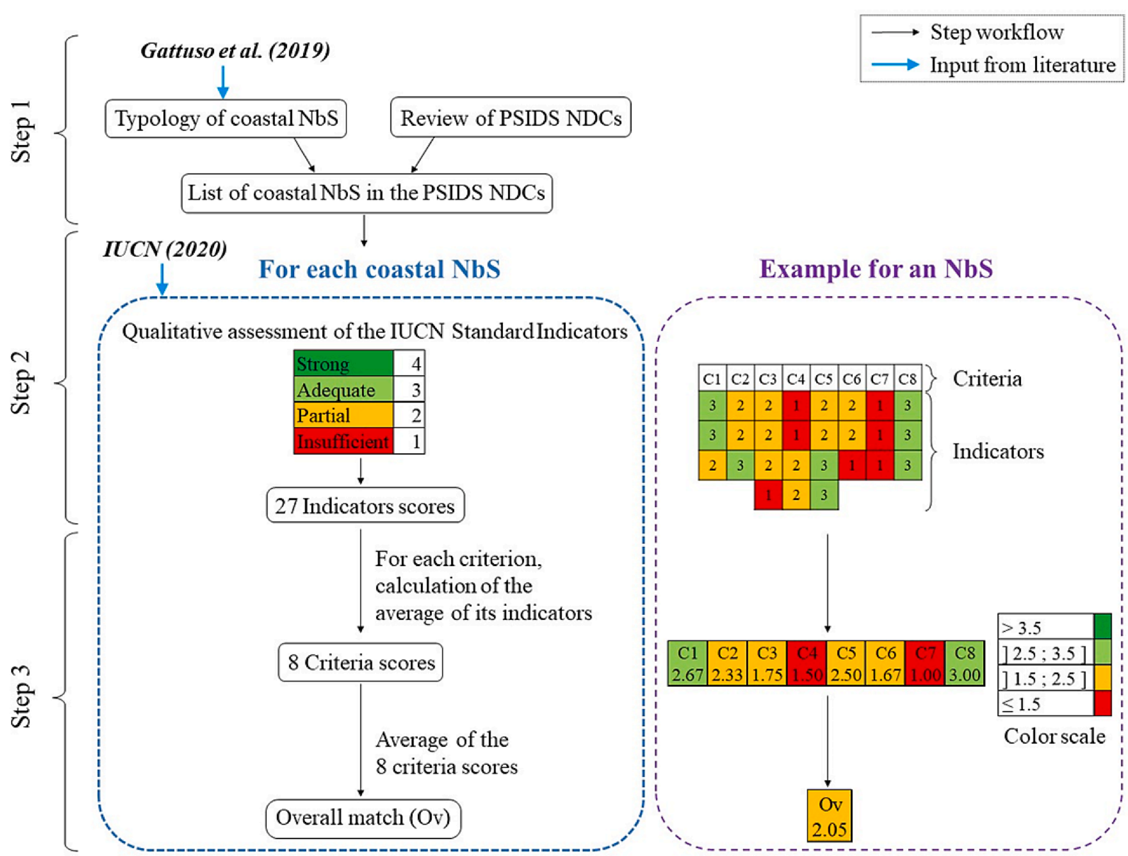

Fig. 2. Overview of method steps. NbS: nature-based solution. NDCs: Nationally Determined Contributions. PSIDS: Pacific Small Island Developing States.

Table 1
Classification of coastal nature-based solutions, adapted from the classification of ocean-based solutions by Gattuso et al. [16].

Coastal nature-based solutions	
Category	**Definition**
A	Restoration, conservation and sustainable management of coastal vegetation for climate mitigation
B	Conservation of coastal ecosystems (seagrasses, mangroves and coral reefs) for climate adaptation, e.g. through marine protected areas
C	Restoration and enhancement of coastal ecosystems (seagrasses, mangroves and coral reefs) for climate adaptation
D	Community-based sustainable management of coastal fisheries for climate adaptation

mangroves in the NDCs of PSIDS. Category B refers to the conservation of coastal ecosystems for adaptation, while category C refers to their restoration and enhancement for adaptation, with coastal ecosystems referring to mangroves, seagrasses and coral reefs in PSIDS NDCs (dunes and coastal vegetated beaches are not mentioned in PSIDS NDCs). Category D focuses on the community-based sustainable management of coastal fisheries for adaptation. Only NbS that explicitly referred to these categories were considered.

2.2.2. Step 2: assessment of indicators' alignment with the Standard

The IUCN Global Standard for NbS is composed of eight criteria (Table 2). Twenty-eight indicators are used to assess the criteria. Supplementary Material, Appendix A provides detailed information about the Standard's criteria and indicators. In this study, we assessed the degree of alignment between all coastal NbS identified in PSIDS NDCs and the 28 indicators of the Standard, except for indicator 5.5 addressing cross-jurisdictional decision-making, which was not relevant for the coastal NbS examined. It is important to note that we used the IUCN Global Standard for NbS to assess the alignment between the description of NbS in NDCs and the Standard, and not to assess the NbS adherence with the Standard, which is the primary intended purpose of the Standard.

We drew on the scale set up by IUCN [25] to assess the alignment of each coastal NbS with each of the indicators composing the Standard. The scale is composed of four levels to evaluate the alignment of the NbS with each indicator, described as "strong", "adequate", "partial" and "insufficient". The semi-quantitative assessment was guided by the description of the indicators available in the IUCN guidance [25]. For the assessment, we developed and used the assessment scale described in Fig. 3, which assigns a level of alignment between the description of NbS and the Standard's indicators. A score was then attributed to each indicator based on the level of alignment assessed, as follows: (4) if strongly adequate, (3) if adequate, (2) if partial, and (1) if insufficient (Fig. 3). These indicator scores were used to calculate criteria scores and overall matches in Step 3.

The assessment proceeded iteratively with two authors of the present paper (FC and MB) conducting independently the entire evaluation of all indicators for all coastal NbS identified in PSIDS NDCs. The iterative process allowed the authors to discuss conflicting entries, revisit their own evaluation, develop a shared understanding of each indicator, and resolve conflicting assessments. In a final step, one of the assessors (FC) reviewed the entire evaluation spreadsheet (Supplementary Material, Appendix E) to ensure that each indicator was evaluated consistently across all countries and coastal NbS.

Table 2
Criteria of the IUCN Global Standard for NbS. Adapted from IUCN [25].

Criteria #	Criteria name	Description
C1	Societal challenges	Addresses the importance of clearly identifying the societal challenge to which the solution will respond.
C2	Design at scale	Guides the design of NbS across social and ecological scales (landscape approach).
C3	Biodiversity net gain	Addresses the importance to ensure net gain to biodiversity and ecosystem integrity.
C4	Economic feasibility	Addresses the need to ensure economic viability, through identifying benefits and cost, and providing cost-effectiveness analysis.
C5	Inclusive governance	Addresses the need to ensure inclusive, transparent and empowering governance processes.
C6	Balance trade-offs	Addresses the needs to balance the trade-offs between achievement of their primary goal (s) and the continued provision of multiple benefits.
C7	Adaptive management	Promotes an adaptive management approach to improve the solution throughout its lifecycle.
C8	Mainstreaming and Sustainability	Promotes integration within national policy, alignment with national and global commitments, and sharing lessons to inform other solutions.

2.2.3. Step 3: criteria scores and overall matches

To obtain the overall match (Ov) between the description of an NbS and the IUCN Global Standard for NbS, we followed the Standard guidance methodology, which states that "all indicators must be normalized so that each criterion has equal weight" [25]. Each criterion score was obtained by calculating the average value across the scores of the indicators composing the criterion (Fig. 2). Finally, the overall match (Ov) for a given NbS is obtained by calculating the average of the eight criteria scores of the NbS. Note that the criteria scores and the overall match are decimal numbers between 1 and 4. In addition, we used a color scale to display both criteria scores and overall matches in the result section: an overall match scoring > 3.5 means that the NbS is strongly aligned with the Standard (dark green); $2.5 < Ov \leq 3.5$ means that the NbS is adequately aligned with the Standard (light green); an overall match scoring $1.5 < Ov \leq 2.5$ corresponds to a partial alignment (orange); $Ov \leq 1.5$ means that the level of alignment is insufficient (red). In addition, the IUCN definition of the Standard states that regardless of its overall match score, an NbS cannot be considered as adhering to the Standard if one of its eight criteria is rated "insufficient" (e.g., ≤ 1.5). We used Student's *t*-test to test for significant statistical differences in average scores across criteria and categories of coastal NbS (see Table B.1 in Supplementary Material, Appendix B).

3. Results

3.1. NbS categorization and assessment

We found that more than two thirds ($n = 17$) of the 24 NDCs released by PSIDS by October 31st 2021 included coastal NbS. A total of 22 coastal NbS were identified, where the majority ($n = 16$) referred to adaptation purposes (categories B, C and D), and six referred to mitigation purposes (category A) (Fig. 4). Further details on these 22 NbS (Table C.1) and two examples of how NbS are described in NDCs (Table C.2) are available in Supplementary Material, Appendix C.

The results of the full assessment of the 22 coastal NbS are presented in Fig. 5. From this assessment, we calculated the eight criteria scores and the overall match for each of the 22 NbS. Seventeen NbS had an overall match corresponding to a partial alignment to the IUCN Global Standard for NbS (column "Ov" in Fig. 6). However, the IUCN definition of the Standard states that regardless of its overall match score, an NbS cannot be considered as adhering to the standard if any one of its eight criteria is rated "insufficient". Based on this definition, the description of only one coastal NbS out of 22 ("Community based marine resource management" in Vanuatu's original NDC) is aligned with the Standard, as this is the only NbS for which none of the criteria is rated "insufficient" (Fig. 6).

	Level of alignment	Alignment with the IUCN Global Standard for NbS?	Rationale for assessment in the context of this study (*)	Score assigned
	Strong	Yes	Assigned if the NDC is extensive and precise enough to conclude that the NbS fulfills the indicator.	4
	Adequate	Yes	Assigned if explicitly mentioned that the NbS partially fulfilled the indicator. Also assigned if the NbS is part of another plan or policy mentioned in the NDC and the NDC explicitly mentions that all the actions in the given plan or policy fulfill the indicator. In that case the NbS is not directly and specifically targeted (the plan or strategy generally refer to several actions), but is implicitly.	3
	Partial	Yes	Assigned in three cases: (i) the NbS is part of another plan or policy mentioned in the NDC and information related to the given plan or policy informs the indicator, but not precisely enough to assign an adequate level; (ii) only a part of the indicator is fulfilled; (iii) the NDC mentioned that the NbS would meet the indicator in the future.	2
	Insufficient	No	Assigned if (i) the NDC explicitly states that the indicator is not filled in at all, or (ii) if no information is available to inform the indicator.	1

Fig. 3. Scale used to assess the alignment of the NbS with the indicators of the IUCN Global Standard for NbS as defined by IUCN [25]. *The rationale for assessment was developed by the authors of the current paper.

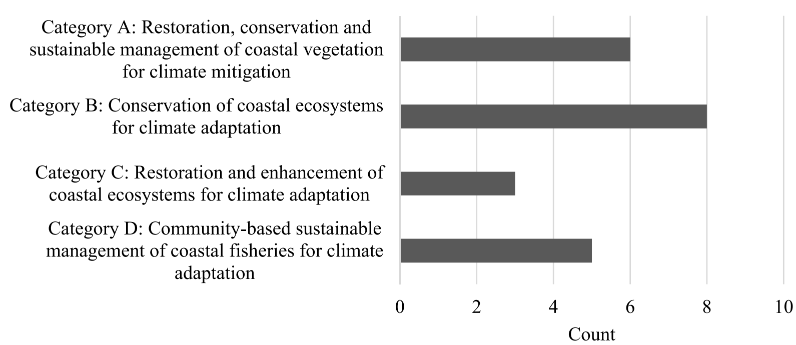

Fig. 4. Number of coastal nature-based solutions in the Nationally Determined Contributions of Pacific Small Island Developing States, for the four categories of solutions.

Coastal NbS often related to indicators in an implicit or indirect manner. For instance, the societal challenges addressed by the NbS were often mentioned (without being called "societal challenges" though), however it was often the case that the NDC did not thoroughly explain how the NbS explicitly contributes to increasing these societal challenges. Moreover, the NbS contribution to enhancing biodiversity net-gain (indicator 3.2) was only detailed in two cases (in Samoa's and Solomon Islands' revised NDCs). Although the lack of funding is often mentioned in PSIDS NDCs as a key barrier to NDC implementation, the costs of implementing and/or monitoring coastal NbS (indicator 4.1) were mentioned in only one case (in Nauru revised NDC). In some cases (e.g., original NDC of the Solomon Islands), countries considered a wide range of funding options (indicator 4.4) for the implementation of their NDC in general, but not at the NbS scale. Similarly, half of the PSIDS NDCs mentioned the importance of engaging a wide range of stakeholders when designing the NDC (indicator 5.3.), or that they did involve stakeholders when designing their NDC. However, stakeholder engagement was only referred to at the NDC scale, not to at the NbS scale. This was for instance the case of the original NDC of the Marshall Islands, which mentioned that the NDC "was developed through an all-inclusive process of engaging relevant stakeholders in and outside government"; however, there is no information at the NbS scale.

3.2. Patterns across criteria

Among the 22 coastal NbS identified in PSIDS NDCs, we found heterogeneity in alignment with the Standard across the criteria. On average for the 22 NbS, five criteria were partially met, and three were

				Criterion C1			Criterion C2			Criterion C3				Criterion C4				Criterion C5					Criterion C6			Criterion C7			Criterion C8		
				Societal challenges			Design at scale			Biodiversity net-gain				Economic feasibility				Inclusive governance					Balance trade-offs			Adaptive manage-ment			Mainstrea-ming and sustaina-bility		
			Indicators of the Standard	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	7.1	7.2	7.3	8.1	8.2	8.3
	PSIDS	Cat.	Coastal NbS																												
Melanesia	Fiji original NDC (2016)	C	Mangrove planting	2	2	2	3	3	1	3	1	1	1	1	1	1	2	1	1	2	1		1	2	1	1	1	2	1	2	3
		D	Sustainable management of fisheries	2	2	2	3	2	2	3	1	2	1	1	1	1	1	1	1	1	1		1	1	1	2	2	1	1	2	3
	Fiji revised NDC (2020)	A	Marine biodiversity protection and restoration	2	2	2	3	3	1	3	2	1	2	1	2	2	2	1	3	3	2		1	1	1	1	2	1	2	3	4
		B	Conservation of critical ocean ecosystems	3	3	2	3	4	2	3	1	1	2	1	2	2	2	1	3	3	3		1	2	1	1	2	1	1	3	3
		D	Sustainable fishing practices	3	2	2	3	3	2	3	2	1	2	1	1	1	1	1	3	3	3		1	2	1	2	3	2	1	3	3
	PNG original NDC (2016)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	PNG revised NDC (2020)	A	Include BC ecosystems in GHG inventory	2	2	1	2	3	1	2	1	1	1	1	1	1	2	1	2	2	2		1	2	1	1	2	1	2	2	3
		B	Conservation, establish MPAs & LMMAs	2	3	2	3	3	3	3	1	1	2	1	1	1	2	1	2	2	2		1	2	1	1	2	1	2	2	3
		C	Coastal ecosystem planting/rehabilitation	2	3	2	3	3	3	3	1	1	2	1	1	1	2	1	2	2	2		1	2	1	1	2	1	2	2	3
	Timor-Leste original NDC (2017)	A	Mangrove planting	2	2	2	2	3	1	2	1	1	1	1	1	1	2	1	2	2	1		1	1	1	1	1	1	1	2	3
		B	Mangrove conservation	2	2	2	2	2	2	2	1	1	1	1	1	1	2	1	2	2	1		1	1	1	1	1	1	1	2	3
		D	Ecosystem management to develop nurseries	2	1	1	2	2	1	2	1	1	2	1	1	1	2	1	2	2	1		1	1	1	1	1	1	1	2	3
	Solomon I. original NDC (2016)	B	Management of fisheries and marine resources	2	2	1	2	2	1	2	1	1	1	2	1	1	2	1	1	1	2		1	2	1	2	1	1	2	2	3
	Solomon I. revised NDC (2021)	A	Sust. manag. & protect coastal ecosystems	2	2	1	3	2	2	1	3	2	2	1	1	1	2	1	1	1	1		1	1	1	1	2	1	1	2	4
	Vanuatu original NDC (2016)	D	Community-based marine resource manag.	2	2	1	3	3	2	2	1	2	2	2	2	2	2	1	2	3	3		1	3	1	2	2	2	2	3	3
	Vanuatu revised NDC (2021)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Micronesia	FSM original NDC (2016)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Kiribati original NDC (2016)	A	Mangrove, seagrass protection/enhancement	2	2	1	2	3	2	3	2	1	2	2	1	1	2	1	2	2	2		1	2	1	2	2	2	1	2	3
	Nauru original NDC (2016)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Nauru revised NDC (2021)	B	Implement coastal NbS to increase resilience	3	3	2	3	3	2	2	1	1	2	2	1	2	1	1	2	2	1		1	1	1	1	1	1	1	2	3
	Palau original NDC (2016)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	RMI original NDC (2016)	A	Mangrove rehabilitation	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2		1	2	1	1	1	1	1	2	3
	RMI revised NDC (2018)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	RMI 2nd revised NDC (2020)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Polynesia	Cook I. original NDC (2016)	B	Designate the entire EEZ as a marine park	1	2	1	2	2	1	1	1	1	2	2	1	1	1	1	1	1	1		1	1	1	1	1	1	1	2	4
	Niue original NDC (2016)	D	Ecosystems approach to fisheries manag.	2	2	1	2	2	2	1	1	1	2	2	1	1	1	1	1	1	2		1	1	1	2	1	2	1	2	3
	Samoa original NDC (2016)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Samoa revised NDC (2021)	C	Expand the area of mangrove forests	2	2	2	3	2	2	2	3	1	3	2	1	1	1	2	2	2	2		1	2	1	2	2	1	1	2	3
	Tonga original NDC (2016)	B	Double the 2015 nb. of MPAs by 2030	2	2	1	2	2	2	1	2	1	2	2	1	1	2	1	2	2	2		1	2	1	1	2	1	1	2	3
	Tonga revised NDC (2020)	B	Expand MPAs & SMAs to 30% of EEZ	3	3	2	3	3	3	3	2	1	2	1	1	2	1	1	2	3	2		1	2	1	3	2	2	2	2	4
	Tuvalu original NDC (2016)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Total		Total coastal NbS	2.1	2.2	1.6	2.5	2.6	1.8	2.2	1.4	1.1	1.7	1.4	1.1	1.2	1.6	1.0	1.8	2.0	1.8		1.0	1.6	1.0	1.4	1.6	1.3	1.3	2.2	3.2

Fig. 5. Degree of alignment of coastal nature-based solutions in the Nationally Determined Contributions of Pacific Small Island Developing States with the IUCN Global Standard for NbS. Dark green: strong; Light green: adequate; Orange: partial; Red: insufficient. FSM: Federated States of Micronesia. PNG: Papua New Guinea. RMI: Republic of the Marshall Islands. BC: blue carbon. LMMA: locally managed marine area. MPA: marine protected area. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

insufficient (Fig. 6). The three criteria rated insufficient corresponded to economic feasibility (C4), balancing trade-offs (C6), and adaptive management (C7) (Fig. 6). For instance, only one of the 22 coastal NbS (Nauru revised NDC) is costed in NDCs. In contrast, more attention was given to the link between the NbS and societal challenges (C1), and to its design at scale (C2). All coastal NbS identified climate change mitigation or adaptation as a priority challenge they would address. Other frequent challenges coastal NbS sought to address were "environmental degradation and biodiversity loss", "disaster risk reduction", and "economic and social development". In general, the NbS recognized and responded to interactions between the economy, society and ecosystems (indicator 2.1), and their design were partially integrated with other complementary interventions and sought synergies across sectors (indicator 2.2) (Fig. 5). Heterogeneity across coastal NbS for a given indicator is the highest for indicator on risk identification and risk management (indicator 2.3) (Fig. 5). Criterion C3 on biodiversity net gain and criterion C8 on mainstreaming and sustainability are very heterogeneous among their indicators. For C3, only the indicator relating to the current state of the ecosystem and drivers of degradation (with climate change being generally identified as the main one) was partially met, where others, such as setting clear biodiversity targets, were insufficient. For instance, several PSIDS, such as Cook Islands, Papua New Guinea and Tonga, identified marine protected areas (MPAs) as adaptation measures in their NDCs; however, how these MPAs will actually support biodiversity is not explicitly articulated. For C8, only the last indicator on the NbS contribution to national and global targets was adequately aligned, since all identified NbS contribute to the Paris Agreement goals and to the 2030 global biodiversity goals of the Convention on Biological Diversity.

3.3. Patterns across NBS categories, countries, and between original vs. revised NDCs

The four categories of NbS shared similar patterns in terms of alignment with the Standard (Fig. 6), with no significant difference except for criterion C7 (see Table B.1 in Supplementary Material, Appendix B, for statistical tests). Criterion C7 regarding adaptive management was partially met for coastal NbS part of category D ("Community-based sustainable management of coastal fisheries for adaptation"), whereas this criterion was evaluated as "insufficient" for the three other categories (Fig. 6). The fact that coastal NbS part of category C ("Restoration and enhancement of coastal ecosystems for climate adaptation") were on average 'adequate' for criterion C2 on "Design at scale", compared to the three other categories of actions which were scored "partial" (Fig. 6), was nevertheless not statistically significant.

Coastal NbS were less likely to be included in Micronesian PSIDS NDCs (38%), while they were more likely to be included in Polynesian (71%) and Melanesian (78%) NDCs. Among the fifteen original NDCs, nine (60%) included coastal NbS, whereas among the nine revised NDCs, six (67%) included coastal NbS. We found that, on average, the description of coastal NbS included in revised NDCs more closely met the IUCN Global Standard for NbS than those included in original NDCs (Table B.2 in Supplementary Material, Appendix B). This is particularly significant regarding criteria C1, C2 and C3 (see *t*-test in Table B.1 in Supplementary Material, Appendix B). For all three countries that included NbS in both their original and revised NDCs (Fiji, Solomon Islands, Tonga), the NbS included in the revised NDCs have better average score than NbS in their original NDCs; this improvement is more marked for Fiji (+0.42 in average Ov) and Tonga (+0.52) than for Solomon Islands (+0.11). Also, the three countries that have average Ov

PSIDS	Cat.	Coastal NbS	C1	C2	C3	C4	C5	C6	C7	C8	Ov
Fiji revised NDC (2020)	A	Marine biodiversity protection and restoration	2	2.33	2	1.75	2.25	1	1.33	3	1.96
PNG revised NDC (2020)	A	Include BC ecosystems in GHG inventory	1.67	2	1.25	1.25	1.75	1.33	1.33	2	1.57
Timor-Leste original NDC (2017)	A	Mangrove planting	2	2	1.25	1.25	1.5	1	1	1.67	1.46
Solomon I. revised NDC (2021)	A	Sust. manag. & protect coastal ecosystems	1.67	2.33	2	1.25	1	1	1.33	2.33	1.61
Kiribati original NDC (2016)	A	Mangrove, seagrass protection/enhancement	1.67	2.33	2	1.5	1.75	1.33	2	2	1.82
RMI original NDC (2016)	A	Mangrove rehabilitation	2	2	1	1	1.5	1.33	1	1.67	1.44
Average Category A			1.83	2.17	1.58	1.33	1.63	1.17	1.33	2.11	1.64
Fiji revised NDC (2020)	B	Conservation of critical ocean ecosystems	2.67	3	1.75	1.75	2.5	1.33	1.33	2.33	2.08
PNG revised NDC (2020)	B	Conservation, establish MPAs and LMMAs	2.33	3	1.75	1.25	1.75	1.33	1.33	2	1.84
Timor-Leste original NDC (2017)	B	Mangrove conservation	2	2	1.25	1.25	1.5	1	1	1.67	1.46
Solomon I. original NDC (2016)	B	Management of fisheries and marine resources	1.67	1.67	1.25	1.5	1.25	1.33	1.33	2	1.5
Nauru revised NDC (2021)	B	Implement coastal NbS to increase resilience	2.67	2.67	1.5	1.5	1.5	1	1	2	1.73
Cook I. original NDC (2016)	B	Designate the entire EEZ as a marine park	1.33	1.67	1.25	1.25	1	1	1	2	1.31
Tonga original NDC (2016)	B	Double the 2015 number of MPAs by 2030	1.67	2	1.5	1.5	1.75	1.33	1.33	2	1.64
Tonga revised NDC (2020)	B	Expand MPAs and SMAs to 30% of the EEZ	2.67	3	2	1.25	2	1.33	2.33	2.67	2.16
Average Category B			2.13	2.38	1.53	1.41	1.66	1.21	1.33	2.08	1.71
Fiji original NDC (2016)	C	Mangrove planting	2	2.33	1.5	1.25	1.25	1.33	1.33	2	1.63
PNG revised NDC (2020)	C	Coastal ecosystem planting/rehabilitation	2.33	3	1.75	1.25	1.75	1.33	1.33	2	1.84
Samoa revised NDC (2021)	C	Expand the area of mangrove forests	2	2.33	2.25	1.25	2	1.33	1.67	2	1.85
Average Category C			2.11	2.56	1.83	1.25	1.67	1.33	1.44	2	1.77
Fiji original NDC (2016)	D	Sustainable management of fisheries	2	2.33	1.75	1	1	1	1.67	2	1.59
Fiji revised NDC (2020)	D	Sustainable fishing practices	2.33	2.67	2	1	2.5	1.33	2.33	2.33	2.06
Timor-Leste original NDC (2017)	D	Ecosystem management to develop nurseries	1.33	1.67	1.5	1.25	1.5	1	1	1.67	1.36
Vanuatu original NDC (2016)	D	Community-based marine resource manag.	1.67	2.67	1.75	2	2.25	1.67	2	2.67	2.08
Niue original NDC (2016)	D	Ecosystems approach to fisheries manag.	1.67	2	1.25	1.25	1.25	1	1.67	2	1.51
Average Category D			1.80	2.27	1.65	1.30	1.70	1.20	1.73	2.13	1.72
Total		Total coastal NbS	1.97	2.32	1.61	1.34	1.66	1.21	1.44	2.09	1.71

Fig. 6. Criteria (C1 to C8) scores and overall match (Ov) for each coastal nature-based solution in the Nationally Determined Contributions of Pacific Small Island Developing States. Level of alignment – dark green: strong; light green: adequate; orange: partial; red: insufficient. C1: Societal challenges; C2: Design at scale; C3: Biodiversity net-gain; C4: Economic feasibility; C5: Inclusive governance; C6: Balance trade-offs; C7: Adaptive management; C8: Mainstreaming and sustainability. BC: blue carbon. FSM: Federated States of Micronesia. LMMA: locally managed marine area. MPA: marine protected area. PNG: Papua New Guinea. RMI: Republic of the Marshall Islands. SMA: special marine area. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

< 1.5 (Cook Islands, Marshall Islands and Timor-Leste) are countries that only included NbS in their original NDC. Moreover, Vanuatu is the only country that included in its original NDC an NbS that scored Ov > 2 (a table showing differences per countries is available in the tab “original vs. revised” in Appendix E).

4. Discussion

4.1. Standardization of NBS in NDCs to facilitate access to funding

PSIDS often stress in their NDCs the need for external funding to successfully develop, implement and monitor coastal NbS, but rarely provide cost estimates (criterion C4) at the NbS scale. Yet, being able to attract donors for NbS funding requires a thorough understanding about the costs involved (C4), setting clear and measurable targets (C3) and being able to track progress (C7) [45]. Tracking progress implies an effective monitoring system, for which lack of financial and technical capacity is a barrier often stressed by PSIDS in their NDCs. Besides, informing criteria C1 on societal challenges and C3 on biodiversity net-gain for a given NbS may help PSIDS access funding from UNFCCC finance mechanisms, such as the Global Environment Facility (GEF), by informing on how the NbS can respond to a societal challenge (such as climate change). Indeed, the GEF funding for cross-cutting biodiversity-climate projects in PSIDS have gradually increased from US$ 0 in the period 1994–2006 to US$ 368 million between 2018 and 2022 (see Figure D.1 in Supplementary Material, Appendix D, for further details on available GEF funding trends). Meanwhile, GEF funding for projects in PSIDS that related to climate or biodiversity alone decreased in the period 2018–2022 as compared to 2014–2018. In addition, including NbS descriptions in NDCs that are aligned with the IUCN Global Standard for NbS will most likely help countries access certain funding, such as the Blue Natural Capital Financing Facility and the IUCN Global Facility for NbS, launched in 2018 and 2021 respectively by IUCN, for which a selection of projects is evaluated against the IUCN

Global Standard for NbS. However, although donors and project partners do not systematically require full alignment of NbS projects with the IUCN Global Standard, Pettorelli et al. [34] argue that designing NbS according to the Standard requirements increases the likelihood that the NbS will be funded and produce socio-ecological benefits because it is defined in an integrated, best practice, and comprehensive way.

Still, describing NbS in a standardized way in NDCs would only alleviate some obstacles to access NbS funding for PSIDS. The revised NDC of Nauru listed the main barriers to access financial and human capacity support for SIDS, which are: (i) limited institutional capacity, (ii) burdensome application and reporting requirements, (iii) small projects that are not eligible for many international funds, (iv) public debt levels, and (v) high cost of project per capita. Although access to funding could be improved by greater alignment of NbS in NDCs with the IUCN Global Standard for NbS, it is incumbent on the international community to increase its willingness to effectively support those countries that are most dependent on external aid. This support needs to be urgently scaled-up to respond timely to the magnitude of climate impacts and local development needs, to avoid reaching a point where migration is the last option for some island communities [29]. In addition, Hills et al. [20] identify the lack of stable technical capacity, such as access to reliable data on the relative benefits of alternative options, as another major barrier to unlocking NbS potential.

4.2. Standardization of NBS in NDCs to facilitate progress tracking

A unique NDC format that would indicate which elements should be included in NDCs and how, would help assess where countries stand regarding the Paris Agreement's mitigation, adaptation and financing goals according to Hellio [19]. Standardized descriptions of NbS in NDCs with greater level of detail would allow for better compliance with the Paris Agreement's requirement to "provide information necessary for clarity, transparency and understanding" in communicating NDCs (Paris Agreement, Article 4). Moreover, under Article 13 of the Paris Agreement, "each Party shall regularly provide information necessary to track progress made in implementing and achieving its NDC". The global stocktake is a five-year iterative process mandated under the Paris Agreement to monitor progress towards its long-term goals on mitigation, adaptation, and finance, with the first assessment expected to be completed by the end of 2023. The outcomes of the global stocktake should help countries design more ambitious revised NDCs as well as strengthen international cooperation [38]. In 2018, the sources of inputs required for the global stocktake were defined [48]. Required elements include: (a) the state of greenhouse gas emissions and removals, (b) the overall effect of countries' NDCs and overall progress made towards their implementation, (c) the state of adaptation efforts, support, experience and priorities, (d) finance flows (e) loss and damage, (f) barriers and challenges (g) sharing good practices, and (h) fairness consideration, including equity, as communicated by countries in their NDCs. The IUCN Global Standard for NbS contains indicators which allow to account for much of these elements (see Table A.2 in Appendix A for details of the links between elements required for the global stocktake and the indicators of the IUCN Standard).

However, the collection of the information needed for the global stocktake could be challenging in PSIDS. The first phase of the global stocktake focuses on aggregation of NDC targets and is based on the assumption that NDC will be fully implemented. Our results –based on the IUCN Standard– suggest that informing this step might be difficult regarding NbS in PSIDS as indicator 3.2 on clear targets is insufficient on average (Fig. 5). This echoes the conclusions of Craft and Fisher [8] and Jeffery et al. [26] who identified the aggregation of NDC targets as a main challenge for delivering a meaningful global stocktake. This issue is also reflected in the UNFCCC [46] synthesis report on global aggregated NDC targets in which NbS targets for adaptation purpose were not included. Using a standard that requires the specification of mitigation and adaptation targets when including NbS in NDCs would help address this issue. In addition, our analysis of PSIDS NDCs showed that the description of NbS with respect to inclusive governance (C5) and good practices (C8, indicator 8.1) was generally inadequate. Similarly, financial information related to NbS (C4) is generally insufficiently included in PSIDS NDCs, suggesting that the collection of data on climate finance flows and needs for informing the global stocktake is also likely to be challenging. A standardization that includes indicators on finance needs and costs such as the IUCN Global Standard for NbS could provide an opportunity for PSIDS to make their financial needs visible under the global stocktake.

As we enter the first phase of the global stocktake, which is to collect information and prepare the technical assessment of progress, the UNFCCC is currently exploring ways to develop common indicators for NbS and is examining how NDCs could include them [38]. The IPCC's 2013 Wetland Supplement to the National Greenhouse gas Inventory constitutes the reference guideline to assess the contribution of coastal ecosystems in mitigation. Concerning the Paris Agreement's goals on adaptation, the UNFCCC did not define quantified targets but rather proposed guiding questions to assess progress, in order to reflect the variety of adaptation metrics and national circumstances [38]. For Craft & Fisher [8], this lack of a quantified adaptation goal is likely to prevent a robust and comprehensive global stocktake. They argue that there is a need to develop and use outcome-based quantified indicators reflecting institutional capacities, resilience and well-being, to overcome the challenge of assessing adaptation progress as part of the global stocktake. This difficulty in defining clear adaptation indicators is reflected in our analysis, as none of the coastal NbS in PSIDS NDCs included a quantification of expected benefits for adaptation.

4.3. Relevance of the IUCN Global Standard for NBS in PSIDS

According to our results, the most significant gaps in alignment of coastal NbS in PSIDS NDCs with the IUCN Global Standard for NbS relate to economic feasibility (C4), balancing trade-offs (C6) and adaptive management (C7). The consideration of trade-offs (C6) when designing coastal NbS is highly relevant for small Pacific Island communities, as the selection of coastal adaptation and mitigation responses could involve significant trade-offs between multiple and potentially conflicting local priorities [1,29]. For example, the preference of some PSIDS for seawalls instead of NbS to protect coasts against climate hazards [20,30], could involve the destruction of local natural coastal ecosystems that can help reduce coastal impacts. Moreover, considering adaptive management (C7) when designing NbS is likely to help PSIDS cope with the uncertainty, complexity and dynamics of change impacts [12,32]. In addition, the critical importance of designing synergistic linkages between plans and projects to improve the benefits of NbS implementation (indicator 8.2) was highlighted as a key lesson from the Pacific Ecosystem-Based Climate Change Adaptation project [44]. The standardization of NbS based on the IUCN Global Standard may thus provide opportunities to address issues that are relevant for PSIDS.

However, in considering the implications of our results, we need to acknowledge that the description of the NbS in NDCs may not reflect how NbS are actually designed, implemented and monitored in reality. For instance, PSIDS may not consider useful to describe their NbS in details in their NDCs. They could view other plans, such as National Adaptation Programmes of Action (NAPAs), to be more appropriate for including and detailing NbS for adaptation purposes, as illustrated by the increasing inclusion of NbS in PSIDS NAPAs [36]. An in-depth analysis to understand how NbS included in NDCs are actually designed, implemented and monitored would be necessary to understand to what extent the NbS truly adhere to the Standard. This could be conducted through field studies with interviews of some people in charge of developing these NbS at different levels (i.e., government agencies, industrial partners, local communities, regional organizations), as well as document analysis (e.g., NAPAs, national biodiversity plans, national communications).

Furthermore, our results revealing weak alignment with the IUCN Global Standard for 21 out of 22 NbS in PSIDS NDCs questions the suitability of using the Standard for reporting and assessing NbS in NDCs for PSIDS. To enable effective NbS design and reporting, the indicators used to assess NbS must reflect stakeholder needs, concerns and interests, and the standards and overall requirements must be fully understood and supported by authorities [50]. The data to assess progress with regards to indicators must also be practical and feasible to collect. Our findings could suggest that the Standard's requirements may be too high or inappropriate for PSIDS, in particular regarding indicators related to C4 on economic feasibility, C6 on balancing trade-offs and C7 on adaptive management. It may be burdensome or impractical for countries with limited institutional capacity to collect data required to inform adequately the 28 indicators of the Standard for all their coastal NbS.

Beyond the question of the relevance of the IUCN Global Standard for NbS for PSIDS, standardization of NbS in general raises questions about the flexibility for PSIDS to customize approaches when designing their NbS. It may be that countries with financial, human and technological constraints primarily need assistance in developing NbS that are well adapted to their local context and that the issue of standardization is secondary. Further research could therefore examine the potential trade-offs between more standardization and less flexibility in PSIDS. In particular, it could be useful to collect the views of PSIDS government representatives on the use of standards such as the IUCN Global Standard for NbS for both the design and reporting of NbS. This would provide information on the conditions of applicability of the IUCN Global Standard for NbS and inform how it could be adapted to better fit local contexts. This next step would also help design locally-adapted tools to enhance the effectiveness of NbS, through an identification of the specific and concrete barriers faced by PSIDS to develop NbS with ecologically sound, socially just and economically feasible outcomes.

5. Conclusion

In a context where the growing development of NbS raises concerns about their future utilization, we assessed to what extent coastal NbS included by PSIDS in their NDCs are aligned with the IUCN Global Standard for NbS. Our analysis revealed that for the 22 coastal NbS examined in the NDCs of PSIDS, the degree of alignment with the eight criteria of the IUCN Global Standard for NbS is insufficient or partial, with slightly better alignment with the Standard in revised NDCs than in original NDCs. On average, the criteria most aligned with the IUCN Standard across the 22 coastal NbS relate to the societal challenges addressed by the NbS (C1) and its design at scale (C2), while the less aligned criteria relate to the economic feasibility (C4), balancing trade-offs (C6) and adaptive management (C7).

We have identified opportunities provided by a standardized description of NbS in NDCs, specifically with respect to mobilizing funding for NbS and tracking NbS progress. In particular, incorporating NbS in NDCs in such a way that their description allows to assess their adherence with the IUCN Global Standard for NbS could help PSIDS access biodiversity and climate cross-cutting funding, such as through the GEF and IUCN specific funds. It would also allow PSIDS to make their financial needs visible in the global stocktake that must account for financial flows and needs, through informing criterion C4 on economic feasibility. At the global level, this practice could facilitate the global stocktake mandated under the Paris Agreement, by facilitating aggregation and comparison of NDC contents. As such, our research provides insights into the potential of using the IUCN Global Standard as a basis for describing NbS in NDCs, in a context where the modalities of reporting on NDCs implementation progress are being discussed by the UNFCCC technical bodies.

Our results also raised the question of whether the requirements of the IUCN Global Standard for NbS are too high or inappropriate for PSIDS for criteria relating to economic feasibility, balancing trade-offs and adaptive management. Whether there exists a trade-off between more standardization and less flexibility for countries to customize approaches remains an open question, which requires data to better understand PSIDS needs. Therefore, further research to complement our study could be to conduct case studies to collect the views from PSIDS government representatives on the benefits and barriers they identify regarding the use of the IUCN Global Standard for NbS in NDC reporting. This would provide a better understanding of the conditions for the applicability of this Standard in PSIDS and help determine the most suitable options for PSIDS to report on NbS in their climate plans.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.nbsj.2022.100034.

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