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Coastal nature-based solutions for climate adaptation and mitigation in the national policies of Pacific Small Island Developing States

Fanny Châles

► **To cite this version:**

Fanny Châles. Coastal nature-based solutions for climate adaptation and mitigation in the national policies of Pacific Small Island Developing States. Economics and Finance. Université de Bretagne occidentale - Brest, 2023. English. NNT : 2023BRES0030 . tel-04245857

HAL Id: tel-04245857

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THESE DE DOCTORAT DE

L'UNIVERSITE DE BRETAGNE OCCIDENTALE

ECOLE DOCTORALE N° 598
Sciences de la Mer et du Littoral
Spécialité : Sciences Économiques

Par

Fanny CHÂLES

Coastal nature-based solutions for climate adaptation and mitigation in the national policies of Pacific Small Island Developing States

Thèse présentée et soutenue à Plouzané, le 12 juin 2023

Unité de recherche : UMR 6038 Amure – Aménagement des Usages des Ressources et des Espaces
marins et littoraux

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Acknowledgements

First of all, I would like to warmly thank my thesis supervisors, Linwood Pendleton, Leo Dutra, and Denis Bailly. I feel privileged to have been supervised by such a scientifically impressive team! Your trust and guidance throughout the thesis have been very important to me. Thank you for giving me a lot of freedom to carry out my work, while making sure that I did not get lost. Thank you also for the opportunities to participate in a variety of international scientific events and policy conferences and for sharing your networks and experience with me. You have helped me to progress and I am deeply grateful to all three of you.

I am thankful to Virginie Duvat and Ingrid van Putten for their precious enthusiasm, insight and advice.

I warmly thank all the members of my thesis jury for having accepted to examine and evaluate my work.

I thank the co-authors of the articles produced as part of this thesis, Denis Bailly, Manuel Bellanger, Leo Dutra, Bleuenn Guilloux and Linwood Pendleton, for their precious contribution. I learned a lot working with you, both from your scientific expertise and academic writing skills.

I would like to give special thanks to Leo Dutra for his thorough review of the thesis manuscript. Leo, thank you also for allowing me to be part of your research projects, and for your unfailing availability despite the time difference. I would also like to express my gratitude to those who generously offered to proofread some sections of the thesis manuscript, helping me to improve it: Adrien, Bleuenn, Esther, Manuel, Maxime and Odeline.

I thank all the people who made themselves available for work sessions, discussions or interviews. I especially think of Susan Grose Heydler, Olivier Thébaud, Tutti Chilton, Amber Himes-Cornell, Clément Chazot, Louis Loubriat, and Catherine Lovelock.

I thank the members of the “Blue carbon ecosystem services and Livelihoods” project, who welcomed me in the team. A special thank you to Lucille, Adi Vasu, Kini and Inoke, from “Transcend Oceania” in Fiji, as well as to all the other members of the organization, for the implication in the surveys conducted in Tawake.

I thank the people I met during my stay at CSIRO in Brisbane in February 2020 for the warm welcome.

I thank the Ocean University Initiative team in Brest. Denis, you have succeeded in putting together a dream team always working in a joyful atmosphere. I am very grateful to you for giving me the opportunity to work with you and for having accompanied me in the creation of the thesis project.

Bleuenn, I will remember our walks on the coast of Brittany to brainstorm about methodology and our runs in the corridors of COP26 to find our sessions.

Charline, thanks a lot for your help in the graphic design of some figures, and Mathieu, your help in processing excel data in a faster way was much appreciated!

Sophie, thanks for offering your professional proofreading skills for the final tweaks.

I would like to thank the whole team of the AMURE laboratory. What a great environment to conduct a PhD!

For all the good times spent together in Brest, I thank all the doctoral students and “kids” from AMURE, my office mates Maxime, Jean-François, Fabien and Victor (many thanks for your advice about the defense!), as well as the other friends I made here in Brest. By your kindness, you all contributed to make this doctoral experience an enjoyable and enriching one. A special thought to Jean-François, who shared with me his good mood and jokes during the two years we shared the office (minus a few months of lockdown).

To my dear old friends, who will recognize themselves, for the good times in Plaisir, Paris and elsewhere en bord de mer.

To my beloved Family, with whom every moment shared reminds me of what matters most in life.

Finally, I thank you Manuel. Your presence at my side during these years has been essential. Thanks to your ability to put things into perspective, to make me laugh, and to advise me when I needed it, you have allowed me to be more serene. Thank you for your trust, care, and much more.

Abstract

In a global context of climate and biodiversity crises associated with increasing development inequalities, the international expert groups on climate (IPCC) and biodiversity (IPBES) recommend to scale-up the implementation of nature-based solutions (NbS). In particular, the protection, restoration and sustainable use of coastal ecosystems (i.e., coastal NbS) can contribute to enhancing climate adaptation and mitigation, while providing other essential benefits to living species, including humans. Coastal NbS have been identified as highly relevant for the Pacific Small Island Developing States (PSIDS), which are among the most vulnerable countries to climate impacts and nature loss and degradation. However, their implementation in PSIDS is challenging due to difficulties in mobilizing adequate financial, human and technical resources. Recent literature underscores that the inclusion of ambitious coastal NbS in climate policies can be an important step towards more coherent policies that can reduce these constraints to effective NbS implementation.

This thesis examines the inclusion of coastal NbS in the national policies of PSIDS, with a particular focus on the Nationally Determined Contributions (NDCs) developed under the United Nations' Paris Agreement to mitigate greenhouse gas emissions and increase the ability to adapt. We focus on the policy design level to analyze how coastal NbS are included by PSIDS in their NDCs. Then, we examine how different tools that have been proposed to help design effective environmental policies can inform policy-making in PSIDS. These tools include standards, ecosystem services assessments, and best practices recommendations related to policy integration and stakeholder engagement. The methodological approaches mobilized in the thesis include systematic reviews of the literature and policy documents, qualitative and semi-quantitative analyses, and questionnaire surveys.

The results of Chapter 1 highlight an increased consideration of ocean-based climate actions over time in the policies of PSIDS, with a focus on adaptation and nature through coastal NbS. Coastal NbS are increasingly detailed over time (in particular through quantitative targets) and integrated across multiple policies from different sectors (such as climate, environment, and development). Chapter 1 therefore suggests that coastal NbS are being progressively better designed to effectively support PSIDS in addressing the challenges of climate change, nature loss and degradation, and sustainable development.

In Chapter 2, we find that, for the 22 coastal NbS examined in the NDCs of PSIDS, the degree of alignment with the IUCN Global Standard for NbS is either insufficient or partial, with slightly better alignment with the standard in revised NDCs than in original NDCs. We highlight potential risks associated with the current inclusion of coastal NbS in PSIDS' NDCs and identify opportunities provided by the standardization of the description of NbS in NDCs in terms of access to funding and progress tracking. We also highlight potential drawbacks and raise the question of whether the IUCN Global Standard for NbS could be impractical or irrelevant in PSIDS.

In Chapter 3, we conduct a systematic literature review of coastal ecosystems services in PSIDS to investigate the links between coastal ecosystems and people's uses and well-being. We highlight great variability in the number of assessments conducted for different types of ecosystem services as well as in the associated monetary values. We also identify geographical and methodological literature gaps that can bias policy-making and propose pathways to reduce these gaps.

Chapter 4 consists of a case study in a Fijian coastal community to understand how community members perceive their involvement and that of their political leaders in the management of coastal ecosystems. Based on survey interviews, we collected local perceptions and proposals for improving coastal management through increased awareness and cooperation between communities, authorities, and research.

Finally, we identify research perspectives, particularly through fieldwork in PSIDS. This could include surveys targeting government officials in PSIDS to gather their views on the concrete aspirations, needs, concerns, and potential obstacles and opportunities they identify with regard to the implementation of coastal NbS for climate, nature and people.

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Foreword

By its content and approach, this thesis mobilizes tools and knowledge from various disciplines: economics, environmental management, marine policy and regulation. This type of interdisciplinarity work relates to the “sustainability science” approach that is increasingly embraced by scientists and scientific institutions (IRD, 2022). Sustainability science is an applied science that examines the interactions between human and environmental systems in order to help find solutions to complex challenges that threaten humanity and the integrity of life, such as climate change and nature loss and degradation. Drawing on interdisciplinary and transdisciplinary approaches, sustainability science is best defined by the practical problems it addresses rather than the disciplines it employs (Clark, 2007). However, sustainability science is not yet one of officially recognized academic specialty within the doctoral school of Marine and Coastal Sciences of the Université de Bretagne Occidentale. This is why this thesis has been attached to the economics specialty, which is the specialty within the doctoral school that best corresponds to this PhD work.

This thesis was co-funded by (i) the ISblue project, Interdisciplinary graduate school for the blue planet (ANR-17-EURE-0015), through a grant from the French government under the program “Investissements d'Avenir” embedded in the programme France 2030 (50%); and by (ii) the Region Bretagne and the Université de Bretagne Occidentale through an allocation to the doctoral school of Marine and Coastal Sciences (50%). This thesis was conducted in co-supervision between the research laboratory AMURE (UMR 6308) (CNRS, IFREMER, UBO) in France (Brest) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia (Brisbane). For the duration of the thesis, I was hosted at AMURE in Brest. Between February 2020 and March 2020, I spent one month at CSIRO in Brisbane to work with my thesis co-director Dr Leo Dutra, with the financial support of an ISblue grant.

The thesis manuscript is composed of four chapters. Each chapter addresses a research question, and is written as an academic article. During the course of the thesis, one article (corresponding to Chapter 2) has been published in a peer-reviewed journal. Two chapters (Chapters 1 and 3) are in the process of submission or review in peer-reviewed journals. I have made minor changes between the articles and the corresponding chapters in order to avoid redundancies between the chapters and thus improve the readability of the thesis manuscript. Some repetitions were unavoidable due to the article format of the dissertation, in particular in the introductions of the chapters. The supplementary material to the chapters can be found at the end of the thesis manuscript. A General Introduction and a General Discussion and conclusion complete the manuscript. The General Introduction presents the thesis context and issues, and introduces the work conducted in each chapter. At the end of the manuscript, the General Discussion and conclusion summarizes and discusses the main findings of the thesis, stresses the limitations, and recommends areas for future research.

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Clark, W. C. (Ed.). (2007). Sustainability science: a room of its own. *Proceedings of the National Academy of Sciences*, 104(6), 1737-1738.

IRD (2022). Institut de Recherche pour le Développement. Dangles, O., Fréour, C. et al. Science de la durabilité. Comprendre, Co-construire, Transformer.

Scientific production

	Corresponding section of the thesis manuscript
<p>Published in a peer-reviewed journal:</p> <p>Châles, F., Bellanger, M., Bailly, D., Dutra, L. X., & Pendleton, L. (2023). Using standards for coastal nature-based solutions in climate commitments: Applying the IUCN Global Standard to the case of Pacific Small Island Developing States. <i>Nature-Based Solutions</i>, 3, 100034. https://doi.org/10.1016/j.nbsj.2022.100034.</p>	Chapter 2
<p>Accepted for publication in a peer-reviewed journal:</p> <p>Châles, F. (forthcoming). A systematic review of coastal ecosystem services in the Pacific Small Island Developing States. <i>Mondes en développement</i>.</p>	Chapter 3
<p>In preparation for publication:</p> <p>Châles, F., Guilloux, B. (<i>in prep.</i>) Ocean-based climate actions in the Nationally Determined Contributions of Pacific Small Island Developing States: an overview of typology, precision and integration.</p>	Chapter 1
<p>Report:</p> <p>CSIRO, (2023). Livelihoods from blue carbon ecosystems. Ecosystem services values, impacts and governance - Tawake, Vanua Levu, Fiji. Dutra, X.C., Adi Vasulevu, M.L., Chute, L., Skewes, T., Baleinakorodawa, P., Ceyaqalo, K., Tupou, I., Butler, J., Stevens, A., Châles, F., Drauna, R.I., Crosswell, J., Taboada, M.B., van Putten, I., Powell, W. <i>In prep.</i></p>	
<p>Policy brief:</p> <p>Châles, F. (2021). Including coastal ecosystems in Nationally Determined Contributions (NDCs). Ocean University Initiative Policy Brief, N°4. UBO, France. / Châles, F. (2021). Les enjeux de l'inclusion des écosystèmes côtiers dans les Contributions Déterminées au niveau national (CDN). Ocean University Initiative Policy Brief, Numéro 4. UBO, France.</p>	
<p>Book contribution:</p> <p>« Évaluer l'état écologique des récifs coralliens - Réflexions à la croisée des politiques publiques de protection : Synthèse des séminaires du groupe de travail "récifs coralliens" ». DCE-Ifreco 2016-2019. Office français de la biodiversité. ISBN: 978-2-38170-112-7.</p>	

Communications in international conferences and workshops:

Châles, F. (2022). *Revue systématique des services écosystémiques côtiers dans les Petits Etats Insulaires en Développement du Pacifique*. Conference « Mondialisation, Développement & Vulnérabilités des espaces maritimes et côtiers. XXXVIIèmes Journées du développement de l'Association Tiers-Monde ». 23-25 May 2022. Brest, France.

Châles, F. (2022). *A systematic review of coastal ecosystem services in the Pacific Small Island Developing States*. Conference BECoME 2022 “The Second International Conference on Biodiversity, Ecology and Conservation of Marine Ecosystems”, 3-7 January 2022. Hong Kong, China. (*Online*).

Châles, F. (2021). *A systematic review of coastal ecosystem services in the Pacific Small Island Developing States*. Conference “Eco-health and ecosystem services in Asia: Bottom-up aspects for planetary health.” 3rd Ecosystem Services Partnership Asia Conference, 14-17 December 2021. Nagasaki, Japan. (*Online*).

Conference award:

Award for the best conference paper and presentation among young researchers at the conference « Mondialisation, Développement & Vulnérabilités des espaces maritimes et côtiers. XXXVIIèmes Journées du développement de l'Association Tiers-Monde », May 2022, Brest, France.

Other research activities

In parallel to the thesis work, I participated in other research activities as a member of the Ocean University Initiative team. The Ocean University Initiative, implemented by the Université de Bretagne Occidentale (UBO), aims to promote international collaborative research projects and to create expertise in ocean research, training and communication (<https://ocean-univ.org/>). These activities, described below, were not directly related to my PhD topic, but provided additional training in research communication and general policy knowledge.

- ✚ **Presentation at an international workshop and facilitation of the workshop.** In 2019, the Ocean University Initiative launched a survey to gather the views of researchers and policy-makers on what should be the priorities for ocean research in the South Atlantic region. A workshop was held at the end of the project to communicate the survey results to the steering research committee.

Châles, F., Recuero Virto, L. (2019). *Ocean research priorities for the Ocean decade in the South Atlantic*. Ocean University Initiative, Workshop held 1-3 October 2019 in Lisbon, Portugal.

- ✚ **Participation in communication events around COP26 on climate change.** I had the opportunity to participate in the COP26 climate conference in Glasgow, UK (31 October - 12 November 2021) with the mission to report in real time on its progress in relation to the ocean in order to feed the debates taking place in Brest within the Agora Glaz initiative (<https://www-ium.univ-brest.fr/dans-le-cadre-de-la-cop-26-lagora-glaz-au-sein-de-liuem/>). The Agora Glaz initiative aimed at fostering dialogue within the local communities of Brest on the climate international negotiations.

- ✚ **Contribution to the elaboration of a call for action under the One Ocean Summit held in Brest in February 9-11, 2022.** The One Ocean Summit brought together around 100 countries with the aim to enhance global ambition on ocean protection, restoration and sustainable management. A call for action was elaborated by early career researchers to raise awareness on the most urgent issues related to the ocean according to them. This initiative involving early career researchers had been initiated by UBO and partner networks. The call for action can be found at: <https://www-ium.univ-brest.fr/one-ocean-university-at-unoc/>.

- ✚ **Popularized rendition of a peer-reviewed article (“A model of mercury distribution in tuna from the western and central Pacific ocean”, Houssard et al., 2019) to make it more accessible to the public.** The popularized version of the article is available at: <https://www-ium.univ-brest.fr/le-thon-cest-bon-mais-sans-mercure/>.

List of abbreviations

AOSIS	Alliance of Small Island States
BC	Blue carbon
BCESL	Blue Carbon Ecosystem Services and Livelihoods
BNCFF	Blue Natural Capital Financing Facility
CBD	Convention on Biological Diversity
CC	Climate change
COP	Conference of the Parties
COVID-19	Coronavirus disease 2019
CO ₂	Carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EEZ	Exclusive Economic Zone
ES	Ecosystem services
ESVD	Ecosystem Services Valuation Database
FLMMA	Fijian Locally Managed Marine Area
FSM	Federated States of Micronesia
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas(es)
GLPCA	Green List of Protected and Conserved Areas
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPCC AR6 WGII	IPCC Sixth Assessment Report. Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II.
IUCN	International Union for Conservation of Nature
JNAP	Joint National Action Plan for Disaster Risk Management and Climate Change
LMMA	Locally Managed Marine Area
MEA	Millennium Ecosystem Assessment
MPA	Marine Protected Area
NAMA	Nationally Appropriate Mitigation Actions
NAP	National Adaptation Plan
NAPA	Nationally Adaptation Programme of Actions
NbS	Nature-based Solution
NBSAP	National Biodiversity Strategy and Action Plan

NDC	Nationally Determined Contribution
NGO	Non-Governmental Organization
NOP	National Ocean Policy
OBCA	Ocean-based climate action
OECD	Organisation for Economic Co-operation and Development
PIF	Pacific Island Forum
PNG	Papua New Guinea
PSIDS	Pacific Small Island Developing States
RMI	Republic of the Marshall Islands
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
SLR	Sea level rise
SPC	Pacific Community (or South Pacific Commission)
SPREP	Secretariat of the Pacific Regional Environment Programme
TEEB	The Economics of Ecosystems and Biodiversity
UK	United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WRI	World Resources Institute
WWF	World Wide Fund for Nature Inc. (or World Widelife Fund)

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General Introduction

1. A changing planet under climate change: context and political frameworks

Climate change is recognized as one of the most pressing challenges of our time (IPCC, 2022; Pörtner et al., 2021). At the current level of warming (an increase of 1.2°C compare to the pre-industrial era), climate change impacts are already affecting many species and human populations around the world. The current and future impacts of climate change on natural ecosystems and human societies are expected to rapidly worsen if no massive transformation to a low-carbon society is undertaken (IPCC, 2022; UNEP, 2022a). Two types of climate change events and impacts can be distinguished: sudden onset events - or extreme events - such as major floods, and slow onset events such as sea level rise (SLR) (UNFCCC, 2012). Climate impacts add to the current sustainable development challenges faced by countries and further exacerbate development inequalities (Pörtner et al., 2021; Diffenbaugh & Burke, 2019). Although developed countries are not spared (Van Oldenborgh et al., 2021; Blöschl et al., 2017), climate change impacts are on average more severe in the poorest, lowest-emitting, and most vulnerable countries, where institutions and infrastructure lack the resources to adequately and timely cope with climate impacts and environmental challenges (IPCC, 2022). This is the case of Pacific Small Island Developing States (PSIDS), which are among the most vulnerable countries to the adverse effects of climate change (IPCC, 2022; IPCC, 2014).

1.1. The need to frame climate action at the international scale: the adoption of the United Nations Framework Convention on Climate Change and the Paris Agreement

Climate change is sometimes referred to as a "wicked problem" because of its complexity, which arises from multiple activities and interactions between natural and social systems, and for which there is no single, simple solution (Levin et al., 2012; Levin et al., 2009). Climate impacts are spatially heterogeneous but the physical mechanisms driving climate change (e.g., the greenhouse effect) are global (IPCC, 2007). Scattered and *ad hoc* measures are not sufficient to effectively address the climate crisis; on the contrary, effective action against climate change requires collective and coherent action at the international level (Stern, 2006).

The fight against climate change was institutionalized at the international level for the first time at the Rio Summit in 1992, with the adoption of the United Nations Framework Convention on Climate Change (UNFCCC). The main objective of the UNFCCC is to “stabilize greenhouse gas concentrations at a level that would prevent dangerous human interference with the climate system” (UNFCCC, Article 2). Under the UNFCCC, a first international climate agreement, the Kyoto Protocol, was signed in 1997 and entered into force in 2005 to reduce the emissions of six greenhouse gases (GHG) by 2012.

However, this goal was not met (Prins & Rayner, 2007). In 2015, several years after the failure of the Kyoto Protocol, the members States of the UNFCCC (called “Parties”) adopted a new international climate mechanism: the Paris Agreement, which entered into force on 4 November 2016. Today, 194 Parties (193 States plus the European Union) have joined the Agreement. The Paris Agreement differs primarily from the Kyoto Protocol by: a) targeting all countries instead of developed countries only, b) targeting all GHG instead of specific ones, and c) setting a limit on the temperature rise instead of a limit on the concentration of GHG in the atmosphere.

There are two main ways to address climate change. The first is to reduce its causes (referred to as ‘mitigation’) and the second it to adapt to its effects (adaptation). It is important to note that these are not mutually exclusive and must be used together to tackle ‘wicked problems’ associated with climate change (IPCC, 2022). For a long time, the international scientific and policy communities have focused on climate mitigation considerations. Only recently have they turned their attention to adaptation¹ and vulnerability² issues, recognizing that adaptation is necessary due to the inertia of the climate system (Comte, 2018; Ayers & Huq, 2009). The Paris Agreement has reinforced the consideration of adaptation issues in the climate negotiations, by encouraging balanced allocation of funds for adaptation and mitigation (Shrestha & Dhakal, 2019).

Article 2 of the Paris Agreement lists the three main objectives of the Agreement on mitigation, adaptation and finance, respectively. These are: (a) “holding the increase in global average temperature well below 2°C compared to pre-industrial levels, and continue efforts to limit the temperature increase to 1.5°C”; (b) “increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience”; and (c) “making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development”. In particular, Parties have agreed to deliver climate financial flows to USD 100 billion by 2025. The Green Climate Fund has been established within the UNFCCC framework to assist developing countries in climate adaptation and mitigation practices. This fund is intended to be the main channel for raising climate finance under the UNFCCC.

1.2. The need to plan and implement climate action at the national scale: the Nationally Determined Contributions elaborated under the Paris Agreement

While climate action should be defined at the international level to allow for a robust framework (Stern, 2006), the Paris Agreement requires each Party to “prepare, communicate and maintain successive Nationally Determined Contributions (NDCs) that it intends to achieve” (Article 4, paragraph 2). NDCs

¹ The IPCC (2022) defines adaptation as “the process of adjustment to actual or expected climate and its effects in order to moderate harm or take advantage of beneficial opportunities. In natural systems, adaptation is the process of adjustment to actual climate and its effects; human intervention may facilitate this.”

² The IPCC (2022) defines vulnerability as “the propensity or predisposition to be adversely affected and encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.” This notion is further explained in the sub-section 3.3 of this manuscript.

are the national climate plans containing specific targets and actions that countries intend to implement in order to mitigate climate change and adapt to its effects. The formulation of climate plans is a novelty of the Paris Agreement as compared to previous climate agreements. The elaboration of NDCs is mandatory for Parties to the Paris Agreement, and all Parties should develop mitigation actions. As NDCs represent national climate priorities, processes and capacities, they vary greatly among countries in terms of format, scale and level of detail (Crumpler & Bernoux, 2020). The Paris Agreement recognizes the specific needs and special circumstances of least developed and developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change. Accordingly, NDCs should reflect the country's "highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances" (Paris Agreement, Article 4, paragraph 3).

Parties are required to periodically submit a revised (or "updated") NDC to the UNFCCC Secretariat, which should represent an improvement over their previous NDC in order to increase ambition over time (Fig 0.1). So far, all Parties to the Paris Agreement have developed and submitted at least a first NDC. Most of these original (or "first") NDCs were submitted by countries in 2015 or 2016. Parties were therefore asked to submit their revised NDCs before December 2020 (extended to the end of 2021 due to delays associated with the COVID-19 pandemic), and then every five years (i.e., by 2025, 2030), regardless of their respective implementation schedules. As of 2 November 2021, just after the deadline for the first round of NDC update, 151 Parties had submitted a revised NDC to the UNFCCC Secretariat. This deadline corresponds to the beginning of the 26th Conference of Parties (COP26) of the UNFCCC held in Glasgow (United Kingdom). A first global assessment, called "global stocktake", will be conducted in 2023 to evaluate progress toward the long-term goals of the Paris Agreement at the global scale. The results of this global stocktake will inform the next round of NDC submissions (Fig 0.1).

Limiting global temperature rise to 1.5°C by 2100 is unlikely (IPCC, 2022; Raftery et al., 2017). Based on policies currently in place around the world as of September 2022, the global temperature increase would reach approximately 2.8°C by 2100 (UNEP, 2022a) (Fig. 0.2). The implementation of the NDCs submitted to date (September 2022) would reduce this increase to 2.4 - 2.6°C by 2100, for conditional³ and unconditional pledges respectively (UNEP, 2022a). When binding long-term or net-zero targets are included, warming would be limited to about 2.0°C above pre-industrial levels (Fig. 0.2). To foster climate action, the Glasgow Climate Pact was adopted in November 2021 during the 26th Conference of Parties (COP26) of the UNFCCC. This Pact calls on all Parties to revisit and strengthen the 2030 targets

³ A NDC document may include some actions (or commitments) that are conditional, and others that are unconditional. An unconditional contribution is one that the country could implement based on its own resources and capacities, whereas a conditional contribution could be undertaken only if international support is provided, or if other conditions are met.

in their NDCs by the end of 2022. However, only 24 revised NDCs have been submitted between November 2021 and September 2022 (United Nations, 2022).

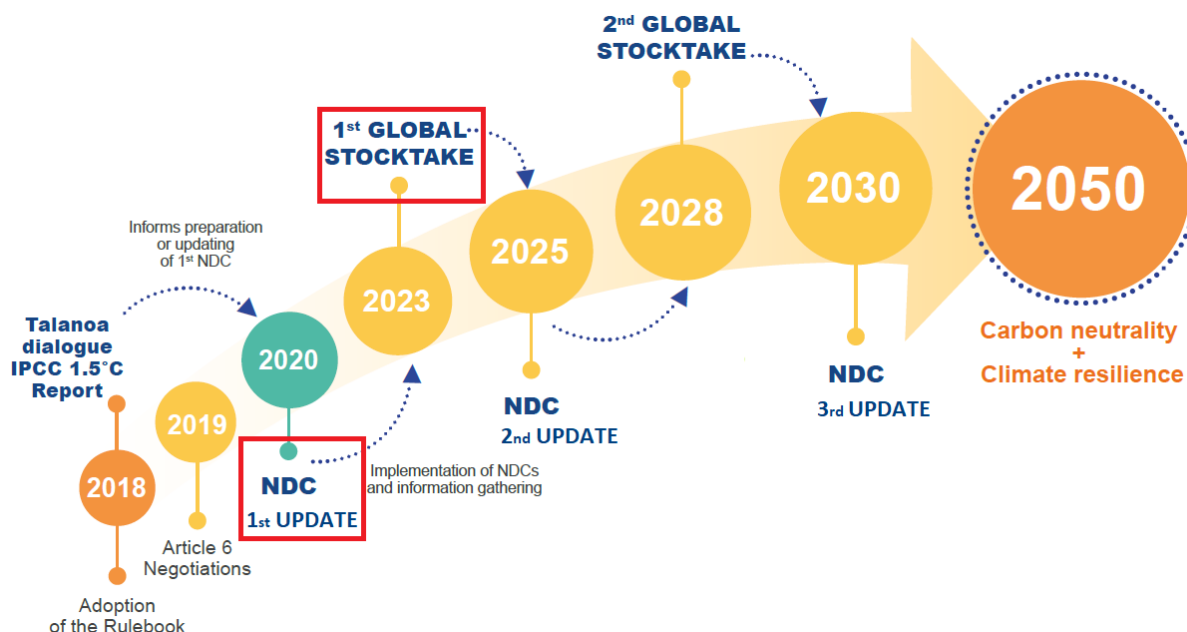


Fig. 0.1: Ambition mechanism of the Paris Agreement. Adapted from the World Resources Institute (wri.org/publication/NDC-enhancement-by-2020).

Limiting global warming to 1.5°C will require a deep cut in GHG emissions (of 43%) by 2030 and achieving net-zero emission by 2050 (Fig. 0.2) (IPCC, 2021; Rogelj et al., 2018). Deep cuts in GHG emissions will imply switching away from burning fossil fuels and towards using energy from low-carbon sources, such as wind or solar. Conserving and restoring natural ecosystems such as terrestrial and coastal forests (i.e., mangroves) and seagrasses can also help mitigate climate impacts, as they remove carbon from the atmosphere and store it in their roots and soil (Alongi, 2014; Canadell & Raupach, 2008). Conversely, their destruction stops carbon sequestration and releases in the atmosphere the carbon they had stored. Recent research suggests that initiatives based on the conservation and restoration of natural ecosystems could provide in a cost-effective way 30% of the mitigation that is need by 2030 to stabilize warming to below 2°C (Seddon et al., 2019), while providing many other co-benefits for nature health and people (Chausson et al., 2020; Seddon et al., 2020b; Hoegh-Guldberg et al., 2019a). Transition toward low-carbon and resilient societies requires urgent action to realign the financial system toward environmental finance flows (UNEP, 2022a; UNEP, 2022b). The Intergovernmental Panel on Climate Change (IPCC) estimated that global investment in climate mitigation needs to increase three to six times in developed countries, and even more in developing countries (UNEP, 2022a). In terms of adaptation, the finance gap is likely to be five to ten times greater than current international adaptation finance flows (UNEP, 2022b).

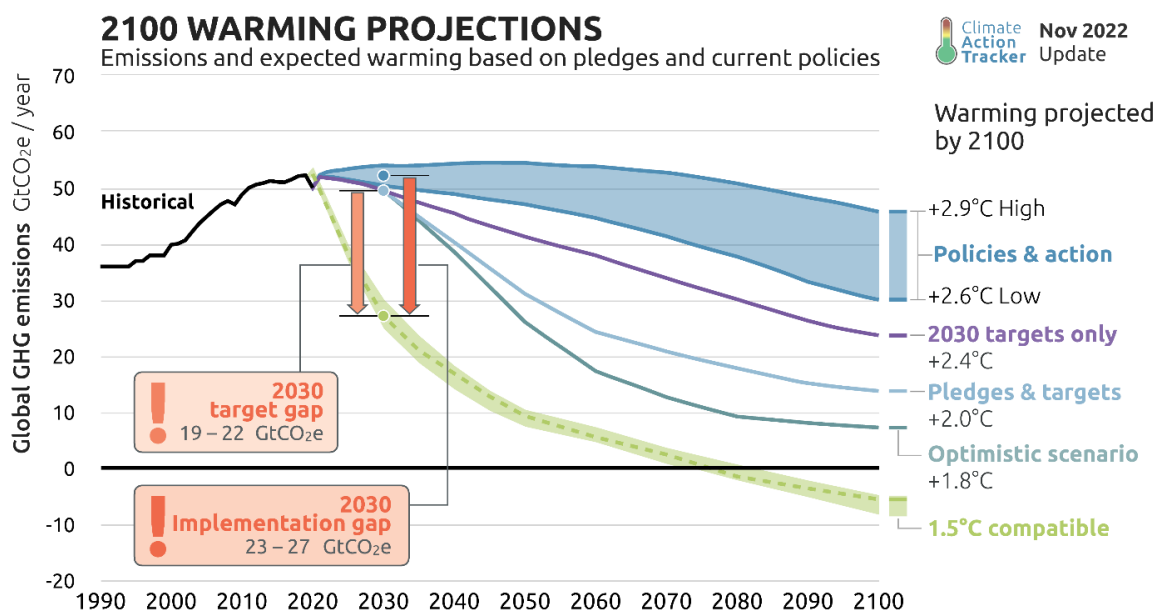


Fig. 0.2: Global emissions and expected warming by 2100 based on pledges and current policies. Pledges refer to the NDCs undertaken under the Paris Agreement. Source: Climate Action Tracker 2022.

2. The interconnections between the climate, biodiversity and ocean systems

2.1. The biodiversity crisis and the growing recognition of nature’s contribution to human health and well-being

The biosphere is today probably engaged in the sixth mass extinction (Dirzo et al., 2014; Butchart et al., 2010). The current rate of global biodiversity⁴ loss is estimated to be 100 to 1000 times higher than background extinction rate (Dasgupta, 2021). This nature loss and degradation is due to the combined effects of habitat alteration, resource overexploitation, pollution, climate change and invasive alien species (IPBES, 2019). These effects threaten not only species but also human health, safety and well-being (Cardinale et al., 2012).

To limit the decline of biodiversity and associated impacts on human well-being, the international community adopted the Convention on Biological Diversity⁵ (CBD) at the Rio Summit in 1992 (simultaneously with the UNFCCC on climate change). The three main objectives of the CBD are (1)

⁴ “Biodiversity” – or “biological diversity” is commonly defined as “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems” (Romanelli et al., 2015).

⁵ While equitable human development is at the heart of the Sustainable Development Goals (SDGs) and while the 2050 carbon neutrality target is at the heart of the Paris agreement under the UNFCCC, there is no equivalent specific target for nature in the global biodiversity conventions and agreements (i.e., the CBD). For Locke et al (2021), the following three measurable time biodiversity targets should be adopted: net positive nature by 2030, and full recovery by 2050.

the conservation of biological diversity, (2) the sustainable use of its components, and (3) the fair and equitable sharing of benefits arising from genetic resources. The same year, the sustainable development principle was also first institutionalized with the Rio Process. Sustainable development recognizes the need to maintain the stability of natural ecosystems through the sustainable use of these ecosystems, in order to support human development now and for future generations (Imperatives, 1987).

The contribution of nature to human well-being was first reaffirmed in the reports of the Millennium Ecosystem Assessment (MEA, 2005) and of The Economics of Ecosystems and Biodiversity (TEEB, 2010) (Cullen-Unsworth et al., 2014). The MEA (2005) recognizes that biological diversity contributes not only to human well-being and livelihoods, but also to human security, resilience, social relationships, and health. Ecosystem services, which are the benefits that humans derive from nature, reflect this link between biodiversity and human well-being (Sala et al., 2021; MEA, 2005). Although the MEA emphasizes the links between ecosystems and human well-being, it also recognizes the intrinsic value of species and ecosystems (MEA, 2005). The TEEB is an international initiative framed into the MEA, which aims at drawing attention to the global economic benefits of biodiversity. Both approaches seek to highlight the importance of nature to people, including by assigning economic values to natural resources and assets.

Biodiversity issues are increasingly integrated with human well-being challenges with the emergence of influential initiatives promoting holistic and interdisciplinary approaches to protecting biodiversity and human health. Three of these most influential concepts include One Health (launched in 2008 by the United Nations to promote interdisciplinary research in public health and veterinary medicine), EcoHealth (more focused on biodiversity with an emphasis on all living creatures) and Planetary Health (the most recent of the three, primarily focused on human health) (Lerner & Berg, 2017). These concepts affirm the interdependence of animal, human and ecosystem health through (i) the identification of solutions that address the root causes and links between risks and impacts, and (ii) the development of shared databases and surveillance across different sectors and research fields (e.g., public health, ecosystem management, climate sciences, ecology, anthropology, veterinary medicine) (WHO, 2017). These concepts incorporate climate considerations in both their principles and work approaches, recognizing the need to mitigate climate change to improve natural ecosystem and human health. They also underscore the need to work in a more interdisciplinary manner with climate researchers in order to (i) better understand the impacts of climate-related environmental change on human health (Patz & Hahn, 2012) and (ii) to find common solutions or, when these are not possible, carefully manage trade-offs (Romanelli et al., 2015). Although these concepts are increasingly well-known⁶ by policy-makers, they still suffer from a significant lack of practical recognition (Olive et al., 2022).

⁶ For instance, a recent report from the Pacific regional program SPREP (2021) outlines the importance of the One Health approach to enhance the health and resilience of natural and social systems in the Pacific.

2.2. The need to tackle the climate and biodiversity crisis jointly: from separateness to convergence

Climate change and biodiversity issues have historically been addressed separately at international (Dobush et al., 2022) and national policy levels (Schmidt-Traub et al., 2021). Through the 17 Sustainable Development Goals (SDGs) defined in 2015 by the United Nations, both climate change and biodiversity are seen as major challenges to meeting global human development needs. The Sustainable Development Goals are a universal attempt to provide a roadmap of pathways leading to sustainability for 2030 (Bitoun et al., 2022). They consist of 17 interlinked global goals designed to be a “shared blueprint for peace and prosperity for people and the planet, now and into the future” (United Nations, 2015). Climate change is currently embodied in the SDG framework through SDG 13 “Climate action”, while biodiversity is addressed through SDG 14 “Life below water” and SDG 15 “Life on Land”.

The achievement of the 17 SDGs is strongly dependent on the preservation and good management of natural ecosystems, and on adequately addressing climate change (Bitoun et al., 2022). For example, climate change can undermine 16 of the 17 SDGs, while combatting climate change can reinforce all 17 SDGs (Fuso Nerini et al., 2019). More specifically, the climate and biodiversity crises are interconnected and share common causes induced by anthropogenic activities: while climate influences biodiversity, the reverse is also true (Fig. 0.3) (Deprez et al., 2021; Pörtner et al., 2021; Romanelli et al., 2015). For example, climate change can affect species distributions and abundances (Cheung et al., 2009), while vegetation can mitigate climate impacts by sequestering carbon (McLeod et al., 2011; Lal et al., 2005). This interconnectedness is expressed in the preamble of the Paris Agreement (2015), which notes “the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity [...] when taking action to address climate change”. In December 2020, the workshop co-sponsored by the IPCC and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) concluded that these two crises are closely linked and, importantly, that they must be addressed in an integrated manner to reduce their causes and avoid maladaptation (IPCC, 2021; Pörtner et al., 2021; IPBES, 2019). An “equitable, carbon-neutral, nature-positive world” is a concept that has recently emerged to help address biodiversity loss, climate change and development inequalities in a more coherent way (Deprez et al., 2021; Locke et al., 2021). The need to address in a holistic manner the global climate and biodiversity crisis is also highlighted in the cover Decision of the climate COP27 (November 2022). This Decision “underlines the urgent need to address, in a comprehensive and synergetic manner, the interlinked global crises of climate change and biodiversity loss in the broader context of achieving the Sustainable Development Goals, as well as the vital importance of protecting, conserving and restoring nature and ecosystems for effective and sustainable climate action”.

Nevertheless, the global targets for climate (SDG 13) and biodiversity (SDG 14 & SDG 15) are not being met; like inequality, they continue to rise, and some trends appear to be nearing their tipping points

(IPBES, 2019). Despite the growing awareness of the interconnectedness of global challenges illustrated by the establishment of a UN 2030 Agenda for Sustainable Development, there is room to improve this interconnectedness in policy frameworks (Dobush et al., 2022). This can be achieved by further integrating the international conventions on biodiversity (i.e., the CBD) and climate (the UNFCCC) and the SDGs more generally, and by fostering dialogue between stakeholders (Bitoun et al., 2022; Dobush et al. 2022; Fuso Nerini et al., 2019; Smith et al., 2019).

From climate risk to climate resilient development: climate, ecosystems (including biodiversity) and human society as coupled systems

(a) Main interactions and trends

(b) Options to reduce climate risks and establish resilience

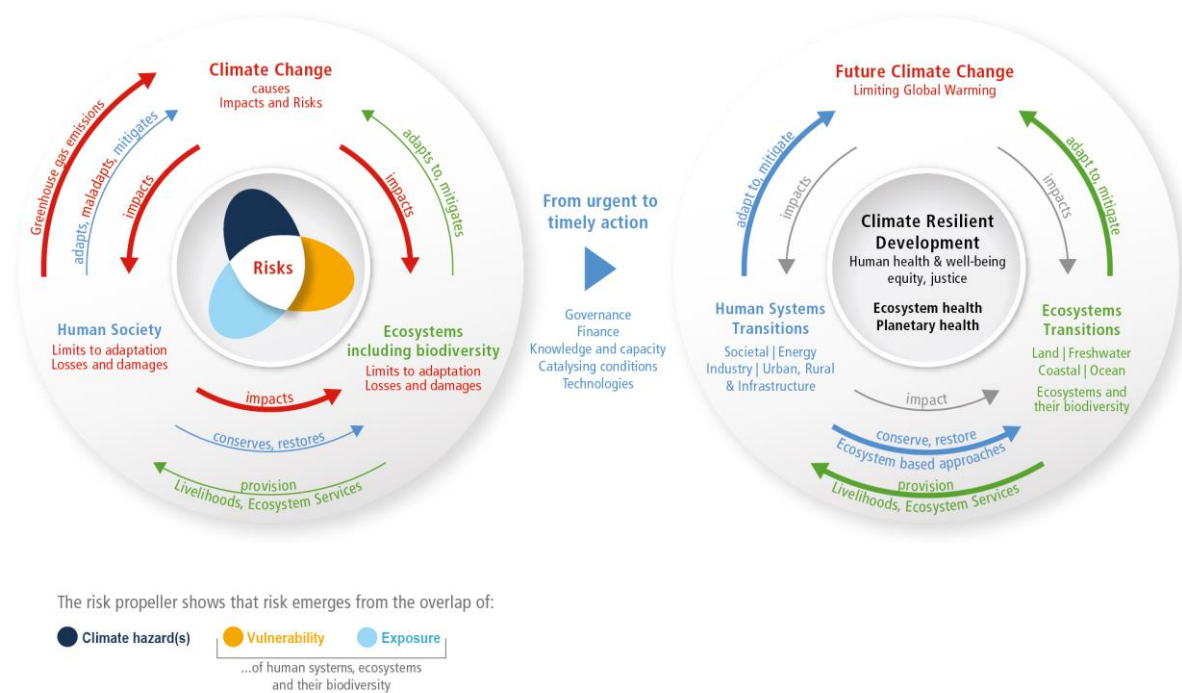


Fig. 0.3: Interactions between climate, ecosystems and their biodiversity, and human society. Source: IPCC AR6 WGII, Summary for policymakers (2022).

2.3. Nature-based Solutions: an increasingly recognized concept

2.3.1. Definition of Nature-based Solutions

The recent emergence and popularization of the concept of Nature-based Solutions (NbS) illustrates the growing recognition of the need to address the global environmental crisis in a more integrated manner, and the role that nature can play in climate mitigation and adaptation (Seddon et al., 2020b). In 2016, the International Union for Conservation of Nature (IUCN) defined NbS 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” (Cohen-Shacham et al., 2016). In 2022, the Fifth Session of the United Nations Environment Assesmbly

(UNEA-5) has made a resolution on adopting a multilaterally agreed definition of NbS. This multilateral agreement defines NbS as « **actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits** ». The NbS concept embraces established approaches, such as “ecosystem-based adaptation”, “natural infrastructure”, “green and blue infrastructure”, “ecosystem-based disaster risk reduction” (Chausson et al., 2020), and the more recently coined “nature climate solutions” (Griscom et al., 2017). A growing body of literature advises to scale-up the implementation of NbS worldwide to address climate change mitigation and adaptation with broader essential benefits for life. This echoes the “new social contract” between science and society in the 21st century, according to which science should provide solutions and guidance to address major societal challenges in addition to generating new knowledge (Clark, 2007; Lubchenco, 1998).

2.3.2. Characteristics of NbS: multiple co-benefits and low costs in many contexts

Through their global systematic map of evidence on the effectiveness of NbS interventions, Chausson et al. (2020) have shown that most of the NbS were reported to have less trade-offs between climate, ecological and social outcomes than solutions based on infrastructure or created ecosystems such as seawalls or afforestation. As compared to engineered solutions, NbS also present the advantage to provide a wider range of co-benefits for nature and people (e.g., food security, coastal protection, habitats for species) (Chausson et al., 2020; Seddon et al., 2020b; Reid et al., 2018). For example, restoring mangroves can help protect coastal populations from flooding, while protecting biodiversity and increasing carbon sequestration. It should be noted, however, that any management initiative can lead to positive, negative or neutral outcomes depending on the viewpoint (O’Leary et al., 2022). Furthermore, in many contexts, NbS are low-cost options compared to technical solutions (Gattuso et al., 2021; Chausson et al., 2020; Seddon et al., 2020a; Hoegh-Guldberg et al., 2019a; Morris et al., 2018; Narayan et al., 2016).

2.3.3. Endorsement of NbS in global policy instruments

For all of these reasons, the NbS concept has gained momentum under the CBD and UNFCCC frameworks (Martin et al., 2020), as illustrated by their recent inclusion in the Kunming-Montreal Global Biodiversity Framework adopted at biodiversity COP15 in December 2022, and in the climate COP27 cover decision in November 2022. More specifically, the COP27 cover decision text (Draft decisions 1/CP.27 and 1/CMA.4) “encourages Parties to consider, as appropriate, nature-based solutions and ecosystem-based approaches for their mitigation and adaptation action while ensuring relevant social and environmental safeguards”. The NbS concept has also been endorsed in the IPBES Global Assessment, the Climate Change and Land Report of the IPCC, and the Global Adaptation Commission

Report (Seddon et al., 2020b). In addition, ecosystem restoration has become a significant feature of policy agendas, with a global goal of restoring at least 20% of ecosystems for 2050, including freshwater and marine habitats. This is one of the five main goals of the CBD Post-2020 Framework. Today, more than 90 countries worldwide have committed to scaling up the adoption of NbS through the signature of the Leaders Pledge for Nature, a commitment to take urgent action to address biodiversity loss. However, we should note here that the NbS concept also raises concerns related to potential misuses and caveats, in particular in the Global South (Melanidis & Hagerman, 2022). These concerns are further detailed in Section 6 of the General Introduction, entitled “Potential caveats and challenges associated with NbS”.

2.4. The need to take the ocean into account for addressing the joint climate-biodiversity crisis

Until recently, the ocean has been the forgotten part of the fight against climate change. Yet it is at the heart of the Earth's climate system because it regulates the planet's temperature and weather patterns, through its capacity to absorb heat and carbon dioxide, and redistribute them around the globe (IPCC, 2019). The increasing pressures faced by the ocean (climate change and direct anthropogenic pressures) affect its ability to regulate the climate and provide many other benefits for biodiversity and human well-being (IPCC, 2019). The ocean is at the same time very affected by anthropogenic pressures, and a source of solutions to tackle the global climate-biodiversity crisis (Sala et al., 2021; Hoegh-Guldberg et al., 2019b; IPBES, 2019; IPCC, 2019; Barbier et al., 2011; Mcleod et al., 2011). These aspects are further explained in the subsections below.

2.4.1. The effects of climate change and other anthropogenic pressures on the ocean and coastal ecosystems

Climate change contributes to the decline in coastal ecosystems worldwide, threatening many marine species as well as human populations who depend upon these ecosystems (IPCC, 2022; IPBES, 2019; Hills et al., 2013). The main direct effects of climate change on the ocean include ocean warming, acidification and deoxygenation (IPCC, 2019). These effects are inducing physio-chemical and ecological changes in the ocean that are already highly affecting marine species and humans⁷ (IPCC, 2019). Coastal human populations are not the only ones affected, as “all of Earth's inhabitants depend directly or indirectly on the ocean” (IPCC, 2019). A major impact of climate change is sea level rise (SLR), caused primarily by the added water from melting ice sheets and glacier and by the expansion of ocean water due to ocean warming (IPCC, 2019). SLR is already affecting many coastal ecosystems and human populations worldwide. It increases coastal erosion and flooding, which damage coastal

⁷ Changes induced by climate change on coastal and marine ecosystems in the Pacific tend to have negative effects but can also provide opportunities and positive societal outcomes at the local scale in certain circumstances, for example by providing new harvesting opportunities due to change in fisheries (Dutra et al., 2019 ; Johnson et al., 2020).

ecosystems and infrastructure, and threaten food and water security through the salinization of crops and ground waters (Chui et al., 2013). The impacts of SLR on human populations are expected to increase worldwide due to the combined effect of climate change and coastal population growth (Neumann et al., 2015). According to the IPCC (2019), 20–90% of current coastal wetland areas could be lost by 2100 due to SLR inundation alone.

Warmer waters and change in ocean currents induce change in species distribution and abundance. For instance, the tuna biomass of the South Pacific region is projected to progressively move eastward and to higher latitudes in response to changes in ocean properties (Bell et al., 2021). This will have severe implications for the many PSIDS that are economically highly tuna-dependent (Bell et al., 2021). Change in tuna biomass is particularly critical for Kiribati, where the average annual tuna-fishing access fees (for the period 2015-2018) accounted for more than 70.6% of the government revenues, as well as for the Federated States of Micronesia (47.6%), the Marshall Islands (47.8%) and Tuvalu (53.9%) (Bell et al., 2021).

Ocean acidification and warming, combined with other pressures (mainly pollution, destructive fishing methods, mining), pose a major threat to coral reefs (Burke et al., 2011) by altering their biological and physical structure (Pratchett et al., 2017). Coral reef degradation is projected to increase, with an estimated loss of 99% of warm-water corals if global temperatures rise above 2°C (UNEP, 2021; IPCC, 2018). Even if the Paris Agreement’s goal of limiting the global temperature increase to 1.5°C is met, 70-90% of the world’s corals would be lost by 2100 (Frieler et al., 2013; Donner et al., 2009). This degradation is likely to have disastrous consequences for both marine life - as coral reefs are critical habitats for marine species (Roberts et al., 2002) - and for humans, given the human dependence on coral reefs worldwide (Comte and Pendleton, 2018; Hughes et al., 2017). Indeed, over 500 million people depend on coral reef fisheries and other resources provided by coral reefs (e.g., medicines) (Hoegh-Guldberg, 2011a). Climate change also puts additional pressure on mangrove ecosystems, which are already affected by other anthropogenic impacts (e.g., clearing for development, pollution) and natural disasters (e.g., cyclones). In particular, mangrove decline associated with climate change is related to unstable and changing shorelines: mangroves respond rapidly to sea-level variations through erosion and accretion of sediments and changes in salinity and frequency of inundation (Duke et al., 2015). Global mangrove cover is estimated to have declined by 35% between 1980 and 2000 (Valiela et al., 2001) and to have further declined by 2.1% (3363 km²) between 2000 and 2016. However, this global decline would be mainly due to conversion to aquaculture and agriculture (Hagger et al., 2022; Goldberg et al., 2020). Mangrove loss and degradation diminishes the livelihood, income, and welfare services of mangrove-dependent people in the tropics (Mohammed, 2012): mangrove support the livelihoods of at least 4.1 million small-scale fishers and provide flood protection worth an estimated \$US 65 billion per year globally (Hagger et al., 2022). Along with coral reefs and mangroves, seagrass ecosystems are declining worldwide, despite their importance for sustaining marine life and human

livelihoods notably through their contribution to coastal fisheries and coastal protection (McKenzie et al., 2021a; McKenzie et al., 2021b; Unworth et al., 2019; Cullen-Unsworth et al., 2014; Waycott et al., 2009). Rates of seagrass loss are comparable to those reported for coral reefs, mangroves and tropical rainforests, and make seagrasses among the most threatened ecosystems on the planet (Waycott et al., 2009).

2.4.2. Coastal ecosystems as part of the solution to tackle the climate and biodiversity crisis

The ocean and its coastal ecosystems contribute to reduce the causes and consequences of climate change, globally and locally (IPCC, 2019), and therefore provide opportunities to tackle climate change, as promoted by recent scientific reports (Gattuso et al., 2022; Von Schuckmann et al., 2020; Hoegh-Guldberg et al., 2019a). Several initiatives promoting the contribution of coastal ecosystems to climate adaptation and mitigation are flourishing, both globally (e.g., through the Because the Ocean (2019) initiative, and the United Nations Decade of Ocean Science for sustainable Development 2020-2030) and regionally (e.g., the Pacific Initiative for Climate and Biodiversity, and the Kiwa Initiative for climate resilience of Pacific communities).

The ocean contributes to climate mitigation by absorbing heat and carbon dioxide from the atmosphere. Since the pre-industrial era, the global ocean has so far absorbed about 90% of the global thermal surplus (IPCC, 2013) and more than 25% of atmospheric carbon dioxide (Le Quéré et al., 2012). Ninety percent of the process of carbon dioxide sequestration is physico-chemical: at the ocean-atmosphere interface, the carbon dioxide is dissolved and then transported by ocean currents into the deep ocean (POC, 2023; IPCC, 2019). Ten percent of this process is biological, through the photosynthetic mechanisms of ocean species, such as phytoplankton, mangroves, salt marshes and seagrasses. On the coasts, the ecosystems that contribute to climate change mitigation by sequestering and storing carbon are commonly referred to as “blue carbon ecosystems” and generally refer to mangroves, seagrasses, and salt marshes (IPCC, 2019; Duarte et al., 2013). The contribution of blue carbon ecosystems to climate change mitigation has gained attention in the international scientific and policy arenas (Howard et al., 2017), as they exhibit disproportionately high rates of carbon storage compared to other ecosystems (Alongi, 2014; Duarte et al., 2013; Mcleod et al., 2011). Per year, blue carbon ecosystems contribute to storing about 0.5-2% of annual human-induced GHG emissions (IPCC, 2019; POC, 2023). Moreover, assuming that the historical losses of blue carbon ecosystems (50% for mangroves since the 1940s, 29% for seagrasses since 1879, 25% for salt marshes since the early 1800s (McLeod et al., 2011; Waycott et al., 2009) are rapidly reversed by restoration, the maximum cumulative carbon burial by these ecosystems would be 26 million tons of carbon by 2100 (Gattuso et al., 2021). This is equivalent to about 2.5 years of current anthropogenic emissions (Gattuso et al., 2021). When wider impacts on the environment and social well-being are considered, actions based on the protection and restoration of coastal ecosystems offer the best combination of carbon mitigation and broader co-benefits, according to Hoegh-Guldberg et al. (2019a).

Blue carbon ecosystems exclude coral reefs, seaweeds, and phytoplankton (Lovelock and Duarte, 2019). Coral reefs release more carbon than they store (Howard et al, 2017; Gattuso et al., 1999; Ware et al., 1992). While seaweeds are important components of the oceanic carbon cycle, and despite the existence of studies highlighting their role in carbon sequestration and storage (e.g., in Froehlich et al., 2019, and Chung et al., 2011), their contribution in long-term sequestration is not scientifically enacted (Gallagher et al., 2022; Ross et al., 2022; Lovelock and Duarte, 2019; Macreadie et al., 2019; Howard et al., 2017). Indeed, scientific gaps remain in understanding their carbon stocks and fluxes. In addition, the potential management or accounting of carbon sequestration associated with seaweed is currently limited (Lovelock and Duarte, 2019). Regarding phytoplankton, their mitigation potential is recognized (Howard et al., 2017), but their limited management potential excludes - for now - phytoplankton from blue carbon ecosystems (Lovelock and Duarte, 2019; Howard et al., 2017).

In terms of adaptation, coastal ecosystems are essential to help people cope with climate change impacts. Mangroves, coral reefs and seagrasses help protect coastlines against the impacts of intense storms and tsunamis, as well as from erosion and submersion, by acting as natural barriers to wave energy (Fig. 0.4) (Cameron et al., 2021; McKenzie et al., 2021b; Hochard et al., 2019; Earp et al., 2018; Guannel et al., 2016). More generally, coastal ecosystems provide numerous ecosystem services to people worldwide, such as food provision (e.g., through coastal fisheries), culture (e.g., through coastal tourism and recreation, spiritual beliefs), and maintenance of life and natural cycles (McKenzie et al., 2021b; Barbier et al., 2017; Hilmi et al., 2014).

Coastal ecosystems such as coral reefs, mangroves and seagrasses have developed a capacity to withstand and recover from disturbances caused by anthropogenic activities and climate hazards (Earp et al., 2018). This resilience is explained in part by cross-ecosystem interactions, where one ecosystem provides favorable conditions to the maintenance and health of its neighbors (Fig. 0.4) (Earp et al., 2018). For instance, coastal ecosystems complement each other to reduce climate impacts (Earp et al., 2018; Guannel et al., 2016). Guannel et al (2016) showed that, together, coral reefs, mangroves and seagrasses supply more coastal protection services than any individual habitat or combination of two habitats. The resilience of coastal ecosystems is nevertheless challenged by the threats that weigh on them, reducing their ability to sustain life and human well-being (Doney et al., 2012; Harley et al., 2006). The challenges of protecting, restoring or managing coastal ecosystems in general in a context of high environmental pressures are further described in Section 3 of the General Introduction entitled “Coastal nature-based solutions for climate” below.

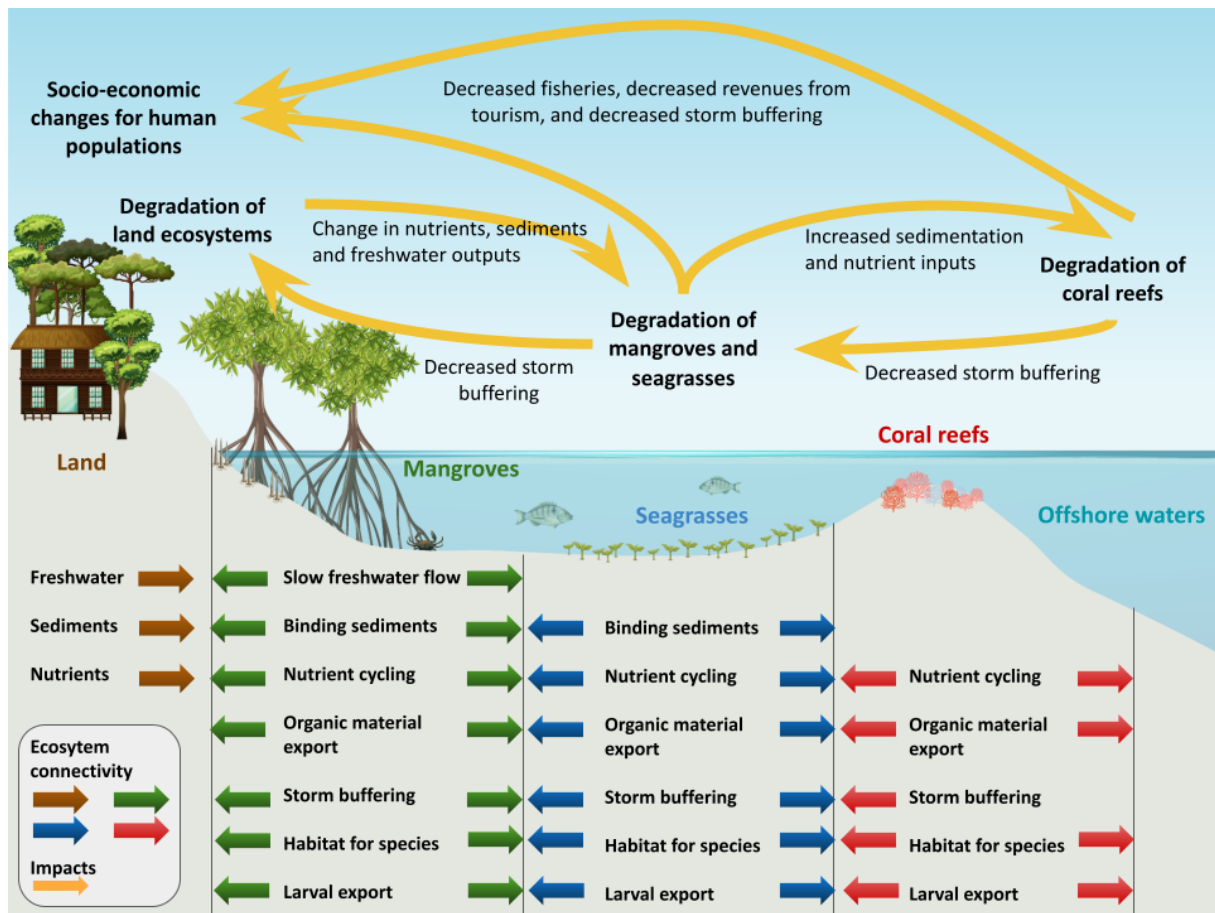


Fig. 0.4: Interdependencies between coral reefs, mangroves and seagrasses along the tropical seascape. Conception: Châles, F. & Guillou, C. Adapted from Earp et al. (2018).

2.4.3. The emergence of ocean policies

Today, the ocean is governed by multiple policies at international⁸, regional, and national levels. National policies have traditionally been sector-based, focusing on fishing, tourism, transportation or environmental related issues (Hills et al., 2021). The recognition in international agreements of the ocean's key contribution to reduce climate impacts and nature loss and degradation is recent (Dobush et al., 2022). Understanding how the climate governance regime should address ocean-related issues is part of ongoing debates within the UNFCCC framework (Dobush et al., 2022). The Ocean and Climate Change Dialogue, launched during COP25 in 2020, is the first forum for Parties and non-Party stakeholders of the UNFCCC to share their opinion on how the ocean should be integrated within the climate policy mechanisms (Dobush et al., 2022). The submissions to this Dialogue highlight a political evolution towards the nexus between climate, ocean, and biodiversity issues. Dobush et al. (2022) found

⁸ In particular, the United Nations Convention on the Law of the Sea (UNCLOS), which came into force in 1994, is an international agreement that establishes a legal framework for marine activities. As UNCLOS does not currently provide a framework for marine areas beyond national jurisdictions, the agreement "Biodiversity Beyond National Jurisdiction" is currently being negotiated at the United Nations.

that the submissions recognize that the ocean and the climate systems are inextricably linked, and that consideration of ocean action will enhance climate action and vice versa.

The health of the ocean and its ecosystems are also a high and growing focus of the CBD (CBD, 2022) and of the 2030 Agenda for Sustainable Development (“2030 Agenda”) of the United Nations. In particular, the 196 Parties to the CBD have committed to reach the Aichi targets (2010-2020), which include a commitment to protect at least 10% of the marine and coastal areas globally by 2020, through marine protected areas (MPAs). However, this goal has not been reached, as MPAs cover 8.1% of the ocean surface in November 2022 (for the updated percentage of MPAs, the reader can refer to the website: <https://www.protectedplanet.net/en/thematic-areas/marine-protected-areas>). As pressure on the ocean continues to increase (IPCC, 2019), the global goal of “30x30” to protect 30% of the ocean by 2030 is supported by various institutions, such as the European Commission and the IUCN.

National level policies for the oceans are more holistic (i.e., less sector-based) than they were in the past, and increasingly include actions that are designed to tackle intertwined challenges, such as the degradation of the environment, climate change, and human needs and development (Hills et al., 2021). At the national level, National Ocean Policies (NOPs) are increasingly developed by countries, including PSIDS (Hills et al., 2021), as an attempt to address ocean issues in a more holistic approach. However, these national policies have sometimes failed to deliver on their promises, which is the case with Australia's Oceans Policy (Vince et al., 2015). As another example, the Solomon Islands' NOP does not fundamentally set a new direction for ocean governance but builds primarily on existing national or regional policies and their key themes (Hills et al., 2021). For this reason, Hills et al. (2021) argue that the advantage of the NOP lies less in its content than in the creation of an allied inter-ministerial architecture.

3. Coastal nature-based solutions for climate

3.1. Definition and characteristics of coastal NbS for climate

The IPCC (2022) highlights a range of solutions to mitigate climate change and enhance the adaptation of ecosystems and human populations, which include coastal nature-based solutions (“coastal NbS”). Applying the UNEA definition of NbS (see sub-section 2.2.2) to the coastal environment, coastal NbS for climate⁹ refer to the protection, conservation, restoration and other sustainable management measures of coastal ecosystems for climate mitigation and/or adaptation purposes, with simultaneous benefits for biodiversity and human well-being, ecosystem services and resilience. The IPCC (2022) distinguishes three types of marine NbS: (i) the marine protected areas (MPAs), (ii) the restoration of ecosystems, and (iii) the sustainable management of fisheries. MPAs are marine geographical areas that

⁹ The terms “coastal NbS” and “coastal NbS for climate” will be used interchangeable in this manuscript, as all coastal NbS refer to NbS for climate (adaptation and/or mitigation) in this thesis.

are subject to a protection regime and whose objective is to preserve the biodiversity they contain. The higher level of protection, the more human activities are restricted or even prohibited, and the greater the ecological benefits. Ecological restoration refers to interventions aimed at promoting the regeneration of degraded or destroyed ecosystems. Mangrove replanting is an example of a coastal restoration initiative. Sustainable fisheries management helps to better protect species from the impacts of pressures induced for example by climate change, to support biodiversity and fish resources and sustain the livelihoods of the human populations that depend on them. Measures include, for example, setting quotas on fish caught, a minimum catch size to protect juveniles, or a ban on fishing techniques that are harmful to ecosystems, such as trawling (POC, 2023; IPCC, 2022).

When adequately designed, coastal NbS demonstrated effectiveness in both mitigating climate change and in supporting coastal biodiversity and the livelihoods and safety of local human populations (Chausson et al., 2020; Seddon et al., 2020b; Hoegh-Gulberg et al., 2019a). Coastal NbS contribute to major societal challenges of the century, as illustrated by their contribution to the SDGs. In addition to contributing to climate action (SDG 13) and to the preservation of marine life (SDG 14), coastal NbS also contribute to the maintenance of fisheries and thus to the achievement of the goals on “No poverty” (SDG 1), “Zero hunger” (SDG 2), “Good Health and Well-Being” (SDG 3) and “Sustainable cities and communities” (SDG 11). Moreover, including citizens and ensuring better representation of women in ecosystem management contributes to the goals on “Reduced Inequalities” (SDG 10) and “Gender Equality” (SDG 5) (POC, 2023).

Like terrestrial NbS, coastal NbS are in many contexts low-cost (Seddon et al., 2020a; Seddon et al., 2020b) and low-risk (Gattuso et al., 2021) options compared to engineering climate options. This does not mean that coastal NbS are cost-free, but their benefits are considered greater on average than their costs. For instance, Narayan et al. (2016) estimated that coastal NbS such as mangrove restoration are two to five times cheaper than a submerged breakwater for wave heights up to half a meter and can become more cost-effective at greater depths. For these reasons, coastal NbS are considered as “low-regret” and priority actions for climate by Gattuso et al. (2021). This is not the case of many other ocean-based climate actions, such as ocean alkalization (considered as “risky”) and marine bioenergy with carbon capture and storage (effect unproven) to mitigate climate change, and infrastructure-based adaptation¹⁰ (risky) (Gattuso et al., 2021).

However, the potential of coastal ecosystems for climate mitigation and adaptation is challenged, because coastal ecosystems are highly sensitive to climate impacts, which are going to worsen in the coming decades (Williamson & Gattuso, 2022). In particular, the restoration of blue carbon ecosystems

¹⁰ Seawalls and other infrastructure-based adaptation measures can protect densely populated coastlines from sea level rise, but they can be counterproductive for natural coastal ecosystems (e.g., sand dunes, mangroves, coral reefs) because they tend to undermine ecosystems’ natural adjustments to ocean change, inland migration, and buffering function against storm surges (Gattuso et al., 2022; Nunn et al., 2021).

is questionable when it comes to climate mitigation. Williamson & Gattuso (2022) have shown that significant challenges and uncertainties remain in achieving quantified and reliable carbon removal through the restoration of blue carbon ecosystems. These challenges are due to high variability in carbon burial rates, errors in determining these rates, uncertainties on methane, carbon, nitrous oxide fluxes and vulnerability to future climate change and other factors. Hence, restoring blue carbon ecosystems would have questionable cost-effectiveness when considered as a climate mitigation action only, either for carbon-offsetting or for inclusion in NDCs (Williamson & Gattuso, 2022). However, coastal restoration remains highly advantageous for climate adaptation, including coastal protection, food provision and biodiversity conservation (Williamson & Gattuso, 2022). In their meta-analysis of the peer-reviewed literature on the outcomes of mangrove restoration, Su et al. (2021) showed that mangroves perform less ecosystem functions than natural mangroves, but much more than unvegetated mud, sand flats or abandoned aquaculture ponds. Su et al. (2021) also argued that mangrove restoration is a cost-effective form of ecosystem management. Hence, urgent action is needed to prevent further degradation and loss of coastal ecosystems by protecting them, and reverse the downward trends of the recent decades by restoring them (Su et al., 2021; Duarte et al., 2020; Mcleod et al., 2011).

The challenge is to implement those actions that are most likely to be effective in the long term, i.e. actions that will produce long-term benefits for life on Earth. This implies determining where (proper places), what (right species) and how (e.g., through which management arrangements) actions should be prioritized (Song et al., 2023). In particular, restoration actions must carefully consider the unique local characteristics of coastal ecosystems (such as their exposure and sensitivity to threats and to environmental adequate conditions including hydrology, soil and water pH, soil texture, wave energy and nutrients) to secure long-term benefits for biodiversity and people (Lovelock & Brown, 2019; Kamali & Hashim, 2011). Restoration actions should also be based on a thorough understanding of the causes of ecosystem degradation or loss. Coastal ecosystems (especially mangroves and seagrasses) can even recover naturally if environmental conditions are appropriate (Kamali & Hashim, 2011). The expansion of mangroves can occur naturally in space if available; thus, if a decline is expected in the shoreline, expansion may happen further downstream (Duke et al., 2015). Section 6 of the General Introduction further describes the challenges associated with coastal NbS design and implementation.

3.2. Inclusion of coastal NbS in climate policies

For all the reasons listed in the previous sub-section, the political and scientific communities increasingly view coastal NbS as valuable actions to tackle the global environmental crisis (Griscom et al., 2017). Incorporating coastal NbS in climate plans such as NDCs is one way to foster the implementation of coastal NbS, through enhanced policy coherence across sectors like climate, ocean and biodiversity, and enhanced ambition through the five-year revision process of the NDC cycle (Fig. 0.1). The opportunity to include coastal NbS in climate plans such as NDCs is therefore supported by

various research studies (e.g., in Dencer-Brown et al., 2022; Lecerf et al., 2021; Northrop et al., 2020; Cooley et al., 2019; Seddon et al., 2019; Herr & Landis., 2016). It is also supported by the United Nations Environment Programme under the UNFCCC (UNEP, 2019), as well as by non-governmental organizations (e.g., IUCN) and international initiatives (e.g., Because the Ocean, The Ocean Solutions Initiative). Comparisons between original and revised NDCs showed that NDCs increasingly incorporate coastal NbS over time globally¹¹ (Khan et al., 2022; Lecerf et al., 2021). This suggests a greater appreciation of the role played by coastal NbS in achieving the goals of the Paris Agreement. Seventy-seven of the 106 revised NDCs from island and coastal states worldwide (73%) include at least one ocean-based climate action (Khan et al., 2022). Despite this growing recognition, coastal NbS are still largely under-exploited in climate policies such as NDCs, according to Gattuso et al. (2022).

4. Scope of the thesis work

4.1. Geographical scope of the thesis work

The implementation of coastal NbS appears to be particularly relevant in countries that are vulnerable to both climate impacts and coastal ecosystem degradation and loss. This is the case of PSIDS, which are (i) highly exposed to climate impacts (IPCC, 2022; IPCC, 2014), (ii) heavily reliant upon coastal ecosystems and ocean resources for livelihoods (Buckwell et al., 2020; Veron et al., 2019; Veitayaki & Ledua, 2016), and (iii) have limited adaptive capacity to cope with impacts (Asch et al., 2018).

The geographical scope of the thesis corresponds to the fifteen PSIDS that are independent¹² countries of the United Nations and members of the Alliance of Small Island States (AOSIS). AOSIS is an intergovernmental organization of coastal and small island countries established in 1990. PSIDS spread across the three macro-regions of the South West Pacific Ocean, which are Melanesia, Micronesia and Polynesia (Fig. 0.5). PSIDS are the Cook Islands, the Federated States of Micronesia, Fiji, Kiribati, Nauru, Niue, Palau, Papua New Guinea, the Republic of the Marshall Islands, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, and Vanuatu. I chose to include Timor-Leste in the scope of the thesis because it is part of the Pacific SIDS grouping (and not to the Indian Ocean grouping) according to the United Nations¹³ and according to the AOSIS¹⁴. Timor-Leste is geopolitically and culturally situated at the crossroads of Southeast Asia and of the Pacific Islands region, and is part of some regional governance structures and institutions of both regions (Sousa-Santos, 2015). However, Timor-Leste is

¹¹ According to Khan et al. (2022), 51 revised NDCs of coastal and island states include at least one ocean target, policy, or measure for climate mitigation, compared to 31 original NDCs in the first round of submissions.

¹² Niue is not a member of the United Nations, but United Nations organizations have accepted its status as a freely associated state to New Zealand as equivalent to independence for the purposes of international law.

¹³ PSIDS grouping according to the United Nations can be found at: <https://sustainabledevelopment.un.org/topics/sids/list>

¹⁴ PSIDS grouping according to the AOSIS can be found at: <https://www.aosis.org/about/member-states/>

absent from major Pacific groups, such as the Pacific Island Forum¹⁵. This decision to include Timor-Leste in the analysis was driven by the fact that Timor-Leste is recognized as a PSIDS by the United Nations and AOSIS. Furthermore, I did not consider as part of the scope the Territories of the Pacific region, such as American Samoa, French Polynesia, New Caledonia or Tokelau. Indeed, this thesis work is based on an analysis of national policies developed under the United Nations framework (such as NDCs), and the Territories are non-United Nations Members and therefore do not develop NDCs. In thesis Chapter 1, Chapter 2 and Chapter 3, all these fifteen PSIDS are considered. In Chapter 4 however, I focus on the local scale (a village) in one specific PSIDS, Fiji.

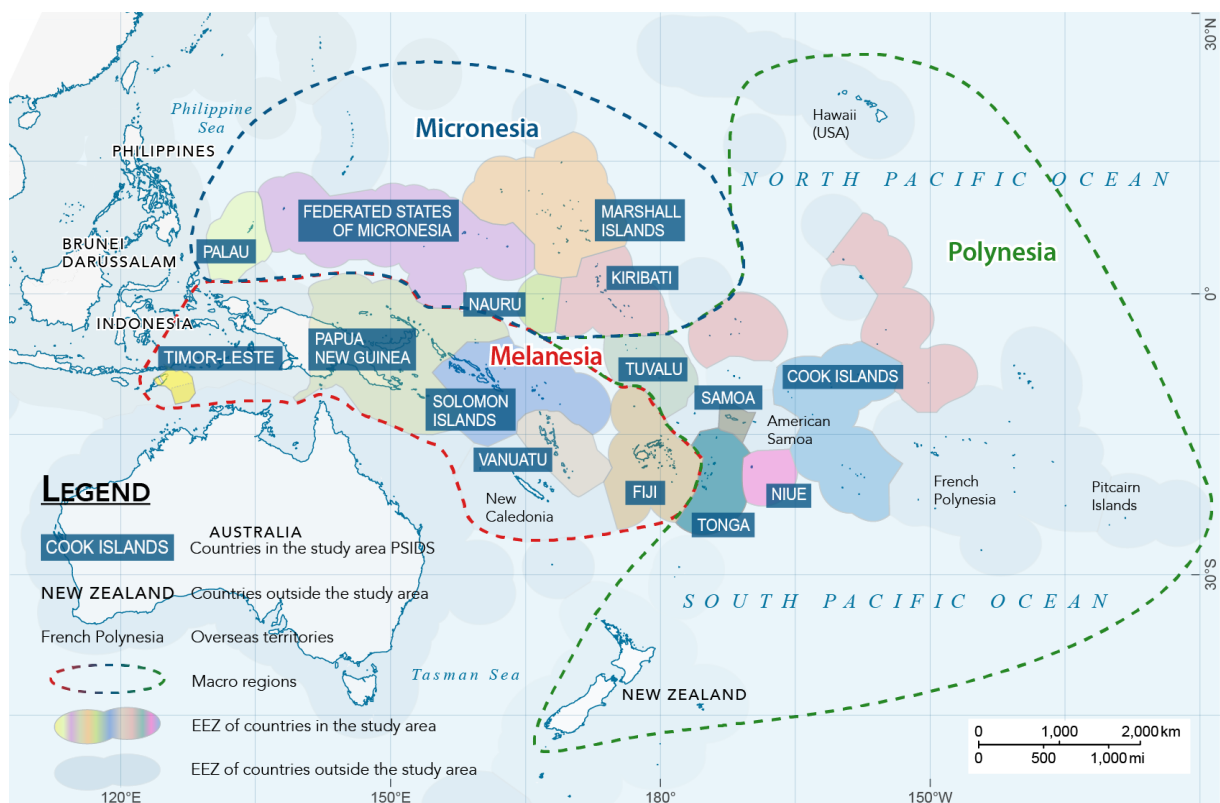


Fig. 0.5: The Pacific Small Island Developing States, their exclusive economic zones and macro-regions.

4.2. Ecosystems considered in this thesis

In this thesis, the coastal ecosystems considered in coastal NbS are coral reefs, mangroves, seagrasses, and associated coastal fisheries. These coastal ecosystems are manageable and iconic coastal ecosystems in PSIDS, providing valuable site-specific goods and services (Himes-Cornell et al., 2018; Howard et al., 2017; Gilman et al., 2006). While mangroves and seagrasses play an important role in both climate mitigation and adaptation, coral reefs contribute to adaptation only (Howard et al, 2017; Gattuso et al.,

¹⁵ Members of the Pacific Islands Forum can be found at: <https://cooperation-regionale.gouv.nc/en/cooperation-pacific/pacific-islands-forum-pif>.

1999; Ware et al., 1992), as detailed in sub-section 2.4.2. Despite their role in climate mitigation and adaptation, I did not include salt marshes in the scope of research because their abundance in PSIDS is mostly unknown and likely to be very low (Himes-Cornell et al., 2018; Mcowen et al., 2017). Salt marshes are more abundant in temperate latitudes (Himes-Cornell et al., 2018). I did not include offshore ecosystems as part of the scope because there are currently knowledge gaps on how offshore ecosystems such as phytoplankton and algae contribute to climate mitigation (Ross et al., 2022; Lovelock & Duarte, 2019). In addition, their potential for management is limited as these ecosystems are difficult to observe and extend across national boundaries (Lovelock & Duarte, 2019).

4.3. A first overview of the thesis work

This thesis mainly focuses on policy design, which refers to the formulation of policies to address societal issues. It does not study the implementation and the monitoring of policy actions. This thesis first investigates how PSIDS include coastal NbS in their policies to address the joint climate-biodiversity-ocean challenges, by analyzing a wide range of policies, including NDCs. One problem is that policies do not always achieve the desired outcomes (i.e., their goals). Hence, assessment and management tools and principles have been developed at the global level to help practitioners and policy-makers design actions that are more likely to produce positive outcomes. Hence, this thesis also explores how certain tools and principles for policy design are relevant for PSIDS. Section 8 entitled “Thesis research questions and outline” describes into more detail the scope and structure of the thesis.

5. Case study: the Pacific Small Island Developing States

5.1. A diversity of geographical, socio-economic and ecological characteristics among PSIDS

This Section 5 develops some characteristics of the PSIDS that are relevant for the thesis. The PSIDS have a combined human population of about twelve million (Table 0.1). The PSIDS’ land territories consist of approximately 200 high islands and 2,500 low islands (Vince et al., 2017). PSIDS exhibit a wide range of island sizes, geographical and ecological features, and differences in socio-economic characteristics (SPREP, 2021; Campbell and Barnett, 2010). For example, Niue is composed of a single atoll with a population of 1,591 inhabitants, while the Solomon Islands are composed of 900 islands (with the highest peak at 2335 meters), and are home to approximately 712,000 people (Table 0.1). Papua New Guinea is considered a SIDS despite its size (462,840 km²). With a population of about 9 million, Papua New Guinea accounts for about 80% of the total population of the PSIDS. While Cook Islands have a human development index considered high (0.829 in 2018), the United Nations (2021) consider Kiribati, Solomon Islands, Timor-Leste, Tuvalu and Vanuatu as least developed countries.

Table 0.1: Characteristics of the Pacific Small Island Developing States. Population estimates and Gross domestic product (GDP) per capita are from: <https://sdd.spc.int/topic/population>. Proximity from the sea is from McKenzie et al. (2021a). Land area and coastal lengths estimates are from McKenzie et al. (2021a). Estimates for exclusive economic zones are from <https://mpatlas.org/countries/>.

	PSIDS	Population (2020)	Proximity from the sea (% of total population)			Land area (km ²)	Exclusive economic zone (km ²)	Coastline length (km)	GDP (USD) per capita
			< 1 km	< 5 km	< 10 km				
Melanesia	Fiji	894,960	27	76	91	18,333	1,282,978	4,638	6,152
	Papua New Guinea	8,934,474	8	21	30	462,840	2,403,355	20,197	2,854
	Timor-Leste	1,321,929	N/A	N/A	N/A	15,000	70,474	783	5,400
	Solomon Islands	712,077	65	91	98	28,230	1,605,325	9,880	2,295
	Vanuatu	294,691	64	94	99	12,281	810,608	3,132	3,260
Micronesia	Federated States of Micronesia	105,504	89	100	100	701	3,010,644	1,295	3,830
	Kiribati	118,749	100	100	100	811	3,440,220	1,961	1,636
	Nauru	11,691	93	100	100	21	309,261	30	11,666
	Palau	17,934	93	100	100	444	614,807	1,482	15,673
	R. of Marshall Islands	54,584	100	100	100	181	2,001,567	2,106	4,337
Polynesia	Cook Islands	15,277	91	100	100	237	1,969,553	120	24,913
	Niue	1,568	25	83	100	259	318,140	64	18,757
	Samoa	198,656	61	97	100	2,934	130,480	463	4,284
	Tonga	99,775	84	100	100	749	666,052	909	5,081
	Tuvalu	10,577	100	100	100	26	753,133	24	4,223
Total	All PSIDS	11,897,486				543,047	19,386,597	47,084	

PSIDS are home to biodiversity-rich island ecosystems characterized by a high level of endemism (SPREP, 2021; Jupiter et al., 2014). There are great differences in the abundance and diversity of coral reefs (Chin et al., 2010), mangroves (Bhattarai et al., 2011) and seagrasses (McKenzie et al., 2021a) in PSIDS (Table 0.2). Coastal ecosystems can be abundant (for instance, in Palau, the area of coral reefs represents seven times the country’s land area; Table 0.2), or almost absent (for example, mangrove estimations are very low in Kiribati and in the Marshall Islands; Table 0.2). On average, the coverages of both coral reefs, mangroves and seagrasses decrease as the distance to the nearest continent (Australia) increases (Table 0.2).

Table 0.2: Mangrove, seagrass and coral reef coverages in the Pacific Small Island Developing States, and associated proportion of the countries' land areas.

	PSIDS	Mangroves		Seagrasses		Coral reefs	
		Coverage (km ²)	% of the country's land area	Coverage (km ²)	% of the country's land area	Coverage (km ²)	% of the country's land area
Melanesia	Fiji	525	3	500	3	6,704	37
	Papua New Guinea	4,801	1	1,091	<1	14,535	3
	Solomon Islands	470	2	506	2	6,743	24
	Timor-Leste	13**	<1	43**	<1	146**	1
	Vanuatu	14	<1	27	<1	1,803	15
Micronesia	Federated States of Micronesia	99	14	67	10	4,925	703
	Kiribati	0.2	<1	N/A	N/A	3,041	375
	Marshall Islands	0.02	<1	N/A	N/A	3,558	1,965
	Nauru	0.04	<1	N/A	N/A	15	71
	Palau	57	13	75	17	966	218
Polynesia	Samoa	3.7	<1	14	<1	402	14
	Cook Islands	0	N/A	N/A	N/A	528	223
	Niue	0	N/A	N/A	N/A	45	17
	Tonga	7.8	1	23	3	1,662	222
	Tuvalu	0.09	<1	0.01	<1	3,175	12,212
Data Source		Bhattarai & Giri (2011), Alongi (2014)		McKenzie et al. (2021a), **Seagrass watch		Chin et al. (2011), **Seagrass watch	

5.2. Large Ocean States

PSIDS also share common features and characteristics. First, their marine territories are often extremely larger than their land territories (Table 0.1). The maritime jurisdiction of PSIDS is around 40 million km² while the region's land area is less than 0.6 million km² (Vince et al., 2017; Power, 2002). Land in PSIDS represents only 2% of the total area, and less than 0.4% if Papua New Guinea, the biggest country, is excluded (Vince et al., 2017; Veitayaki & Ledua, 2016). For instance, Tuvalu's exclusive economic zone (EEZ) is 27,000 times larger than its land territory. As a result, PSIDS occupy an important and strategic position in the global geostrategic arena, with increasing interest from companies and states in their marine resources (e.g., tuna, deep-sea minerals) (Veitayaki & Ledua, 2016). In addition, 90% of the PSIDS population live within 10 km of the ocean, a number that increases to 97% when Papua New Guinea is excluded (Andrew et al., 2019).

PSIDS place great cultural and spiritual value on the ocean and land as their common heritage. They traditionally view the land and ocean as a whole, with a spiritual entity. In Fiji, this concept is called “Vanua” (Sangha et al., 2019; Long, 2017; Sloan & Chand, 2016). Pacific people do not view the ocean as a place that divides or separates people, but rather as a place that connects them to living species and to each other, as the ocean allows and supports transportation, trade, food, recreation, and solace (Prasad, 2022). To emphasize the fact that they are custodians of vast stretches of ocean to which their economies, cultures, identities, and livelihoods are inextricably linked, PSIDS also identify themselves as “Large Ocean States” (or “Large Ocean Island States”) (Chan, 2018). In this thesis, the term “SIDS” will be used instead of “Large Ocean States” for consistency with the terminology widely used in the UNFCCC framework and in the scientific literature.

5.3. A high vulnerability to environmental changes

In the past, Pacific people have continually responded to environmental changes through their extensive traditional knowledge and practices (Veitayaki et al., 2002). Today, this traditional resilience is eroding, due to the increased exploitation and degradation of environmental resources and the weakening of customary knowledge induced by the attempt to modernize and participate in global economic activities (Remling & Veitayaki., 2016). Due to limited geographical space, the population growth in PSIDS places increasing pressure on available resources (Remling & Veitayaki, 2016). Climate change puts additional pressure on PSIDS, threatening local livelihoods, infrastructures and development aspirations (Remling & Veitayaki, 2016).

5.3.1. Definition of climate vulnerability

The IPCC (2022) defines climate vulnerability as “the propensity or predisposition to be adversely affected” by climate impacts, due to a sensitivity or susceptibility to be harmed and the lack of capacity to cope and adapt. This capacity to cope and adapt is also called “adaptive capacity”. Vulnerability is thus characterized by three attributes: exposure, sensitivity, and adaptive capacity (Comte, 2018; Adger, 2006) (Fig. 0.6).

- (i) Exposure is defined by the IPCC (2022) as “the presence of people; livelihoods; species or ecosystems; environmental functions, services and resources; infrastructure; or economic, social or cultural assets in places and settings that could be adversely affected”.
- (ii) Sensitivity, sometimes referred to as dependence or susceptibility to harm, is the degree to which the exposed system can be affected by climate change.
- (iii) Adaptive capacity is defined as “the ability of a system to evolve to accommodate environmental hazards or policy changes and to cope with increased variability” (IPCC, 2014). Adaptive capacity is an essential condition for reducing vulnerability and allow the resilience of ecosystems and

people. Resilience is defined by the IPCC (2022) as “the ability to maintain essential function, identify and structure, and also the capacity for transformation”.

PSIDS are considered highly vulnerable to climate change impacts by the IPCC (2022, 2014), as they are both exposed and sensitive to environmental changes and have limited resources to cope with adverse impacts. These aspects (exposure, sensitivity and adaptive capacity) are detailed in the three following sub-sections.

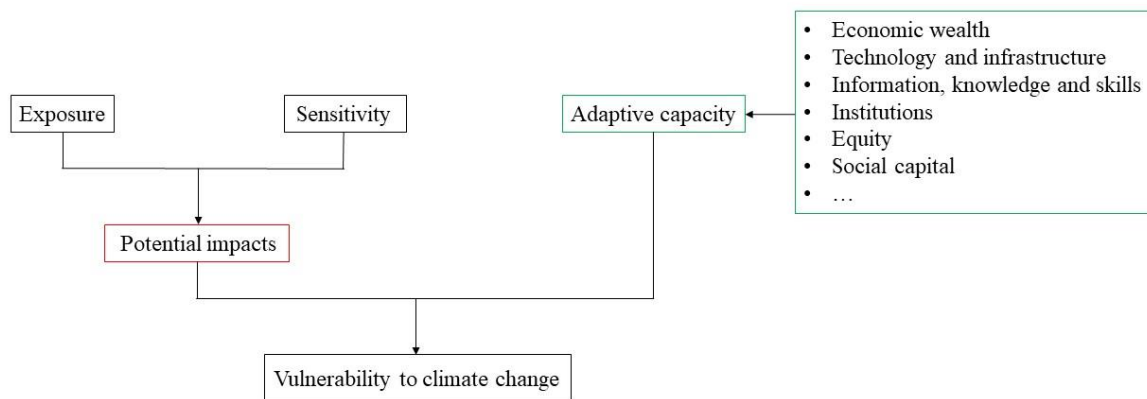


Fig. 0.6: Conceptualization of vulnerability to climate change. Adapted from Ionescu et al. (2009) and Comte et al. (2018).

5.3.2. High exposure of PSIDS to climate impacts

PSIDS are considered highly exposed to climate change impacts, and in particular ocean-related impacts such as SLR and storm surges (IPCC, 2022; CDKN, 2014). This is primarily due to:

- (i) their location in the Tropics where extreme events such as tropical cyclones and low pressure systems are frequent and severe (Kelman, 2009);
- (ii) low-lying island geomorphologies (Kelman, 2009);
- (iii) the fact that more than 90% of the PSIDS population lives within 10 km of the ocean (Andrew et al., 2019).

SLR and changing fishing patterns are expected to be among the greatest challenges of the century for PSIDS (Johnson et al., 2020; Kelman, 2009). In particular, the slow-onset impacts of SLR are perhaps the most certain and potentially devastating negative impacts of climate change (Kelman, 2009). Current SLR impacts in PSIDS include land loss (particularly in Tuvalu, Tonga, Kiribati, and the Marshall Islands), coastal erosion, increased coastal flooding and tides, storms and waves, as well as increased salinization of coastal aquifers, resulting in a loss of biodiversity and a deterioration of human health (Duvat et al., 2021; Martyr-Koller et al., 2021; IPCC, 2019; Chui et al., 2013). Although risk levels vary significantly between islands, depending on geomorphology and local shoreline disturbances (Duvat et

al., 2021), even large PSIDS such as Fiji and Samoa are exposed to SLR since most settlements and infrastructure are located in the coastal zone (Kelman, 2009).

5.3.3. High sensitivity of PSIDS: dependence on coastal ecosystems

In addition, PSIDS rely heavily on coastal ecosystems for livelihoods and income (SPREP, 2021; Buckwell et al., 2020; Grantham et al., 2020; Smallhorn-West et al., 2020; Selig et al., 2019; Veron et al., 2019; Veitayaki et al., 2017; Veitayaki & Ledua, 2016). In PSIDS, coastal ecosystems provide multiple services to people, including through food provision (fish and shellfish), tourism, recreation and solace (Grantham et al., 2020; Smallhorn-West et al., 2020; Veitayaki & Ledua, 2016).

The consumption of fish provides 50-90% of the animal protein for coastal communities in many PSIDS (Bell et al., 2018; Hills et al., 2013; SPC, 2008). Most of this fish comes from small-scale coastal fisheries that contribute to food security both directly through subsistence, and indirectly through incomes earned from selling fish (Bell et al., 2018). Gleaning, which refers to the collect of marine organisms predominantly from intertidal¹⁶ habitats such as reefs and mangroves, also significantly contributes to coastal subsistence and income in PSIDS, particularly in the context of seasonal availability and accessibility of other coastal fisheries (Grantham et al., 2020; Bell et al., 2018).

In addition, the beauty of coastal ecosystems in PSIDS attracts each year a growing number of tourists (Everett et al., 2018). Since the 2010s, coastal tourism has become the main driver of economic growth in many PSIDS, particularly in the Cook Islands, Fiji, Samoa and Vanuatu (Harrison & Prasad., 2013), and it is projected to continue growing in the coming years (Everett et al., 2018; Narayan et al., 2010). In the Cook Islands for instance, tourism accounts for approximately 70% of the gross domestic product (GDP) (Everett et al., 2018).

However, the ability of coastal ecosystems to supply food, tourism and other services to Pacific people is declining, due to the combined effects of coastal development (resulting in ecosystem destruction, pollution and overharvesting) and climate change (Johnson et al., 2021; Hills et al., 2013; Pratchett et al., 2011). In Fiji for instance, mangrove loss rate was of 5% between 1992 and 2007 due to logging and tropical cyclones (Mangubhai et al., 2019). Cameron et al (2021) estimated that tropical cyclones in Fiji were responsible for 77% of mangrove loss between 2001 and 2018. However, predicting how climate change will influence the pattern of tropical cyclones remains unsure (Cameron et al., 2021).

The impacts of climate change on coral reefs are more evident and well-known (Roberts et al., 2002). Ocean warming and acidification have been identified as the main drivers for the deterioration of coral reef structures (Bell et al., 2018; Hoegh-Guldberg et al., 2011b; Pratchett et al., 2011). This decline in coral reef ecosystems and associated coastal fisheries poses an enormous challenge to PSIDS' communities and economies, threatening the livelihoods of people who depend on coastal fisheries for

¹⁶ "Intertidal" designates the area of a seashore that is covered at high tide and uncovered at low tide.

their subsistence and income (Johnson et al., 2020; Hills et al., 2013; Pratchett et al., 2011). More specifically, the productivity of coral reef fisheries is projected to decline by 20% by 2050 under high GHG emissions scenario, due to both the effects of coral reef degradation (Bell et al., 2018; Hoegh-Guldberg et al., 2011b; Pratchett et al., 2011) and changes in fish distribution, availability, and catchability (Pratchett et al., 2017). According to Asch et al. (2018), under a business-as-usual emission scenario (i.e., the RCP 8.5¹⁷ of the IPCC), more than half of PSIDS are likely to experience more than a 50% decrease in maximum fish catch potential by 2050, while impacts can be significantly reduced by mitigation measures under the RCP 2.6 scenario¹⁸. This is particularly the case of Kiribati, Tuvalu, the Cook Islands, the Marshall Islands, the Federated States of Micronesia, Solomon Islands, Papua New Guinea and Niue (Asch et al., 2018).

Dependence on coastal ecosystems is increasing because of lack of food production options to support the growing urban and coastal populations in PSIDS. For example, the number of people in the main (coastal) cities of Kiribati (South Tawara), the Marshall Islands (Majuro), and Tuvalu (Funafuti) is expected to double every 13 years, and space to accommodate this growing population is very limited. This high population growth in PSIDS' urban areas increases the demand for food supply and puts intensive pressure on coastal and marine resources through overfishing and pollution (Veitayaki & Ledua, 2016).

5.3.4. Limited adaptive capacity

PSIDS have limited adaptive capacity to rapidly and effectively adapt to climate change impacts (IPCC, 2022; CDKN, 2014; Campbell and Barnett, 2010). The low adaptive capacity of PSIDS can be explained by both limited resources (financial, human, technical) to deal with climate change impacts (Vince et al., 2017; Campbell & Barnett, 2010) and by their remoteness, which hinders the development of their economies (Van der Veecken et al., 2016; Armstrong et al., 2006). In particular, PSIDS have small administrations facing severe technical and financial constraints (Manoa & Veitayaki, 2009). The revised NDC of Nauru lists 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. Domestic financial resources in most PSIDS are lacking to both rebuild damaged infrastructure (e.g., roads, houses, hospital) after extreme events, and to prevent damage, for instance

¹⁷ RCPs, or “Representative Concentration Pathways”, are the GHG concentration trajectories established in 2014 by the IPCC in 2014 (Fifth Assessment, AR5). They are seven RCPs, corresponding to seven hypothetic climate futures, all of which being considered possible depending on the levels of GHG emissions. The most pessimistic pathway is the RCP 8.5, which corresponds to a “business-as-usual” scenario.

¹⁸ RCP 2.6 was originally (in the Fifth Climate Assessment of the IPCC in 2014) the most optimistic climate pathway, corresponding to a scenario where the peak in GHG emissions would be reached before 2050. It is now the second most optimistic pathway, the most optimistic being the RCP 1.9, which corresponds to a scenario where global warming is limited to below 1.5°C, the aspirational goal of the Paris Agreement.

by building seawalls, planting mangrove or developing early warning systems (UNEP, 2021). A climate vulnerability assessment of Fiji showed that 32,000 people could be pushed into hardship each year because of the impacts from climate change, and that additional US\$ 4.5 billion are needed to help protect the country from climate impacts (Government of Fiji & World Bank, 2017).

Climate change, through hazards, exposure and vulnerability generates impacts and risks that can surpass limits to adaptation and result in losses and damages (Fig. 0.3(a)) (IPCC, 2022). This terminology of “loss and damage” is used under the UNFCCC to refer to the impacts and risks surpassing adaptation potential. Article 8 of the Paris Agreement specifically focuses on this question, which is constantly subject to debates and adjustments. The Warsaw International Mechanism for Loss and Damage, created in 2013, is the main vehicle under the UNFCCC to avert, minimize and address loss and damage. However, in practice, the Warsaw International Mechanism does not make provision for liability or compensation for loss and damage. The climate COP27 (in Sharm el-Sheikh, Egypt, 6-18 November 2022) adopted for the first time a proposal¹⁹ for compensation for loss and damage, whose modalities (who pays and how, who is eligible, in which circumstances) still have to be discussed. This issue is of major importance to PSIDS because, to date, much damage has been done to PSIDS that cannot be repaired (McLean & Heckler, 2017). For example, Cyclone Winston in 2016 killed 44 people, and the associated economic losses in Fiji amounted to almost one third of Fiji’s GDP (OCHA, 2016). These losses and damages are expected to continue growing if no adequate resources are provided to PSIDS to implement adequate actions to cope with climate change (UNEP, 2021).

5.4. Climate leaders and regional cooperation in the South Pacific

PSIDS have strengths to reduce their vulnerability to climate change, such as strong cultural identity, sharing of communal resources, and cultural obligations of reciprocity (Veitayaki & Ledua, 2016). PSIDS are also highly cohesive with each other, and have adopted a regional approach to facilitate marine management through improved cooperation and collaboration (Ourbak and Magnan, 2018). There are many advantages in using a regional approach to develop strategic responses to issues such as climate change (Power, 2002). These advantages include the sharing of high investment or establishment costs for activities; better ability to overcome constraints that arise in small populations and economies; better formulation of policies or activities that have transboundary or mutually reinforcing impacts; resolution of conflicts; and, importantly, stronger voice in global forums (Vince et al, 2017; Power, 2002).

One of the first institutionalized manifestation of the PSIDS’ commitment to political and economic cooperation was the establishment of the Pacific Island Forum (PIF) in 1971. The PIF constitutes the

¹⁹ This proposal is called “Santiago network for averting, minimizing and addressing loss and damage under the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts - Decision - /CP.27” and can be found at: https://unfccc.int/sites/default/files/resource/cp2022_L05_adv.pdf.

main regional cooperation body of the Pacific countries and territories of Oceania (Fry and Tarte, 2016). In 1990, prior to the creation of the UNFCCC, the SIDS (not just those of the Pacific) created the Alliance of Small Island States to help bring the voices of SIDS on climate issues to the United Nations. The creation of this coalition illustrates the early awareness of SIDS regarding climate impacts on their territories. In 2013, PSIDS declared their political commitment to be a region of climate leaders through the Majuro Declaration for climate leadership.

Over the last two decades, the PSIDS have become more organized and stronger on the international stage. They have succeeded in building a common diplomatic discourse and strategy, and in mobilizing political leaders on the climate emergency (Ourbak and Magnan, 2018). In 2015, they demonstrated leadership in raising the ambition of the Paris Agreement to limit global temperature rise to 1.5°C. PSIDS also called for the most developed and high-emitter countries to drastically reduce their GHG emissions and increase financial flows to more vulnerable countries, in line with the goals of the Paris Agreement on mitigation and finance flows. In 2017, the Fiji's presidency at the 23rd Conference of Parties of the UNFCCC (COP23) and at the "2017 Ocean Conference" have allowed Fiji and the other PSIDS to raise awareness of the role of the ocean for sustaining livelihoods. An outcome of COP23 was the launch of the Ocean Partway, which calls for oceans to be an integral part of the UNFCCC process to ensure sustainable development of marine resources.

The PSIDS' regional ocean policy framework is grounded in the Pacific Island Regional Ocean Policy, which was endorsed by the PIF in 2002 (Vince et al., 2017). The determination of PSIDS to protect their ocean environment was reaffirmed in the "2050 Strategy for the Blue Pacific". The 2050 Strategy for the Blue Pacific was endorsed during the 51st meeting of the PIF in July 2022 in Fiji, to collectively achieve the long-term aspirations of PSIDS, through seven thematic areas: political leadership and regionalism, people centered development, peace and security, resource and economic development, climate change and disasters, ocean and natural environment, technology and connectivity. This 2050 Strategy builds on a number of regional agreements and declarations such as the Pacific Plan (2003), the Framework for a Pacific Oceanscape (2010), the Regional Roadmap for Sustainable Fisheries (2015) and the Blue Pacific Narrative (2017).

The Pacific Community (or South Pacific Commission, SPC) and the Secretariat of the Pacific Regional Environment Programme (SPREP) are regional agencies mandated to help PSIDS achieve their policy objectives, by providing technical and scientific advice and facilitate access to funds from donor countries. The SPC is governed by 27 members, including 22 Pacific Island Countries and Territories. The SPREP is governed by 19 members, including the fifteen PSIDS without Timor-Leste, plus

Australia, France²⁰, New Zealand²¹, the United Kingdom²² and the United States of America²³. Unlike the PIF, SPC and SPREP do not deal with military or security issues. Example of ongoing initiatives implemented by SPC or SPREP and focusing on coastal NbS for climate in PSIDS include the joint “Pacific Initiative on Biodiversity, Climate Change and Resilience” launched in 2018, and the “Kiwa Initiative” launched in 2020. Although these regional agencies have provided PSIDS financial and technical support in the past decades (SPC, 2020), they are also criticized for adopting continental-focused solutions that can be inadequate or inappropriate for PSIDS (Veitayaki & Ledua, 2016; Barnett, 2002). Other initiatives have been developed to support the implementation of coastal NbS in PSIDS, such as the “Pacific Mangroves Initiative”, established in 2009 to promote investment and action for sustainable mangrove management in the Pacific Island Countries. Other institutions supporting PSIDS cooperation include the University of the South Pacific and the Pacific Islands Forum Fisheries Agency. Furthermore, the Regional Pacific NDC Hub was created in 2017 at the climate COP23 to support the implementation of NDCs specifically in fifteen Pacific Island Countries and Territories (PICT)²⁴.

5.5. Coastal NbS in PSIDS

Coastal NbS are developed and implemented at the national and sub-national levels in PSIDS, through various policies. Apart from the NDCs, the main national policies dealing with climate issues include the National Adaptation Programmes of Action (NAPAs), the National Adaptation Plans (NAPs), the Nationally Appropriate Mitigation Actions (NAMAs), and the Joint National Action Plans for Disaster Risk Management and Climate Change (JNAPs). These plans are developed under the UNFCCC framework. For instance, all PSIDS have developed a JNAP to address disaster risk issues. The main national policies addressing biodiversity issues are the National Biodiversity Strategy and Action Plans (NBSAPs). NBSAPs are the main instruments for implementing the CBD and, like NDCs, they need to be regularly updated by countries to enhance ambition. As Parties to the CBD, all PSIDS have developed an NBSAP. National forest policies also address issues related to the sustainable management, restoration or conservation of mangroves. More recently, some PSIDS have developed National Ocean Policies (NOPs), as attempts to address in a more coherent manner ocean-related issues, e.g., issues linked to fisheries, tourism or ocean-based energy (Hills et al., 2021).

Governance systems linked to coastal NbS in PSIDS are not limited to modern approaches that are mainly supported by government agencies. Today, many PSIDS manage coastal ecosystems and resources using mixed governance approaches that encompass both centralized government approaches

²⁰ Territories are French Polynesia, New Caledonia, Wallis and Futuna.

²¹ Territory is Tokelau.

²² Territory is Pitcairn Islands.

²³ Territories are American Samoa, Guam, and Northern Mariana Islands.

²⁴ The fifteen PICT of the Regional Pacific NDC Hub include the fifteen PSIDS part of our scope, plus Tokelau, and excluding Timor-Leste.

and traditional and customary practices (Aswani et al., 2017; Vierros et al., 2010). The coastal customary practices, linked to spiritual beliefs and stewardship, have a long history in many PSIDS communities. In most cases, these customary practices were established by traditional leaders to allow depleted marine resources to recover (Vierros et al., 2010). Customary management practices include seasonal harvesting bans, temporary closed (no-take) areas, and restrictions on certain times, places, species or persons. Closed areas include the *tabu* areas of Fiji, Vanuatu and Kiribati, the *ra'ui* in the Cook Islands, the *tambu* in Papua New Guinea, the *bul* in Palau, the *mo* in the Marshall Islands, and the *tapu* in Tonga (Vierros et al., 2010). The specificities of the closed areas differ from country to country. For instance, in Fiji, when a traditional chief dies, certain marine areas are restricted for approximately one hundred nights (Vierros et al., 2010). Some customary practices are still used in many PSIDS to varying degrees, but most have experienced gradual erosion due to the decline of traditional authority and the weakening or loss of respect for customary laws and knowledge during the 20th century colonization (Veitayaki et al., 2011; Vierros et al., 2010; Techera et al., 2009).

Despite these similarities in ways to manage coastal resources and ecosystems (e.g., community-based, sharing-based, mix between traditional and more modern management methods), a coastal management approach that is successful in a given PSIDS cannot be simply duplicated in other PSIDS, as tenure systems and associated political systems remain substantially different among PSIDS (Aswani et al., 2017; Aswani et al., 2014). For instance, Fiji has a more centralized tenurial and political model, while the Solomon Islands and Vanuatu have a more decentralized and politically eclectic tenurial model (Aswani et al., 2017). While the locally managed marine area²⁵ (LMMA) network model was successful in Fiji, similar approaches have failed to deliver desired outcomes in the Solomon Islands and in Vanuatu. This illustrates the fact that solutions to climate change must carefully take into account local social and environmental characteristics.

In PSIDS, coastal management has primarily focused on coral reefs, whereas seagrasses have not been widely considered in policy and legislation so far (McKenzie et al., 2021a; Brodie et al., 2020). The main policy and regulation instruments for coastal NbS in PSIDS include restoration initiatives, as well as MPAs and LMMAs, even though their uses vary widely among PSIDS (Table 0.3). In 2005, Fiji was the first PSIDS to take a commitment of converting 30% of its EEZ into MPAs by 2020. In 2006, the Federated States of Micronesia, Marshall Islands and Palau pledged to follow similar pathways within the framework of the Micronesian Challenge. MPAs are today established globally as effective tools to protect the ocean ecosystems from impactful human activities such as fishing or mining, for enhancing marine biodiversity and promoting sustainable fisheries (Grorud-Colvert et al., 2021). However, levels of protection vary greatly from one MPA to one another, from those that fully protect marine species

²⁵ The IPBES defines an LMMA as an area of nearshore waters and its associated coastal and marine resources that is largely or wholly managed at a local level by the coastal communities, land-owning groups, partner organizations, and/or collaborative government representatives who reside or are based in the immediate area.

and those that allow intensive fishing or mining (Grorud-Colvert et al., 2021). Challenges associated with MPAs notably relate to enforcement, due to difficulties in monitoring and enforcing regulation in large ocean areas, funding (to adequately manage and monitor MPAs), public awareness of the importance of ocean ecosystems, and multidisciplinary research collaborations (Chaboud et al., 2016; Rife et al., 2013). The implementation of coastal NbS such as MPAs and more generally of ocean management actions faces challenges in PSIDS. This aspect is further detailed in the next section.

Table 0.3: Marine Protected Areas (MPA) in the Pacific Small Island Developing States (PSIDS). EEZ: Exclusive Economic Zone. Data is from <https://mpatlas.org/countries/> and are for November 2022. *Fishing protection status.

PSIDS	Country EEZ (km ²)	MPA Status*	Number of zones	MPA Area (km ²)	% EEZ
Cook Islands	1,969,553	Fully /highly protected	8	30.7	< 1
		Less protected/unknown	10	323,108	16
		Total implemented	18	323,138	16
Federated States of Micronesia	3,010,644	Fully /highly protected	0	0	0
		Less protected/unknown	4	180,760	6
		Total implemented	4	180,760	6
Fiji	1,289,978	Fully /highly protected	1	13.6	< 1
		Less protected/unknown	112	12,120	< 1
		Total implemented	113	12,134	< 1
Kiribati	3,440,220	Fully /highly protected	2	395,569	12
		Less protected/unknown	1	2,436	< 1
		Total implemented	3	398,005	12
Marshall Islands	2,001,567	Fully /highly protected	4	6,360	< 1
		Less protected/unknown	7	260	< 1
		Total implemented	11	6,621	< 1
Nauru	309,261	Fully /highly protected	0	0	0
		Less protected/unknown	0	0	0
		Total implemented	0	0	0
Niue	318,140	Fully /highly protected	2	126,974	40
		Less protected/unknown	2	0.111	0
		Total implemented	4	127,053	40
Palau	614,807	Fully /highly protected	19	477,418	78
		Less protected/unknown	25	133,703	22
		Total implemented	44	611,121	> 99
Papua New Guinea	2,403,355	Fully /highly protected	5	10.9	< 1
		Less protected/unknown	30	3,529	< 1
		Total implemented	35	3,540	< 1
Samoa	130,480	Fully /highly protected	0	0	0
		Less protected/unknown	4	98.7	< 1
		Total implemented	4	98.7	< 1

Solomon Islands	1,605,325	Fully /highly protected	19	201	< 1
		Less protected/unknown	30	756	< 1
		Total implemented	49	956	< 1
Timor-Leste	77,474	Fully /highly protected	0	0	0
		Less protected/unknown	12	566	< 1
		Total implemented	12	566	< 1
		Proposed/committed	2	367	< 1
Tonga	666,052	Fully /highly protected	0	0	0
		Less protected/unknown	32	310	< 1
		Total implemented	32	310	< 1
		Designated but not implemented	9	32.8	< 1
Total designated	41	343	< 1		
Tuvalu	753,133	Fully /highly protected	7	165	< 1
		Less protected/unknown	8	41.2	< 1
		Total implemented	15	206	< 1
Vanuatu	810,608	Fully /highly protected	0	0	0
		Less protected/unknown	7	187,080	23
		Total implemented	7	187,080	23

6. Potential caveats and challenges associated with NbS

6.1. Potential caveats and risks

Although the NbS concept has gained momentum in the international scientific and policy spheres (Seddon et al., 2021), the common definition of NbS (i.e., UNEA’s definition, see sub-section 3.1) does not allow for easy operationalization of the concept because it does not provide a definitive set of practical core characteristics (Riisager-Simonsen et al., 2022). Moreover, there is limited experience in developing marine and coastal NbS initiatives worldwide (Riisager-Simonsen et al., 2022).

Many Indigenous people and non-governmental organizations express concerns regarding NbS implementation, especially in the Global South (ILO et al., 2022). While NbS can be viewed as opportunities to conserve local ecosystems and create employment, some communities may view NbS with resistance or skepticism, especially if they are not familiar with the NbS concept or perceive NbS as a threat to their traditional way of life. According to the report “Decent Work in nature-based solutions 2022” (ILO et al., 2022), these concerns are mainly related to the fear of turning nature into a marketable commodity due to the lack of implementation of biodiversity and human rights safeguards in NbS projects. For instance, the Global Forest Coalition expresses concern in a press release²⁶ that the final Global Biodiversity Framework agreement “opens the door widely to private sector financing of

²⁶ The press release is available at: <https://globalforestcoalition.org/press-release-global-biodiversity-deal-calls-for-divestment-from-harmful-industries-recognizes-rights/>.

biodiversity policy, including through false solutions like biodiversity offsets and so-called “Nature-based solutions”, which is code language for the carbon-offset market”.

According to Melanidis & Hagerman (2022), the concept of NbS has two narratives. The first narrative (1) positions NbS as an essential element in tackling climate change, while the second narrative (2) views NbS as “dangerous distractions” that allows for the maintenance of status quo, i.e., not engaging in the deep societal transformations needed to adequately address climate change (IPCC, 2022; Melanidis & Hagerman, 2022). For the advocates of this second narrative, there is a problematic association between NbS and carbon market offsets, which cannot be considered sustainable options if biodiversity and human rights are not properly considered (Melanidis & Hagerman, 2022). Carbon offsets linked to monoculture tree-plantings is commonly used to illustrate this concern (Melanidis & Hagerman, 2022). For example, the concept of NbS, as currently defined, may allow some high GHG emitting companies to offset their emissions by replanting trees in a way that is neither biodiversity-positive nor human-respectful²⁷, and with emissions potentially linked to fossil fuels - which is incompatible with the long-term goals of the Paris Agreement (Melanidis & Hagerman, 2022).

In addition, the long-term climate mitigation effects of some types of NbS initiatives - particularly those focusing on ecosystem restoration (Friedlingstein et al., 2019) - are partly unknown due to the lack of monitoring of carbon fluxes and consideration of carbonate dynamics (Williamson & Gattuso, 2022). Regarding coastal NbS specifically, the climate mitigation potential of coastal restoration initiatives (e.g., planting seagrass or mangrove seedlings in subtidal or intertidal sediments) is uncertain - it would be equivalent to 0.02 to 6.6% of 2020 CO₂ emissions (Friedlingstein et al., 2022). In addition, the long-term climate mitigation effect of coastal ecosystem restoration initiatives is likely to be overestimated and is unpredictable: the security of carbon storage in these ecosystems may be jeopardized by future climate change or direct anthropogenic impacts when ecosystems are destroyed or degraded (Williamson & Gattuso, 2022). For these reasons, Williamson & Gattuso (2022) and Macreadie et al. (2022) argue that it is premature to operationalize marketable blue carbon. NbS initiatives should be carried out in addition to, not a substitute for, deep cut in anthropogenic GHG emissions (Williamson & Gattuso, 2022; Seddon et al., 2021). Additional governance precautions are likely to be needed to avoid perverse incentives and loopholes (Climate Analytics, 2017), which have often occurred when financial incentives to reduce deforestation have been used in the UNFCCC mechanisms under the Kyoto Protocol, such as REDD+²⁸. Nevertheless, only part of NbS can be used in offset and marketable

²⁷ Some communities have been forced to hand over their land to companies or governments in order to generate carbon offsets (Fairhead et al., 2012). The process of appropriation of land and resources for environmental purposes is called « green grabbing » (Fairhead et al., 2012).

²⁸ REDD+ stands for « Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries ». It is a framework created by the UNFCCC to guide activities in the forest sector that reduces GHG emissions from deforestation and forest degradation in developing countries. REDD+ activities are voluntary. The Warsaw

projects, as NbS carried out for climate adaptation purpose do not rely on carbon offset schemes, and are very promising in maintaining or enhancing biodiversity and societal aspirations and needs (Williamson & Gattuso, 2022; Seddon et al., 2021).

6.2. Challenges to NbS implementation: mobilizing funding, monitoring effectiveness and overcoming governance challenges

Even in the case where intentions to safeguard biodiversity and human rights are real, the success of coastal NbS implementation is not guaranteed (Seddon et al., 2020a). Gann et al. (2019) pointed out that many restoration projects and programs for climate and nature have underperformed. Major difficulties can hamper the effectiveness of coastal NbS in delivering climate change mitigation and adaptation outcomes, while sustaining natural ecosystems and other ecosystem services (Wamsler et al., 2020). These include difficulties in measuring NbS effectiveness, mobilizing funding and expertise for their implementation, and overcoming governance challenges (Seddon et al., 2020a). Governance challenges include working with stakeholders from different expertise fields (Wamsler et al., 2020), establishing priority actions that are effective and likely to minimize costs and trade-offs, and in representing the needs and interests of the various stakeholders concerned by the NbS initiative. Trade-offs can arise from the multiplication of policy goals and from interactions between several management actions (Shrestha & Dhakal, 2019). Moreover, implementing ecosystem approaches such as NbS, with the full participation of local stakeholders as required by the IPBES (2022), takes considerable time and, usually, financial resources (Vierros et al., 2010). NbS planning processes and donor funding processes should take these aspects into account (Vierros et al., 2010). The development and implementation of successful NbS projects therefore requires long-term stakeholder involvement (which is sometimes not compatible with the duration of political mandates) and the monitoring of changes through relevant indicators of social, economic and ecological status and well-being (Gattuso et al., 2021; Dutra et al., 2019). Verifying whether NbS provide "biodiversity" and "human well-being" benefits can be difficult in practice and requires in-depth assessments on an almost case-by-case basis (ILO et al., 2022). These challenges are particularly acute in PSIDS, where limited resources and capacities prevent the broad and effective deployment of climate actions, including coastal NbS (IPCC, 2022; SPREP, 2020; Campbell and Barnett, 2010; Manoa & Veitayaki, 2009). Combined with high climate ambition, this can lead in some cases to high ambition statements in NDCs, but without details on how this ambition will be concretely achieved. For example, Michalena et al. (2018) observed that Fiji's NDC is unrealistic in terms of funding, and that improved energy modeling and strategic planning in Fiji and other PSIDS is critical to achieve the countries' climate ambitions.

framework on REDD+ adopted at the climate COP19 in 2013 provides the complete methodological and financing guidance.

7. General principles and tools to address the challenges of coastal NbS implementation

7.1. Policy coherence and integration

Achieving policy coherence is particularly important for policy goals that entail a global dimension, such as climate change, environmental degradation and biodiversity loss (Duguma et al., 2014). Policy coherence is defined by the Organisation for Economic Co-operation and Development as “the systematic promotion of mutually reinforcing policy actions across government departments and agencies in order to create synergies towards achieving the agreed objectives” (OECD, 2015). The policy coherence for sustainable development is an approach and policy tool for integrating the environmental, governance, social and economic dimensions of sustainable development into policy-making, and ensure that they are mutually supportive²⁹ (OECD, 2015). Article 2 of the Paris Agreement calls for fostering action consistent with a low GHG climate resilience path and increased resilience. For instance, an investment in mitigation is climate consistent only if it simultaneously increases resilience (Cochran & Pauthier, 2019).

Environmental policy integration is globally acknowledged as one of the most essential governance processes for developing sustainable development policies in a coherent manner (Adelle & Russel., 2013; United Nations, 1992). While the concepts of policy integration and policy coherence are sometimes used interchangeably (Domorenok et al., 2021), Cejudo & Michel (2017) view policy integration as a *process* by which policies can be coherent (“coherent” is an attribute). For Meijers and Stead (2004), policy integration “concerns the management of cross-cutting issues in policymaking that transcend the boundaries of established policy fields, and which do not correspond to the institutional responsibilities of individual departments”. This concept refers to both horizontal sectoral integration (e.g., between different authority departments such as ministries) or vertical inter-governmental integration in policymaking (e.g., between different governmental levels: national, regional, or local). Integrated management approaches can help harness the synergies and create win-win situations, and limit trade-offs for low-regret decisions (Shreastha & Dhakal, 2019). In this thesis, I analyze a narrower aspect of policy integration through integration in policy design. Here, the degree of integration refers to the extent to which policy actions (such as coastal NbS) are incorporated into different policy documents, and how they are designed to respond to different purposes (e.g., climate mitigation and climate adaptation).

²⁹ In the 2030 Sustainable Development Agenda, policy coherence is reflected in the “Systemic Issues” section of SDG 17 on ‘Strengthening the Means of Implementation and Revitalising the Global Partnership’, and covers the entire scope of the SDGs (Duguma et al., 2014).

We still know little about the composition of countries' climate policy portfolios and whether they are based primarily on specific climate policies or on the integration of climate objectives across multiple areas, such as agriculture or biodiversity (Schmidt & Fleig., 2018). Regarding climate and biodiversity integration more specifically, many authors have suggested that a more integrated approach between mitigation and adaptation, and between climate change and biodiversity, should be scaled-up to reduce trade-offs between them and increase action effectiveness (Swart & Raes, 2015; Duguma et al., 2014). For example, investments in GHG reduction can have either a positive or a negative influence on sustainable development and biodiversity; the chances of positive synergies are greatly increased through cooperation and joint policy, planning and implementation (Smith et al., 2019). For Coscieme et al (2021), Smith et al. (2019) and Herr & Landis (2016), climate and biodiversity policies (both at the international and national levels) should be more integrated, across and within them, in order to reduce costs and trade-offs and increase synergetic potential between sectors. According to a growing body of scientific literature (Dencer-Brown et al., 2022; Lecerf et al., 2021; Northrop et al., 2020; Cooley et al., 2019; Seddon et al., 2019; Herr & Landis, 2016), the inclusion of coastal NbS in climate policies such as NDCs would contribute to enhance climate policy integration by increasing synergies between ocean, biodiversity and climate actions.

In PSIDS, the need to rapidly adapt to climate change impacts is pressing and adds to other critical sustainable development priorities, such as access to basic needs, gender equity, peace and security (Kelman et al., 2009). This calls for an integrated and coherent governance that is more likely to reduce costs, trade-offs and increase synergies between sectors (Coscieme et al., 2021; Herr & Landis, 2016). However, actual pathways to implement integrated policies have been difficult to identify in PSIDS (Manoa & Veitayaki, 2009), and even developed countries struggle to achieve these goals (Vince et al., 2017). There is therefore an interest in investigating how these mitigation-adaptation interconnections and ocean-biodiversity-climate interconnections are made within each NDC, and also across the NDCs and other national policies (such as National Adaptation Plans, National Biodiversity Strategies, or National Ocean Policies).

7.2. The importance of describing NbS in policy documents

In its Article 4, the Paris Agreement asks for countries to include information necessary to clarity, transparency and understanding in their updated NDCs. Three years after its adoption, the Work Programme of the Paris Agreement 2018 details which elements should be included in NDCs in order to understand which actions will be implemented and how, and how their effectiveness will be monitored. These elements include (a) targets and description, including target type(s), (b) target year(s) or period(s), (c) reference points, (d) timeframe(s) and/or periods for implementation, and (e) scope and coverage (UNFCCC, CMA, 2018). The importance of describing these elements in NDCs is supported and explained in a growing body of scientific literature (e.g., in Strauß et al., 2022; Coscieme et al.,

2021; Northrop et al., 2020; Hoegh-Guldberg et al., 2019a). In particular, providing details about actions included in NDCs is needed to enable carbon accounting, forecasting of future climate trends and risks readiness (Northrop et al., 2020). Defining quantitative objectives and timeframes for implementation is important to track progress (Seddon et al., 2020) and allow comparisons between countries so that best practices are shared (Strauß et al., 2022). This practice also helps to enhance policy coherence, which requires a clear translation of the many dimensions of policy objectives into quantifiable targets and meaningful indicators, as well as monitoring the performance of these indicators over time (Duguma et al., 2014). For Strauß et al. (2022), there is a need in SIDS to set clear and meaningful targets for NbS for climate in NDCs that create synergies with biodiversity conservation measures.

The initial round of NDCs (2015-2016) left many gaps in transparency (Fransen et al., 2020). According to UNEP (2022b), evidence suggests that the quality of climate plans worldwide is nonetheless improving over time, notably by including more context-specific information on climate trends and impacts, as well as quantified adaptation targets and associated implementation timeframes. However, regarding climate mitigation, Hoegh-Guldberg et al. (2019a) identify the inclusion of quantified NbS within NDCs and other relevant climate policies as a short-time priority for delivering on mitigation potential of ocean-based climate actions. Yet, as of October 31st 2021, the deadline for countries to submit their updated NDCs to the UNFCCC secretariat, only 8 of the 71 countries that had mentioned coastal and marine NbS in their NDCs had included quantified measures to capture the value of these ecosystems in terms of carbon sequestration and storage (Lecerf et al., 2021; Hoegh-Guldberg et al., 2019b).

7.3. Standardization of NbS

Standards refer to a specified level of quality or achievement, determined by scientific research and opinions from varying disciplines, and views of the general populations. According to IUCN (2020), standardizing NbS could help develop robust NbS, through improved clarity and precision of what the concept of NbS entails and what is required to deploy effective and fair NbS (i.e., NbS that deliver positive ecological and societal outcomes). For IUCN (2020), standardization would be particularly relevant in a context where NbS are increasingly included in climate plans and implemented around the world. To this aim, IUCN developed the Global Standard for NbS, released in July 2020. The objective of the Global Standard for NbS is to provide a common understanding of the NbS concept, help practitioners build robust NbS and share lessons learnt to increase the confidence in NbS among decision-makers (IUCN, 2020). The Standard was developed based on research and public consultations, and is composed of a set of criteria and associated indicators. These criteria are: (i) the NbS responds to identified societal challenges (such as climate mitigation), (ii) the NbS is designed at scale, (iii) it provides net biodiversity benefits, (iv) it is economically viable, (v) it involves a wide range

of stakeholders, (vi) trade-offs are balanced, (vii) there is an effective NbS monitoring, and (viii) the NbS reinforces synergies between plans and sectors (IUCN, 2020).

7.4. Knowledge-based decision-making through the assessment of ecosystem services

Knowledge and evidence-based decision-making is one of five drivers identified by Haas et al. (2021) that influence current ocean governance, in addition to formal rules and institutions, legitimacy of decision-making institutions, stakeholder engagement and participation, and community empowerment. Specifically, knowledge of how coastal ecosystems contribute to human health, safety and well-being can influence ocean governance towards greater social and ecological sustainability (Lau et al., 2019; Unsworth et al., 2019). In particular, the widespread use of knowledge by policy-makers and NbS practitioners is key for successful NbS (O’Leary et al., 2022). Relevant local knowledge include detailed and accurate information regarding the importance of coastal ecosystems for human populations, i.e., which ecosystems matters to whom, and why (Lau et al., 2019). Unsworth et al. (2019) identify the lack of awareness of what seagrasses are and a limited societal recognition of their importance in coastal socio-ecological systems as the main challenge to seagrass conservation. The assessment of ecosystem services (ES) is recognized as a useful tool to allow the consideration of coastal NbS in coastal management (Ellis et al., 2019; Börger et al., 2014). ES assessment can provide a way to justify and set priorities for policies and coastal NbS, by highlighting ecosystem benefits and costs that might have been missed if only commercial revenues and costs were considered, through outlining potential trade-offs among multiple management options (Richards & Friess, 2017; Börger et al., 2014). This practice may be particularly relevant in developing countries where the imperative to simultaneously increase human development, nature protection, and climate adaptation involves prioritizing actions and making choices among various management options.

The assessment of ES consists in outlining the importance of ES to people, either by assigning an economic value³⁰ or not. There are many methodologies available to assess ES, both monetarily (e.g., among the most widely used: benefit transfers, contingent valuation, market prices) or non-monetarily (e.g., methods involving preference ranking). For instance, market prices associated with coastal reef fisheries can be used to partly value the contribution of coral reefs to people, in a given location. The contingent valuation method can be used to assess both how people value and interact with ecosystems, and their preference among several management options, through survey questions on willingness to pay for ES and to accept compensation for the loss of ES.

Accessing accurate and up to date information on ES can be challenging for policy-makers, if there is insufficient understanding of local human interactions with ecosystems, or if knowledge is insufficiently

³⁰ The term “ecosystem service *valuation*” instead of “ecosystem service *assessment*” is more commonly used when it refers to the assessment of ecosystem services in monetary units.

shared (Marre et al., 2016). Until now, the contributions of coastal ecosystems to people have remained poorly understood at the local scale, including in the Pacific region (Blythe et al., 2020). Lau et al. (2019) identify the following main challenges to capture people's perceptions on the importance of ES in PSIDS: (i) coastal ES are difficult to value together as they encompass both marine and terrestrial services, (ii) monetary valuation techniques are often inappropriate because of culturally specific attributions of value, and (iii) people within different communities may hold different ES values. The importance of coastal ecosystems for people can be more accurately reflected by using different ES assessment methods in combination. It is increasingly acknowledged that ES assessment studies should include a diversity of approaches and worldviews, interests and power relations (Ellis et al., 2019). In particular, taking into account the values that local communities place on their natural environment is more likely to lead to more equitable and sustainable policy outcomes (IPBES, 2022; UNEP, 2022b; Pascual et al., 2017). For Díaz et al. (2018) and Pascual et al. (2017), the practical work on ES following on the MEA (2005) does not allow to adequately take into account the multiple viewpoints and perspectives from the social sciences and traditional sciences. The concept of "nature's contributions to people" was developed by the IPBES in 2017 to allow for better consideration of a wider set of viewpoints on ES.

Despite increasing efforts worldwide to include the outcomes of ES assessments in the design of policies, implementation and monitoring (Ruckelshaus et al., 2015), Marre et al. (2016) identifies a need to increase policy recommendations in ES research studies in order to improve coastal management. According to Vince et al. (2017), this practice would help increase the coordination between knowledge holders and decision-makers, which is needed in PSIDS to develop more effective ocean policies.

7.5. The participation of local stakeholders in coastal management

Governance goes beyond formal institutions, laws and public policies (Haas et al., 2021). It encompasses multiple stakeholders (e.g., state actors, communities) and the manner they influence and implement actions (Haas et al., 2021). There is growing evidence that incorporating the needs and concerns of local stakeholders into marine conservation and restoration projects is as important as understanding ecological processes (Hilmi et al., 2014; Cinner & David, 2011). Stakeholder engagement is a governance mechanism that is a guiding principle and pillar of recommendations for policy coherence of sustainable development, according to the OECD (2021). The integration of biodiversity into relevant local and international policies requires the involvement of a wide range of stakeholders (governments, civil society, organizations, as well as indigenous and local communities) (Romanelli et al., 2015). Specifically, involving local communities in coastal decision-making and management is essential for achieving sustainable and fair natural resource management and climate adaptation (IPBES, 2022; Lau et al., 2019). This is because inclusive governance promotes social acceptance, provides local knowledge, and enables more effective monitoring of actions (IPBES, 2022; IPCC; 2022). In turn, the

incorporation of local, traditional and indigenous knowledge in the design, implementation and monitoring of NbS strengthens participation by local and indigenous communities, creating a virtuous circle (UNEP, 2022b). This better inclusion of local stakeholders is not always easy as stakeholders may have conflicting values, aspirations, needs and concerns (David et al., 2010). However, this integrated vision of coastal management based on the participation of local stakeholders aims to facilitate consensus between them, to build common representations of problems and solutions, and thus to reduce the risks of conflict and *in fine* to facilitate the implementation of actions and reinforce their effectiveness (David et al., 2010). Moreover, coastal management and adaptation options in PSIDS should build on traditional knowledge and traditional governance systems to support community-based initiatives and cross-sectoral cooperation to minimize climate change impacts (Dutra et al. 2021; Hilmi et al., 2014). Conversely, management models of coastal NbS that are not consented to and supported by local populations are likely to fail and increase development inequalities (Dencer-Brown et al., 2022; Sangha et al., 2019).

In addition, the inclusion of various local stakeholders supports the development of projects whose objectives are more likely to fit local contexts, through a better consideration of local norms and concerns. Piggott-McKellar et al. (2020) have evaluated the extent to which an adaptation project in Kiribati had been successful. They demonstrated that the outcomes of the projects were ineffective among the target communities because of low identification and consideration of contextual factors (such as social norms, environmental and decision-making structures) when designing and implementing local-level adaptation initiatives. Furthermore, Wright et al. (2006) identified the need to strengthen cooperation between local communities, governments, and other institutions as a prerequisite for improved coastal management in PSIDS. Such collaboration are important for the transfer of lessons learnt from coastal NbS projects (Vierros, 2017). Enhancing cooperation on NbS projects between communities and local agencies (governmental and non-governmental) is particularly needed in PSIDS because coastal ecosystems are, in many places, co-managed by local communities through traditional governance systems (Vierros, 2017).

8. Thesis research questions and outline

8.1. Research questions

The implementation of coastal NbS - actions to protect, restore and sustainably manage coastal ecosystems - should be urgently scaled-up to address the joint climate and biodiversity crisis in a more effective and integrative manner, according to the scientific community (IPBES, 2022; IPCC, 2022; Gattuso et al., 2021; Pörtner et al., 2021; Seddon et al., 2020a). However, many countries, including PSIDS, face challenges in implementing effective coastal NbS, such as mobilizing funding for implementation, monitoring actions, and overcoming governance challenges such as policy integration,

local stakeholder involvement, prioritization of actions, and access to relevant information (Seddon et al., 2020a; Manoa & Veitayaki, 2009).

Recent literature (e.g., Dencer-Brown et al., 2022; Lecerf et al., 2021; Northrop et al., 2020; Cooley et al., 2019; Herr & Landis, 2016) increasingly views the inclusion of coastal NbS in climate policies as a key step to enhance climate action, ocean health, and societal benefits (Pörtner et al., 2021; Seddon et al., 2021; Martin et al., 2020). Certain tools and principles, such as standards, ecosystem services assessments and best practice recommendations related to policy integration, transparency and stakeholder engagement are promoted at the global level to design effective policies that support the implementation of robust NbS.

In this context, there is both a need to (i) better understand which coastal NbS are being promoted in PSIDS, through which types of policies and for which purposes; and (ii) examine the relevance for PSIDS of tools promoted to design effective environmental policies. Hence, the research questions that this thesis seeks to address are:

- (i) How do PSIDS incorporate coastal NbS into their policies to address climate-biodiversity-ocean issues, according to principles (e.g., policy integration) and management tools (e.g., standards) that seek to improve the effectiveness of actions?
- (ii) How relevant are some management and assessment tools (e.g., standards, ecosystem services assessments) for PSIDS?

To address these research questions, this dissertation explores four aspects that are linked to:

- (1) the formulation of coastal NbS in the policies of PSIDS, in terms of types of actions, precision and integration (Chapter 1);
- (2) the standardization of coastal NbS in PSIDS' NDCs (Chapter 2);
- (3) the assessment of coastal ecosystem services in PSIDS (Chapter 3), and
- (4) the participation of local stakeholders in the management of coastal ecosystems for a specific location (Chapter 4).

Each aspect is discussed in a distinct thesis chapter. Chapters 1, 2 and 3 focus on the regional scale, embracing all the 15 PSIDS, while Chapter 4 focuses at the village scale, in Fiji. The methodological approaches mobilized include systematic literature reviews, surveys, as well as qualitative and semi-quantitative analyses.

8.2. Outline and methodological background of Chapter 1

In Chapter 1, my collaborator and I investigated the overall inclusion of ocean-based climate actions (OBCAs) in the NDCs and other policies of PSIDS, in terms of typology, precision (i.e., level of detail)

and integration. For the purpose of this analysis, an OBCA is defined as a target or measure that aims to reduce or avoid GHG emissions, or/and support adaptation and improved resilience to climate impacts in the ocean or in coastal environments (definition based on Khan et al., 2022). We have chosen to go beyond coastal NbS and encompass all OBCAs - which include actions that are not necessarily based on nature, such as building seawalls, or developing marine renewable energy) - in order to analyze the place of coastal NbS in the broad landscape of OBCAs in PSIDS. Analyzing not only NDCs but also other relevant policies³¹ (e.g., National Adaptation Plans, National Biodiversity Strategies, National Ocean Policies) was useful to (i) determine the extent to which NDCs reflect the ambition of other national policies, and to (ii) understand how coastal NbS are integrated in the policy frameworks of PSIDS, both within and across policies.

We first examined the characteristics of all OBCAs, in both NDCs and in the policies referenced in NDCs. For that, we created a categorization of OBCAs based on a typology adapted from Gattuso et al. (2018). We investigated which types of OBCAs were most represented in PSIDS' policies (e.g., do they focus more on mitigation or adaptation, on physical infrastructure or on coastal ecosystems for example). Then, we sought to analyze the extent to which OBCAs were precisely described in policy documents, by examining the presence/absence of a set of indicators. These indicators, whose choices were based on scientific recommendations and on the Paris Agreement Work Programme 2018, include the presence of a (a) targeted action, (b) a quantified OBCA objective, (c) a timeframe (date), (d) a cost, and (e) the presence of supporting action³². Similarly, we used indicators to understand how the ocean-biodiversity-climate-development issues are integrated in PSIDS' policy documents. We both investigated how a given action is formulated in a given policy document (is it formulated to respond to several goals, such as for instance climate adaptation and biodiversity protection?), and the extent to which actions are found in different policy documents (i.e., which types of national policies include OBCAs and coastal NbS in particular). This first chapter therefore provides an overview of OBCAs (including coastal NbS) not only in PSIDS' NDCs but also in their national policy frameworks more generally, to understand which types of climate actions are prioritized and how they are integrated across cross-cutting issues (e.g., development, climate, biodiversity) and policies.

8.3. Outline and methodological background of Chapter 2

In Chapter 2, my collaborators and I investigated how coastal NbS are currently included in the NDCs of PSIDS, using a semi-quantitative approach to evaluate their alignment with the IUCN Global

³¹ By "other policies" we mean all the policies mentioned in PSIDS' NDCs: we made a review of all these policies to identify OBCAs and their associated relevant elements (e.g., are they costed, quantified, dated).

³² Targeted actions are OBCAs that directly respond to the purpose of the categories (such as, for instance, "conserve mangroves to enhance carbon sinks") - while Supporting actions do not directly respond to categories but support the creation of an enabling environment (such as, for instance, "improve mangrove carbon accounting").

Standard for NbS. Although coastal NbS are also included in other types of climate-relevant policies (such as the National adaptation plans or the Joint national plans for disaster risk reduction and climate change), we chose to focus on NDCs as they represent the primary mechanism under the UNFCCC to undertake climate action and report for it (Stephenson et al., 2019). This study was motivated by the fact that there is currently no unique definition of blue carbon mitigation activities under the UNFCCC framework, as well as no unique guidance on what elements (e.g., NbS) must be included in NDCs and how to include them (Herr & Landis, 2016). This results in a wide variety of NDC formats and contents across countries. This wide variety makes it difficult to aggregate, compare and monitor commitments, thus compromising the success of the global stocktake mandated by the Paris Agreement to take stock of climate progress at the global scale (Hellio, 2017). To our knowledge, no research study has assessed how coastal NbS have been included in climate plans with regard to standards and good practice principles.

We evaluated the alignment of the descriptions of all coastal NbS identified in all PSIDS' NDCs, with the criteria and indicators of the IUCN Global Standard for NbS. To this aim, we developed an assessment scale. In Chapter 2, we also discussed the potential risks and opportunities provided by the standardization of coastal NbS in PSIDS' NDCs, in terms of access to funding and measurement of their effectiveness. In addition, we questioned the relevance of standardizing NbS in NDCs based on the IUCN Global Standard, and with standards more generally. This chapter thus allows (i) to provide a characterization of the inclusion of coastal NbS in PSIDS' NDCs with respect to the Standard's criteria (e.g., biodiversity net-gain; economic viability, policy mainstreaming, monitoring). It also allows (ii) a reflection on the potential advantages and drawbacks for PSIDS to use the Standard when reporting for their NbS in NDCs.

8.4. Outline and methodological background of Chapter 3

Chapter 3 aimed to understand how coastal ecosystem services (ES) have been valued in PSIDS, and how ES assessments could support coastal management in PSIDS. For that, I conducted a systematic review of the literature on coastal ES in PSIDS. This research builds on the fact that, although the types of services provided by coastal ecosystems are well-known (Barbier et al., 2011), the contribution of these ecosystems to people remains poorly understood at the local scale (Blythe et al., 2020), and in particular in PSIDS (Ruiz-Frau et al., 2017; Liqueste et al., 2013). This research gap can prevent an informed evidence-based coastal management (Börger et al., 2014; Laurans et al., 2013).

The systematic review of coastal ES assessments in PSIDS (either at the scale of the whole region, or just a portion of it such as a village) takes into account both reports and peer-reviewed studies. I proposed to distinguish monetary, quantitative non-monetary and qualitative indicators when analyzing ES. The following questions have been addressed: What are the values (monetary or not) of coastal ecosystems in PSIDS in the literature? Which types of services were more frequently assessed, associated with

which type of coastal ecosystem, and where? Which methodologies and indicators were used to assess coastal ES in PSIDS? Monetary as well as non-monetary assessments are considered, because cultural specific values are often expressed in non-monetary terms (Laurans et al., 2013), and the majority of marine and coastal ES in PSIDS lie outside the market (Pendleton et al., 2007). I also aimed to determine under which conditions the research on coastal ES in PSIDS could better inform coastal policy-making and management, in a context where ES assessments are not widely used by policy-makers (Scemama et al., 2022; Marre et al., 2016; Pendleton et al., 2015). Secondary questions addressed are: Which methodology(.ies) is(are) more likely to reflect the societal importance of coastal ecosystems in PSIDS? How can the research on coastal ES in PSIDS inform policies to support an integrated climate action?

8.5. Outline and methodological background of Chapter 4

Unlike the other three chapters, Chapter 4 does not focus on the regional scale, but on one specific location in Fiji. In Chapter 4, I examined the involvement of coastal community members in the management of its nearby coastal ecosystems. The two main objectives of this chapter were (i) to understand how members of a coastal community in Fiji perceived their involvement in the management of coastal ecosystems, and (ii) to explore how this coastal management could be improved according to the community members. I collaborated with CSIRO (Commonwealth Scientific and Industrial Research Organisation) and the Fijian non-governmental organization “Transcend Oceania” to develop survey approaches. This work was undertaken as part of a regional project (Australia, Fiji) entitled “Blue Carbon Ecosystem Services and Livelihoods”³³, and provides insights into the governance mapping component of the project.

³³ The “Blue Carbon Ecosystem Services and Livelihoods” project is a component of or broader program called “Pacific Blue Carbon Program” and commissioned by Australia. This project is a regional project (Australia, Fiji and Papua New Guinea) that aims to demonstrate better livelihood outcomes for communities in two locations reliant on blue carbon ecosystems, through participatory methods involving local communities and other stakeholders.

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Chapter 1

Ocean-based climate actions in the Nationally Determined Contributions of the Pacific Small Island Developing States: an overview of typology, precision and integration

This chapter is based on a collaborative work with Bleuenn Guilloux, researcher and university lecturer in Environmental Law at UMR 7266 LIENSs, University of La Rochelle, France: methodological background, systematic literature review and some of the analyses were elaborated and conducted jointly. A collaborative article associated with this chapter is in preparation:

Châles, F., Guilloux, B. (*in prep.*). Ocean-based climate actions in the Nationally Determined Contributions of the Pacific Small Island Developing States: an overview of typology, precision and integration.

Abstract

Coastal nature-based solutions to strengthen climate mitigation (e.g., mangrove restoration to enhance carbon sinks) or adaptation (e.g., coral reef conservation to reduce coastal flooding) are increasingly recognized by State and non-State actors as key contributions for addressing the dual climate-biodiversity crisis in a more coherent and effective way. In particular, a growing body of scientific literature promotes the inclusion of coastal nature-based solutions and other ocean-based climate actions (OBCAs) in climate policies, such as the Nationally Determined Contributions (NDCs) developed under the Paris Agreement, in order to increase policy integration between climate, ocean, biodiversity and development issues. The need to formulate precise actions in NDCs is also a requirement of the Paris Agreement Work Programme 2018, to facilitate a clear understanding of countries' climate ambitions, needs and realizations. In this study, we first examined which types of OBCAs are being promoted by Pacific Small Island Developing States (PSIDS) in their NDCs, both explicitly (in NDCs) and implicitly (in the policies referenced in NDCs). Next, using indicators of presence/absence, we analyzed the extent to which actions are precisely described and integrated in the climate policies of PSIDS. We found that 80% of PSIDS explicitly include OBCAs in their NDCs to address climate change adaptation and/or mitigation, and 100% implicitly, especially in relation to climate adaptation (as opposed to mitigation) and coastal ecosystems. In addition to the general increase in the inclusion of OBCAs in PSIDS' NDCs over time, OBCAs are also increasingly precise on the objectives they intend to achieve, as well as on co-benefits they intend to provide. Our results suggest an increased will from PSIDS to implement OBCAs and especially coastal nature-based solutions to mitigate and adapt to climate change. We also identified areas where the NDCs do not fully reflect the national ambitions of PSIDS. This is the case of blue carbon activities for mitigation and infrastructure-based adaptation, which are on average more included, described and ambitious in other policies than NDCs.

Keywords: Ocean, climate, biodiversity, coastal nature-based solutions, Pacific Small Island Developing States, policy integration, typology, Nationally Determined Contributions.

1. Introduction

The ocean plays a central role in the Earth' climate system, through carbon and heat³⁴ sequestration and the provision of multiple services to living species, including humans (Sala et al., 2021; IPCC, 2019; Barbier, 2017). However, the increasing pressures it faces (e.g., from climate change, overfishing, mining, pollution) diminishes its ability to regulate the climate and support life (Malhi et al., 2020; IPCC, 2019; Doney et al., 2012; Harley et al., 2006; Worm et al., 2006). These pressures are already severely affecting ocean ecosystems and human populations around the world (Trebilco et al., 2021; Waters et al., 2016). This is particularly the case in Pacific Small Island Developing States (PSIDS) (IPCC, 2022). PSIDS are among the most vulnerable countries to (i) ocean-climate impacts (such as sea level rise and storm waves) and (ii) ocean ecosystem degradation because of their heavy reliance on ocean resources for livelihoods and income (Buckwell et al., 2020; Smallhorn-West et al., 2020; Selig et al., 2019; Veron et al., 2019; Hills et al., 2013). Impacts on ocean ecosystems and people are expected to worsen if no urgent action is undertaken to drastically reduce pressures (Hoegh-Guldberg et al., 2019; IPCC, 2019). With a global temperature increase of more than 2°C above pre-industrial levels, substantial and irreversible impacts on the ocean are expected for millennia, such as the loss of 99% of the world's coral reefs, with dramatic effects on the multitude of species they support (Souter et al., 2021; IPCC, 2019). While coral reefs cover only 0.2% of the seafloor, they support at least 25% of marine species and underpin the safety, coastal protection, well-being, food and economic security of hundreds of millions of people worldwide (Souter et al., 2021).

The international community adopted the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) in 2015 to limit the global temperature rise well below 2°C as compared to pre-industrial levels and to increase the ability to adapt to climate impacts (Paris Agreement, Article 2). A novelty of the Paris Agreement as compared to previous international climate agreements lies in the formulation of national climate plans that each country must elaborate and regularly update to gradually enhance their ambition in dealing with climate change over time – the Nationally Determined Contributions (NDCs). NDCs represent the national climate priorities, capacities and processes, and thus vary greatly among countries in terms of format, scale, and level of detail (Crumpler & Bernoux, 2020). Increased and urgent action is needed to enhance the ambition of NDCs to achieve the Paris Agreement's goals. Based on information contained in countries' current NDCs, the global temperature rise is likely to reach 2.8°C by 2100 (UNEP, 2022a).

Including ocean-based climate actions (OBCAs) in NDCs is one way to enhance their ambition (Dencer-Brown et al., 2022; Northrop et al., 2020; Cooley et al., 2019; Hoegh-Guldberg et al., 2019; Herr &

³⁴ The global ocean has absorbed around 30% of the anthropogenic carbon dioxide from the atmosphere, which causes ocean acidification, approximately 90% of the excess heat from the enhanced greenhouse effect, which causes ocean warming (Hoegh-Guldberg et al., 2014).

Landis, 2016). Through the important role the ocean plays in climate mitigation and adaptation, OBCAs are increasingly being hailed as key contributors that can help achieve the Paris Agreement's goals (Hoegh-Guldberg et al., 2019; Gattuso et al., 2018; Herr & Landis, 2016). OBCAs are defined as ocean targets or actions that aim to reduce or avoid greenhouse gas emissions and support adaptation and resilience to climate impacts (definition based on Khan et al., 2022). OBCAs could reduce the “emission gap”, which is the difference between emissions expected if current trends and policies continue and emissions consistent with limiting global temperature increase, by 21% by 2050 on a 1.5°C pathway, and by about 25% on a 2°C pathway (Hoegh-Guldberg et al., 2019).

OBCAs refer to both actions that are based on ocean ecosystems (for instance ecosystem-based fisheries management to adapt to changes in species, location, and abundance induced by climate change impacts) and to actions not based on ocean ecosystems such as marine renewable energy (Pörtner & Peck., 2010). Coastal nature-based solutions (NbS)³⁵ - especially the protection and restoration of mangroves, seagrasses and salt marshes - could offer the best combination among OBCAs of carbon mitigation and broader co-benefits, such as through coastal risk reduction, and increased food and water security (Hoegh-Guldberg et al., 2019).

Nevertheless, including OBCAs and coastal NbS in NDCs and other climate policies does not imply that OBCA implementation will be successful, i.e., that it will produce the desired societal, climatic or ecological outcomes. To enhance the likelihood that actions included in NDCs will produce positive outcomes, actions need to be sufficiently described to inform their scope and means of implementation (Paris Agreement, Articles 4 and 13). In addition, their potential co-benefits for biodiversity, climate mitigation, climate adaptation and other critical societal challenges should be better taken into account through integrated policy approaches (Khan et al., 2022).

This chapter examines how OBCAs and especially coastal NbS are included in the NDCs of PSIDS. We review all PSIDS' NDCs, as well as all policies referenced in the NDCs, as it is common for countries to mention certain policies in their NDCs without explicitly incorporating actions from them (Crumpler & Bernoux, 2020). The objectives of this study are to: (i) understand which types of OBCAs are promoted by PSIDS in their NDCs; and (ii) assess the OBCAs' degrees of (1) precision and (2) integration, which are two aspects considered as essential to deliver robust and ambitious policies that are more likely to produce positive outcomes (Khan et al., 2022). These two aspects, i.e., policy precision and policy integration, are explained into more detail in the next paragraphs.

³⁵ The multilaterally agreed definition of NbS set in 2022 by the Fifth Session of the United Nations Environment Assembly (UNEA-5) is “actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits”. NbS for climate are primarily designed to address climate adaptation or/and mitigation challenges.

First, there is a need to include actions in NDCs in a precise manner, by providing a description of the actions and what they are expected to achieve and how, and information on how their effectiveness will be monitored. These are recommendations of the Paris Agreement under which “each Party shall provide a description of its NDC against which progress will be tracked” (Article 4 and Article 13 of the Paris Agreement (UNFCCC, CMA, 2018)). In 2018, the Work Programme of the Paris Agreement lists the elements that are necessary to clarity, transparency and understanding in the updated NDCs, in order to enable carbon accounting, forecasting of future climate trends and risks readiness (Northrop et al., 2020; UNFCCC, CMA, 2018). These are: (a) targets and description, including target type(s), (b) target year(s) or period(s), (c) reference points, (d) timeframe(s) and/or periods for implementation, and (e) scope and coverage (sectors, categories, activities, sources and sinks, gases) (UNFCCC, CMA, 2018). This information should help track collective progress as part of the “Global Stocktake”, a mechanism developed under the Paris Agreement to take stock of climate action progress globally and inform the content of future NDCs. According to Hoegh-Gulberg et al. (2019), the inclusion of quantitative OBCA objectives within NDCs and other relevant climate policies is a short-term priority for delivering on climate mitigation. This clear translation of policy objectives into quantifiable targets and meaningful indicators is necessary to enhance policy coherence and integration (Strauß et al., 2022; Coscieme et al., 2021).

Second, there is a need to better integrate climate, biodiversity, ocean and development policies and actions (Khan et al., 2022; Stafford-Smith et al., 2017). In fact, addressing the complex biodiversity, climate and development crises, which share root causes linked to human activities, requires a high level of policy coordination³⁶, coherence and integration (Domorenok et al., 2021; Petteorelli et al., 2021; Pörtner et al., 2021). The term of policy integration was first used in 1980 by Underdal to analyse marine policy. This concept has been increasingly used scholarly and politically following the adoption in 2015 of the United Nations’ “Agenda 2030” for sustainable development (Domorenok et al., 2021). Sustainable development was defined in the 1987 Brundtland report “Our common Future” as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. Sustainable development is an ongoing process that seeks to reconcile economic development with the protection of environmental and social balance (Newman et al., 2005). The sustainable development goals (SDGs) (17 goals and 169 targets) were adopted in 2015 by the United Nations to provide an agenda for sustainable development (Stafford-Smith et al., 2017). SDG 13 focuses on climate change and SDG 14 on life below waters, but the goals should not be addressed in isolation and actions to achieve one SGD should not undermine another (Stafford-Smith et al., 2017). For the United Nations (2015), policy integration is central to the sustainable development paradigm,

³⁶ Cejudo & Michel., (2017) define policy coordination as “the process in which members of different organizations define tasks, allocate responsibilities, and share information in order to be more efficient when implementing the policies and programs they select to solve public problems”.

and particularly in view of the rising complexity of social problems and global issues such as climate change. According to the outcomes of a report of the United Nations (2015), policy integration across different objectives could refer to balancing key aspirations (such as economic, social and environmental aspirations in the case of sustainable development), and identifying integrative strategies that help countries achieve broader goals than those of each individual policy. For the Organisation for Economic Co-operation and Development (OECD), this notion is very similar to “policy coherence”, which it defines as “the systematic promotion of mutually reinforcing policy actions across government departments and agencies creating synergies towards achieving the agreed objectives” (United Nations, 2015). Cejudo & Michel. (2017) made a proposal to distinguish policy coherence³⁷ and policy integration³⁸ from each other, but to date there is no single common understanding of these concepts (Domorenok et al., 2021), which are often used interchangeably (Cejudo & Michel., 2017). For Cejudo & Michel. (2017), policy integration is a process while policy coherence is an attribute: policy integration can be defined as the *process* by which policies are articulated and made compatible so that they *are coherent* (attribute). While Domorenok et al. (2021) view policy coherence and coordination as essential aspects to design integrated policies, Cejuro et al. (2017) and Adelle & Russel (2013) consider policy integration as a key aspect to design coherent policies. In this study, we will use the term “integration” to refer to the process that helps to improve policy coherence through the articulation of multiple policy instruments or objectives to achieve complex policy goals that encompass the respective objectives of each policy instrument.

Today, a lack of policy integration between the biodiversity, ocean, climate and development challenges still prevents the achievement of effective environmental action (Dobush et al., 2022; Coscieme et al., 2021; Cooley et al., 2019). For Christopoulos et al. (2012) and Mickwitz et al. (2009), society transformations needed to tackle climate change cannot be achieved unless climate change is taken into account in the general and sector-specific policies, which is not the case today. While there is an increased policy integration between climate mitigation and adaptation aspects, including in developing countries (Duguma et al., 2014), we still know too little about the composition of country portfolios on climate policies and whether those rely mainly on specific climate policies or the integration of climate

³⁷ Cejudo & Michel. (2017) define policy coherence as the process where policy-makers design a set of policies in a way, that, if properly implemented, they can potentially achieve a larger goal. Policy coherence means that “while addressing a specific and concrete problem, every policy of the same domain contributes toward addressing a broader problem”. A set of policies can be made coherent through enhancing coherence among different policies’ objectives, instruments and target populations. For policy-makers to achieve policy coherence among objectives, there is a need to analyze policies’ objectives and to harmonize them so that actions that each policy undertake serve a common purpose (Cejudo & Michel., 2017). Policy coherence among instruments means that two polices can potentially contribute, by the way they are designed, to solve a common problem using different tools that address the same or different aspect of the complex problem they are meant to address (Cejudo & Michel., 2017).

³⁸ Cejudo & Michel. (2017) define policy integration as the process of making strategic and administrative decisions aimed at solving a complex problem. For them, policy integration is more than the sum of coherence and coordination, entailing a new mandate by which policies and organizations work under a new logic, subordinating their objectives to a new overall goal.

objectives across issues such as biodiversity and development (Schmidt & Fleig, 2018). For Strauß et al. (2022), NDCs do not sufficiently tackle the climate and biodiversity dilemma together. Measurable and meaningful targets should be set to achieve co-benefits and synergies between NbS for climate and biodiversity conservation measures. In addition, sustainable development issues should be addressed in a more holistic approach that links the different SGDs, including SGD 13 on climate and SDG 14 on life below water (Stafford-Smith et al., 2017). Ocean governance remains largely fragmented globally, including in PSIDS (Vince et al., 2017), despite the essential role of the ocean to support life on Earth and to contribute to climate mitigation and adaptation (Sala et al., 2021; IPBES, 2019, IPCC, 2019). The UNFCCC is currently developing the Ocean and Climate Change Dialogue to strengthen and integrate national ocean climate action under the Paris Agreement, and to promote coherence in addressing ocean-climate issues both within the UNFCCC and between the UNFCCC and other international processes (Dobush et al., 2022; UNFCCC, 2022).

For Dencer-Brown et al. (2022), including OBCAs in NDCs could help reduce the observed integration gap between biodiversity, socioeconomic, and climate policies, thereby enhancing the development of more coherent environmental policies. In particular, coastal NbS for climate adaptation and/or mitigation - which are by nature cross-sectoral actions - are increasingly seen as valuable actions to enhance climate ambition and policy integration by promoting synergies between climate and biodiversity challenges (Dencer-Brown et al., 2022). A growing body of scientific literature therefore suggests incorporating NbS (including coastal ones) into policy documents such as NDCs in order to mainstream these key challenges in a way that minimize trade-offs and implementation costs and increase synergies and policy coherence (Pettorelli et al., 2021; Pörtner et al., 2021; Seddon et al., 2021; Martin et al., 2020; Northrop et al., 2020; Seddon et al., 2020; Herr & Landis, 2016). For instance, Martin et al. (2020) recommends (i) prioritizing in NDCs synergistic actions that have both mitigation and adaptation benefits, (ii) setting ambitious, measurable, and time-bound numerical targets, such as hectares of ecosystems used or tons of carbon dioxide (CO₂) sequestered, and (iii) incorporating commitments into other international conventions and relevant national policies. Northrop et al. (2020) provide guidance on how to strengthen NDCs, and include the recommendations for countries to analyze relevant links, synergies, trade-offs and opportunities between NDCs and other relevant policies, such as National Adaptation Plans or National Communications to the UNFCCC. However, the inclusion of OBCAs in NDCs remains underdeveloped globally (Dencer-Brown et al., 2022; Cooley et al., 2019; Gattuso et al., 2018), and lacks precise information (such as clear targets and metrics to evaluate their effectiveness) and integration both across sectors and policies (Khan et al., 2022).

Objectives:

In this study, we explore how OBCAs, including coastal NbS, are included in PSIDS' NDCs, both explicitly (in the NDC documents) and implicitly (in the policies referenced in NDCs). The research questions guiding this study are:

- 1) To what extent have OBCAs been included in PSIDS' NDCs over time and across countries, and on what aspects do they primarily focus?
- 2) To what extent are OBCAs precisely described in relation to the requirements of the Paris Agreement and scientific recommendations?
- 3) How are OBCAs articulated and integrated across categories of OBCAs and across policy sectors (i.e., biodiversity, climate change and development)?
- 4) To what extent do NDCs reflect the ambition of other policies regarding OBCAs?

We use a typology of OBCA adapted from Gattuso et al. (2018) to categorize OBCAs in relation to the topic(s) they most relate, and use indicators of presence/absence to understand the extent to which OBCAs are precisely described and integrated in policy documents.

2. Materials and method

2.1. Overview of method steps

Figure 1.1 summarizes the steps we followed to analyze the inclusion of OBCAs in PSIDS' NDCs. These steps include:

- (i) the identification of relevant policies for analysis,
- (ii) the identification and categorization of OBCAs,
- (iii) the categorization of policies, and
- (iv) the characterization of OBCAs.

Each step is detailed in a sub-section. PSIDS refer to the fifteen independent countries of the South Pacific, in Melanesia (Fiji, Papua New Guinea, Solomon Islands, Timor-Leste and Vanuatu), Micronesia (Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau) and Polynesia (Cook Islands, Niue, Samoa, Tonga and Tuvalu).

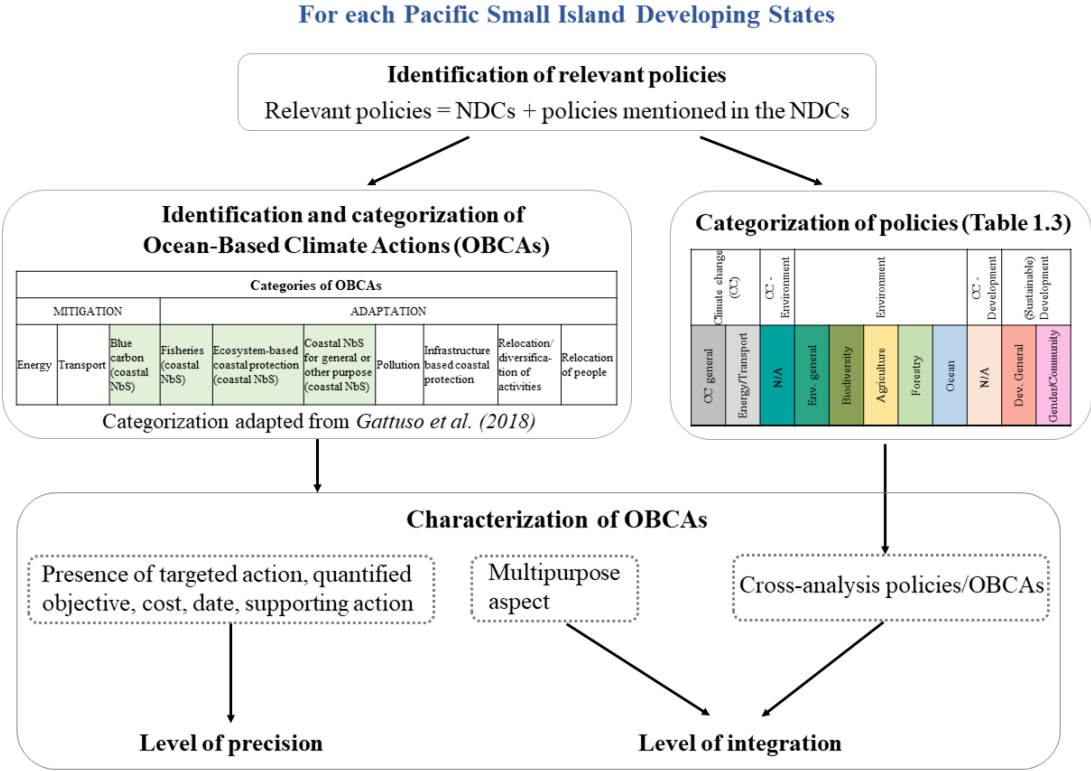


Fig. 1.1: Overview of method steps.

2.2. Step 1: Identification of policies for analysis

In this study, we reviewed NDCs and the policies references (i.e., mentioned) in NDCs. We chose to focus primarily on NDCs as they are considered the primary international mechanism to document and report on climate action (Stephenson et al., 2019; Herr & Landis, 2016). We reviewed policies referenced in NDCs to supplement the information contained in the NDCs. Indeed, in many cases, countries refer to other policies (for instance, their existing National Adaptation Plans (NAPs)), rather than explicitly mentioning in their NDCs the actions that these policies contain.

We considered both the original (i.e., published in 2016 or 2017) and revised (i.e., 2018-2021) NDCs of PSIDS as part of our scope. Revised NDCs correspond to the updated (enhanced) versions of original NDCs, and are sometimes called “new” or “updated” NDCs in the literature. For revised NDCs, we only considered those submitted before October 31, 2021, which was the deadline for countries to submit their revised NDC to the UNFCCC Secretariat ahead of COP26 in Glasgow. Policies mentioned in NDCs (sometimes called “other policies” or “relevant policies” in this thesis chapter) constituted a variety of instruments, such as plans, strategies, national communications, but also legal sources such as laws or acts. In the rest of this thesis chapter, we will use the term « policies » to refer to all types of policy or legal instruments, such as plans, strategies, or legal acts. These policies focused primarily on the national policy level. We did not consider as part of our scope the policies that focused on the local level, such as Town Plan regulations, due to time constraints and for geographical coherence. Policy

documents were found in English and were available online, except for those mentioned but not yet developed.

2.3. Step 2: Identification and categorization of OBCAs

2.3.1. OBCA identification

After the identification of relevant policies referenced in NDCs, we proceeded to the systematic review of OBCAs in the policy documents. This systematic review was conducted twice, by B. Guilloux and F. Châles, in an independent manner, to ensure that we did not miss any document and to minimize bias in the analysis. We used keywords to identify sections of interest in the policy documents. These are: coast, coral, dike, ecosystem, erosion, fish, forest, mangrove, marine, maritime, ocean, offshore, reef, renewable, seagrass, seawall, submersion, tide, tidal, wave. We considered as OBCAs all actions based on the ocean (nature-based or not) explicitly targeting climate mitigation, climate adaptation, or both. Sometimes, the mention of an OBCA in a policy document (i.e., the section of a policy text that can also be defined as an OBCA) is not directly linked to a climate goal in a single sentence, but is part of a paragraph that is linked to a climate goal. In this case, we considered the action to be within our scope. We did not take into account past actions, but only forward-looking and current actions. Each identified OBCA was checked by both B. Guilloux and F. Châles in order to share a common understanding of OBCAs and agree on which actions could be considered OBCAs and which could not. After screening all policies referenced in the 24 PSIDS' NDCs, we found 99 different policies (21 NDCs and 78 other policies) that included OBCAs. The list of the 78 policies is available in Table 1.A in Supplementary Material, Appendix 1.A. We should note here that Table 1.A includes more than 78 policies, as we also listed the policies that only included contextual mentions of ocean-climate impacts but no OBCAs. Although not the focus of our analysis, we noted that all PSIDS include at least contextual mentions of the ocean in their NDCs both concerning its importance for their people and to ocean vulnerability to climate impacts.

2.3.2. OBCA categorization

We then incorporated all textual mentions of identified OBCAs into working tables by categorizing them. We categorized the actions using a typology adapted from the categorization of OBCAs developed by Gattuso et al. (2018) and refined in Gattuso et al. (2022). Gattuso's categorization is available in Supplementary Material Appendix 1.B. Below, Table 1.1 describes our categorization adapted from Gattuso's et al. (2018) by providing a description and an example of what each category can contain in terms of OBCA. Differences between the categorization of Gattuso et al. and ours include, for instance, the removal of some categories (e.g., on marine engineering solutions for climate mitigation such as alkalization or albedo enhancement) because we did not find any actions referring to these categories in PSIDS' policies. We created a category "multiple" to refer to actions that did not fit in a single

category, or whose purposes were not clear enough to assign the action to several specific OBCA categories.

Table 1.1: Our categorization of Ocean-Based Climate Actions (OBCAs) relevant for the policies reviewed part of our scope in the Pacific Small Island Developing States (PSIDS), associated descriptions and examples from PSIDS' Nationally Determined Contributions (NDCs). The categorization is adapted from Gattuso et al. (2018). In green, categories based on coastal ecosystems.

	OBCA categories	Description	Examples from NDCs
CLIMATE MITIGATION	Marine renewable energy	Produce electricity from marine renewable energy (including energy from offshore winds, waves, ocean currents).	"Extract ocean energy for power generation" (original NDC of Marshall Islands).
	Maritime transportation	Reduce greenhouse gas emissions from maritime transportation, through decarbonization or improving ship energy efficiency.	"Reduce GHG emissions from domestic shipping 40% below 2020 levels by 2030 and full decarbonization of the sector by 2050" (revised NDC of Marshall Islands).
	Protection and restoration of blue carbon habitats to enhance carbon sinks	Protect, restore or sustainably manage mangrove or seagrass ecosystems to maintain or enhance carbon storage in their roots and soil.	"Establish 30% of our exclusive economic zone as Marine protected areas for climate mitigation" (revised NDC of Fiji).
CLIMATE ADAPTATION	Ecosystem-based fisheries management	Sustain healthy marine ecosystems and the fisheries they support through a sustainable management of fisheries and associated ecosystems.	"Maintain the existing stocks of fish through a commitment to expand the area covered by Marine protected areas and Special Management Areas to 30% of the Tonga exclusive economic zone" (revised NDC of Tonga).
	Ecosystem-based coastal protection	Protects coastlines from coastal risks (erosion, submersion) through the protection or restoration of coastal natural ecosystems such as coral reefs, mangroves or seagrasses (dunes are not mentioned in PSIDS' NDCs).	"Mangrove planting to adapt to coastal flooding and sea level rise" (revised NDC of Papua New Guinea).
	Protection/restoration or sustainable management coastal ecosystems for other or general purpose	Protect, restore or sustainably manage coastal ecosystems for general purpose or other purpose than those mentioned in the two above categories.	"Plant mangroves, seagrasses and corals to reduce damage on coral reefs" (revised NDC of Papua New Guinea).
	Reduction of marine and coastal pollution for adaptation	Reduce pollution flows to protect coastal ecosystems.	Response measures for marine disposal to reduce damage to coral reefs (revised NDC of Papua New Guinea).
	Infrastructure-based coastal protection	Protect coastlines from coastal risks (erosion, submersion) through physical structures such as seawalls, or through building resilient infrastructure.	"Enhancement in coastal resilience with primary emphasis on continuation of shoreline protection works in South Tarawa" (original NDC of Kiribati).
	Relocation or diversification of marine and coastal economic activities	Diversify or relocate economic activities, i.e., move aquaculture and fishing industries to new areas, develop aquaculture or eco-tourism activities.	"Develop milkfish farming in support of the development and expansion of aquaculture to improve resilience by increasing domestic food production" (revised NDC of Nauru).
	Relocation of people	Relocate to safer places (higher grounds, other islands) people who are vulnerable to ocean-climate impacts such as sea-level rise or storm surges.	"Relocation of communities to higher grounds is part of ongoing initiatives to build resilience" (original NDC of Fiji).

	Multiple	Created for OBCAs whose purposes are multiple or not precise enough to assign them to a distinct category.	<i>Disaster risk management</i> (revised NDC of Papua New Guinea).
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Table 1.2 shows the template of the data entry (or working) table. As there are 24 NDCs released by PSIDS so far³⁹ (15 original and 9 revised NDCs), our database is thus composed of 24 working tables. These working tables containing the detail of OBCAs identified in PSIDS' NDCs and associated policies are available in Supplementary Material, Appendix 1.C. The OBCAs (i) that we found in NDCs and those (ii) that we found in other policies (i.e., policies referenced in NDCs) are listed in different columns in the working tables, as shown in Table 1.2. We make this clear distinction between the OBCAs found in NDCs and those found in other policies in order to show the extent to which the NDCs reflect what is included in other policies, for each country. The categorization of OBCAs was double-checked by F. Châles and B. Guilloux in order to discuss conflicting entities and resolve disagreements. Categories of OBCAs that are in green in Table 1.1 and Table 1.2 correspond to categories referring to coastal NbS as opposed to OBCAs not based on nature. Coastal NbS refer to the following coastal ecosystems: mangroves, coral reefs, seagrasses and associated ecosystems such as coastal fisheries.

Table 1.2: Template of a working table. This template provides a fictional example of ocean-based climate actions (OBCAs) included in one Nationally Determined Contribution (NDC) and in the other policies referenced in the NDC. *[OBCAs]* here are incorporated randomly. Each brown rectangle represents a box. Categories in green are those based on coastal ecosystems.

	Categories of OBCAs (adapted from Gattuso et al., 2018)	In the NDC	In other policies referenced in the NDC	
			Targeted OBCAs	Supporting OBCAs
Climate mitigation	Marine renewable energy			
	Maritime transportation	- <i>[OBCA]</i>		
	Protection or restoration of blue carbon ecosystems (mangrove, seagrass)		- <i>[OBCA]</i> - <i>[OBCA]</i>	- <i>[OBCA]</i>
Climate adaptation	Ecosystem-based fisheries management			
	Ecosystem-based coastal protection			
	Coastal NbS for general or other purpose		- <i>[OBCA]</i> - <i>[OBCA]</i>	
	Reduction of marine and coastal pollution			
	Infrastructure-based coastal protection			
	Relocation/diversification of activities			- <i>[OBCA]</i>
	Relocation of people			
	Multiple			

³⁹ As of October 31st, 2021, the deadline for countries to submit their revised NDC to the UNFCCC Secretariat.

2.4. Step 3: Categorization of policies in sectors: climate, development, environment

In parallel to Step 2, we categorized the policies according to the main sector they relate to, in order to prepare the analysis of OBCA integration between nature, climate change and development issues. We based this policy categorization on a typology of policies according to the main sectors they relate to, which were (i) climate change, (ii) environment, and (iii) development (Table 1.3). Assigning one of these main sectors to each policy document was relatively easy, as these correspond to common policy sectors. Although important, “biodiversity” is not a distinct sector in our analyses, because biodiversity is generally included in environmental policies that focus on other aspects than biodiversity only (e.g., pollution, agriculture, forestry, ocean ecosystems). We found only three policies out of 78 focusing solely on biodiversity (Table 1.A in Supplementary Material, Appendix 1.A).

We created two cross-cutting main policy sector categories: (iv) climate change-environment and (v) climate change-development, for the few policies whose assignment in one of the three main sectors would not have been adequate. Indeed, few policies seemed to equally respond to two main sectors. This was for instance the case of the “Republic of Nauru Environmental Management and Climate Change Act (2020)”. All the policies reviewed (i.e., NDCs and policies referenced in NDCs, for each PSIDS) were categorized in one of these five main sectors. We have also assigned sub-sectors to policies when they specifically referred to a precise topic, for instance energy, agriculture, biodiversity, or gender (Table 1.3). Table 1.A in Supplementary Material Appendix 1.A provides the complete list of the policies containing OBCAs or climate-ocean contextual mentions that are referenced in NDCs, with the sector or sub-sector these policies most relate.

Table 1.3: Main sectors and sub-sectors of the policies reviewed.

Main policy sectors	Climate change (CC) (i)		CC – Environment (iv)	Environment (ii)				CC – Development (v)	(Sustainable) Development (iii)		
Related policy sub-sectors	CC general	Energy/Transport	N/A	Environment general	Biodiversity	Agriculture	Forestry	Ocean	N/A	Development General	Gender/Community

2.5. Step 4: Characterization of OBCAs

2.5.1. Typology of OBCAs

In Step 4, we used the OBCA categorization shown in Table 1.1 to quantify the frequency each OBCA category was referred to in the PSIDS’ policies. The focus of the analysis was on the OBCA category for a given policy or set of policies, what we refer to as “the box level”. A box corresponds to an OBCA category for a given policy or set of policies. It may contain one or more OBCAs. Examples of “boxes”

are represented by the brown rectangles in Table 1.2. The analysis involved identification of the presence or absence of particular components for a given box. In fact, we felt that it was inappropriate to make calculations directly on the number of OBCAs because this number is not meaningful, since our working tables are descriptive and it is delicate to delimit the extent to which an OBCA can be considered as a single OBCA or as several OBCAs.

2.5.2. Levels of precision and integration: and indicator-based analysis focusing on the presence/absence of information

We sought to characterize (1) the level of precision for each box, and the (2) level of integration both (i) across OBCA categories within a single policy document, and (ii) across different policies for each OBCA category. The levels of precision and integration are determined by examining the presence or absence of the indicators listed in Table 1.4.

Table 1.4: Indicators used to assess the level of precision of ocean-based climate actions (OBCAs) and their level of integration across categories and policies/policy sectors. *‘‘sector(s)’’ refer to the three main sectors of the policies reviewed, i.e., climate change, development, environment.

Variable	Indicators	Metric
Precision	Targeted action (indicator a)	Presence/Absence
	Quantitative objective (indicator b)	Presence/Absence
	Cost (indicator c)	Presence/Absence
	Date/timeframe (indicator d)	Presence/Absence
	Supporting action (indicator e)	Presence/Absence
Integration	Multi-purpose (indicator f)	Presence/Absence
	Several policies of the same sector* (indicator g)	Presence/Absence
	Several policies of different sectors* (indicator h)	Presence/Absence

To determine **the level of precision**, we used the five following indicators: (a) targeted OBCA, (b) quantitative objective associated with the OBCA, (c) associated cost, (d) associated date at which the target must be met, or implementation schedule, and (e) supporting actions (Table 1.4). The choice of the five elements as a basis for analysis builds on the recommendations from scientific literature regarding NbS inclusion in NDCs (Strauß et al., 2022; Seddon et al., 2020; Martin et al., 2020; Hoegh-Guldberg et al., 2019). It also builds on the Transparency framework of the Paris Agreement, which recommends setting up clear and transparent information in NDCs such as time-bounded and costed actions with measurable objectives (UNFCCC, CMA, 2018). In each box, we looked at (a) the presence of at least one targeted OBCA mention, (b) the presence of at least one quantitative OBCA objective, (c) the presence of at least one OBCA cost, (d) the presence of at least a date at which a target must be met or timeframe for implementation, and (e) the presence of at least a supporting OBCA mention. In fact, as we reason by box and not by OBCA mention, we did not count the number of OBCAs but rather looked at the presence of these indicators for a given box, i.e., for an OBCA category in a given policy

(or set of policies). Hence, if in for given box there is an OBCA that is dated whereas in the same box other OBCAs from other policy documents are not, we considered that the box is dated, because there is at least one mention of a dated OBCA in this box. In other words, a dated box does not mean that all OBCAs in the box are dated, but that at least one is.

A quantitative objective corresponds to a target that is measurable in quantitative term, such as a percentage or a numerical number. Setting quantitative objectives (indicator b), as well as defining timeframes for implementation or dates by which a target must be met (indicator d) is important to measure progress (Seddon et al., 2020), but also to allow comparisons between countries so that best practices and lessons learnt are shared (Strauß et al., 2022). For Strauß et al. (2022), there is a need in SIDS to set clear and meaningful targets on ecosystem-based climate actions in NDCs that create synergies with biodiversity conservation in order to achieve co-benefits and synergies with biodiversity conservation measures. Concerning information on action costs (indicator c), the Paris Agreement Work Programme (UNFCCC, CMA, 2018, D. 83) notes that “Each Party may also provide costs for each action, policy and measure reported in its NDC”, but does not detail why exactly this can be relevant. A recent report recommends including costs on NbS in NDCs in order to make financial needs more visible on the international stage, attract donors and facilitate access to funding (UNDP, UNEP & WRI, 2020). Highlighting costs in NDCs would be particularly relevant for PSIDS since more than half of PSIDS’ NDCs mention their reliance upon external funding to partially or totally implement their NDCs.

We also distinguished between targeted OBCAs (indicator a) and supporting OBCAs (indicator e). Targeted actions are OBCAs that directly respond to the purpose of OBCA categories. For example, “conserve mangroves to enhance carbon sinks” was considered as a targeting action. In contrast, supporting actions do not directly respond to categories but support the creation of an enabling environment (such as, for instance, “improve mangrove carbon accounting”). Definitions and examples of quantified OBCA objective, targeted and supporting OBCAs are provided in Table 1.5. As the distinction between targeted and supporting actions is sometimes blurred, we (i.e., F. Châles and B. Guilloux) double-checked each OBCA independently in order to ensure a common understanding of OBCA characteristics to allow for a consistent analysis.

Table 1.5: Definitions and examples of some characteristics of ocean-based climate actions (OBCAs).

	Definition	Example
Targeted OBCA (indicator a)	An OBCA that is intended to achieve a specific result in accordance with the OBCA categories. Note: targeted OBCA are not always associated with a quantitative objective.	- Example 1: “Conserve 30% of the exclusive economic zone by 2030 to enhance climate mitigation.” - Example 2: “Conserve mangrove forests to enhance climate mitigation.”
Quantitative OBCA objective (indicator b)	An OBCA target that is measurable in quantitative term, such as a percentage or a numerical number.	- “Conserve 30% of the exclusive economic zone by 2030 to enhance climate mitigation”.
Supporting OBCA (indicator e)	An OBCA that is designed to support a targeted OBCA through the creation of an enabling environment.	Research and monitoring activities, awareness raising activities, fundraising for financing the implementation or the monitoring of targeted OBCAs. “Improve mangrove carbon accounting.”
Multi-purpose OBCA (indicator f)	An OBCA that is intended to address several OBCA categories.	“Restore mangroves in order to enhance carbon sinks and coastal protection”.

To determine **the level of integration**, we use three indicators, namely: (f) the presence (or absence) of the multi-purpose aspect of an OBCA mention; (g) the presence (or absence) of several policies from the same sector that contain OBCAs for a given category; and (h) the presence (or absence) of several policies from different sectors that contain OBCAs for a given category (Table 1.4). The multipurpose aspect (indicator f) focuses at the OBCA scale. It indicates that an OBCA refers to at least two OBCA categories, i.e., it is made explicit in a given policy document that the OBCA is designed to respond to several distinct purposes. “Purposes” means OBCA categories in this context. (Table 1.5). Hence, when policy authors identified multiple goals to an OBCA, we duplicated this OBCA in the adequate categories and indicated that this OBCA was “multi-purpose”. For instance, the following OBCA from Tonga’s revised NDC is considered “multi-purpose” as it responds to two categories (the categories “Protection of blue carbon ecosystems for mitigation” and “Coastal NbS for coastal protection”): *“In line with climate change policy calling for coastal protection, this action prioritises the use of nature-based solutions for protection against storm surges and erosion. Restoration of mangroves, replanting and general strengthening of the coastal ecosystem will also have positive GHG emission sequestration outcomes although these cannot be quantified at the present time.”* (Working Table #21 in Supplementary Material, Appendix 1.C).

Indicator g and indicator h on policies focus at the box level and not at the action level. They are used to look at the extent to which each OBCA category is being covered by policies. To illustrate, for a given country, if there are many OBCAs in a given category but coming from policies from the same sector

(e.g., development), then we considered the category being less integrated across policy sectors than if the OBCAs are from different policies from different sectors⁴⁰.

2.5.3. Graphical representation

Table 1.6 provides two fictional examples illustrating how we proceeded to summarize and graphically synthesize data, based on the definitions provided in Table 1.5 and earlier in Step 4 on OBCA characterization. Each example focuses on one OBCA category. Here, we can see that there are two OBCAs for each of the two categories, from different policies. In example 1, the two policy documents are from the same sector (climate change), and in Example 2, the two policy documents are from different sectors (climate change and environment). For a given country, a document can include several different OBCAs that fit into different categories; this is illustrated by “Document B” in Table 1.6.

⁴⁰ Table 1.A in Appendix 1.A provides the classification of policies according to the sectors they most relate.

Table 1.6: Two fictional examples for a given country illustrating how we translate policy content of interest into synthetic and graphical information.

🎯: Targeted action; 🛠️ Supporting action; ■ Presence of a quantitative objective; ■ Absence of a quantitative objective; \$: Costed action; Δ: Dated action; M: Multi-purpose; • Climate change policy document; • Environmental policy document.

Name of the OBCA category	OBCAs in the policy documents	What do we have?	How the information is synthesized	How the information is graphically synthesized
Example #1				
Category “Protection or restoration of blue carbon habitats to enhance carbon sinks” (mitigation)	<ul style="list-style-type: none"> - [OBCA #1]: “Conserve 30% of the EEZ by 2030 to enhance mitigation”. (from Document A focusing on climate change) - [OBCA #2]: “Seagrass restoration for mitigation and adaptation will cost 1 million. The monitoring of seagrass will be improved.” (from Document B focusing on climate change) 	<ul style="list-style-type: none"> ➤ <u>Precision:</u> Presence of at least one OBCA that is targeted (“TA”), quantitative (“■”), costed (“costed”), dated (“dated”), and supporting (“SA”). ➤ <u>Integration:</u> Multi-purpose (“M”). ➤ <u>Integration:</u> Two policies on climate change (••). Each dot corresponds to a policy document. 	<p>TA ■ costed dated SA M ••</p>	<p>🎯 ■ \$ Δ 🛠️ M ••</p>
Example #2				
Category “Protection, restoration or sustainable management of marine and coastal ecosystems for other or general purpose” (adaptation)	<ul style="list-style-type: none"> - [OBCA #3]: “Seagrass restoration for mitigation and adaptation, costed 1 million. The monitoring of seagrass will be improved.” (from Document B focusing on climate change) - [OBCA #4]: “Actively protect mangroves for increased resilience” (from Document C focusing on the environment) 	<ul style="list-style-type: none"> ➤ <u>Precision:</u> Presence of at least one OBCA that is targeted (“TA”), costed (“costed”), supporting (“SA”). No quantitative objective (“■”), no date/timeframe. ➤ <u>Integration:</u> Multi-purpose (“M”). ➤ <u>Integration:</u> One policy document on climate change (•), one policy document on general environment (•). 	<p>TA ■ costed SA M ••</p>	<p>🎯 ■ \$ 🛠️ M ••</p>
	Format of the 24 working tables (in Supplementary Material, Appendix 1.C).			Format of Table 1.8 in the Results section.

3. Results

3.1. Categories of OBCAs promoted in PSIDS's policies

3.1.1. Categories of OBCAs in NDCs

Twelve PSIDS out of fifteen (80%) directly included OBCAs in their original or revised NDCs. All of these twelve countries included coastal NbS in their NDCs. Two countries (Marshall Islands and Vanuatu) have included coastal NbS in their original NDC but not in their revised one. Countries that have not included OBCAs (and coastal NbS by definition) in their NDCs, which are the Federated States of Micronesia, Palau and Tuvalu, have all included OBCAs in other policies that are referenced in their NDCs, such as NAPs or National Climate Change Policies. Some countries have not included mitigation OBCA in their original or revised NDCs, while OBCAs for adaptation are greatly considered; this is the case of Samoa. On the contrary, the Marshall Islands have included OBCAs for mitigation purpose only.

Figure 1.2 shows the proportion of PSIDS that have explicitly⁴¹ included OBCAs in their NDCs (i.e., OBCAs are written in the NDC document), with light blue, dark blue and grey bars on Fig. 1.2 corresponding to the original, current⁴² and revised NDCs respectively. Figure 1.2 also shows the proportion of PSIDS that have implicitly included OBCAs in their NDCs, i.e., the details on OBCA are mentioned in the policies referenced in NDCs but not in NDCs directly (orange, yellow, and green bars on Fig. 1.2). When we look at the current PSIDS' NDCs (dark blue bars on Fig. 1.2), some OBCA categories are more considered than others on average in PSIDS. By “considered”, we mean that at least one OBCA refer to the category. For certain OBCA categories, only few PSIDS included corresponding actions in their NDCs. This is the case for the categories “marine renewable energy” (considered in 13% of the current PSIDS' NDCs) and “relocation and diversification of marine and coastal economic activities” (13%) (Fig. 1.2). In general, OBCAs assigned to the “multiple” category were wide-ranging and included vague mentions referring to the reduction of coastal risks, such as in the case of Nauru, Marshall Islands and Papua New Guinea (the detail of coastal NbS found in policy documents is available in the working tables in Supplementary Material, Appendix 1.C).

We found that the three most frequently considered OBCA categories in the current NDCs of PSIDS were based on nature. These categories referred to (1) to the protection of coastal areas from erosion or submersion through actions to protect, restore or sustainably manage coastal ecosystems (category “**ecosystem-based coastal protection**”). Indeed, 47% of the fifteen PSIDS included OBCAs as part of

⁴¹ “Explicitly” means directly in NDCs. As opposed to « implicitly » (or “indirectly”) which refers to the fact that actions are included in the other policies that are referenced in NDCs, and not in NDCs directly.

⁴² For a given country, its current NDC corresponds to its most recent NDC, i.e., the most recently revised NDC, or the original NDC when the country has not revised its original NDC. Current PSIDS' NDCs are the following: Cooks Islands 1st NDC (2016), Kiribati 1st NDC (2016), Federated States of Micronesia 1st NDC (2016), Niue 1st NDC (2016), Palau 1st NDC (2016), Timor-Leste 1st NDC (2017), and Tuvalu 1st NDC (2016), and the revised NDCs of Fiji (2020), Marshall Islands (2020), Nauru (2021), Papua New Guinea (2020), Samoa (2021), Solomon Islands (2021), Tonga (2020) and Vanuatu (2020).

this category in their current NDC (Fig. 1.2), mainly through the protection or restoration of mangroves rather than of coral reefs or seagrasses (even if seagrasses are increasingly mentioned over time⁴³ between original and revised NDCs). The two other most frequently considered categories in the current NDCs of PSIDS were (2) “**ecosystem-based fisheries management**” to adapt to climate change impacts (40% of PSIDS), and (3) “**blue carbon habitat (seagrass, mangrove) protection, restoration or sustainable management**” for climate mitigation (40% of PSIDS) (Fig. 1.2). In fact, protecting or restoring blue carbon habitats was the OBCA category most considered in PSIDS’ NDCs regarding climate mitigation, followed by “maritime transportation” and “marine renewable energy” (Fig. 1.2).

Our results show an increasing inclusion of OBCAs in PSIDS’ NDCs over time. While five PSIDS out of fifteen did not include OBCAs in their original NDCs (the Federated States of Micronesia, Palau, Papua New Guinea, Samoa and Tuvalu), all PSIDS that submitted a revised NDC have included OBCAs in their revised NDC. These eight PSIDS that have submitted a revised NDC as of October 31, 2021, are: Fiji (2020), Marshall Islands (2020), Nauru (2021), Papua New Guinea (2020), Samoa (2021), Solomon Islands (2021), Tonga (2020) and Vanuatu (2020). All the OBCA categories were more considered in the revised NDCs than in the original ones, in proportion of PSIDS, except the category on “infrastructure-based coastal protection” (it is considered in 25% of revised NDCs as compared to 40% of original NDCs). The greatest evolution over time was for the categories on (i) “**Maritime transportation**” (50% of revised NDCs contained OBCAs part of this category as compared to 7% of original NDCs), (ii) “**Ecosystem-based coastal protection**” (63% as compared to 13%), (iii) “**Relocation of people to safer places**” (50% as compared to 13%), and (iv) “**Ecosystem-based fisheries management for climate adaptation**” (50% as compared to 33%) (Fig. 1.2).

⁴³ By « over time », we either refer to (1) the difference between original NDCs and revised NDCs, (2) between [original NDCs + policies referenced in original NDCs] and [revised NDCs + policies mentioned in revised NDCs], or (3) between policies referenced in original NDCs and policies referenced in revised NDCs.

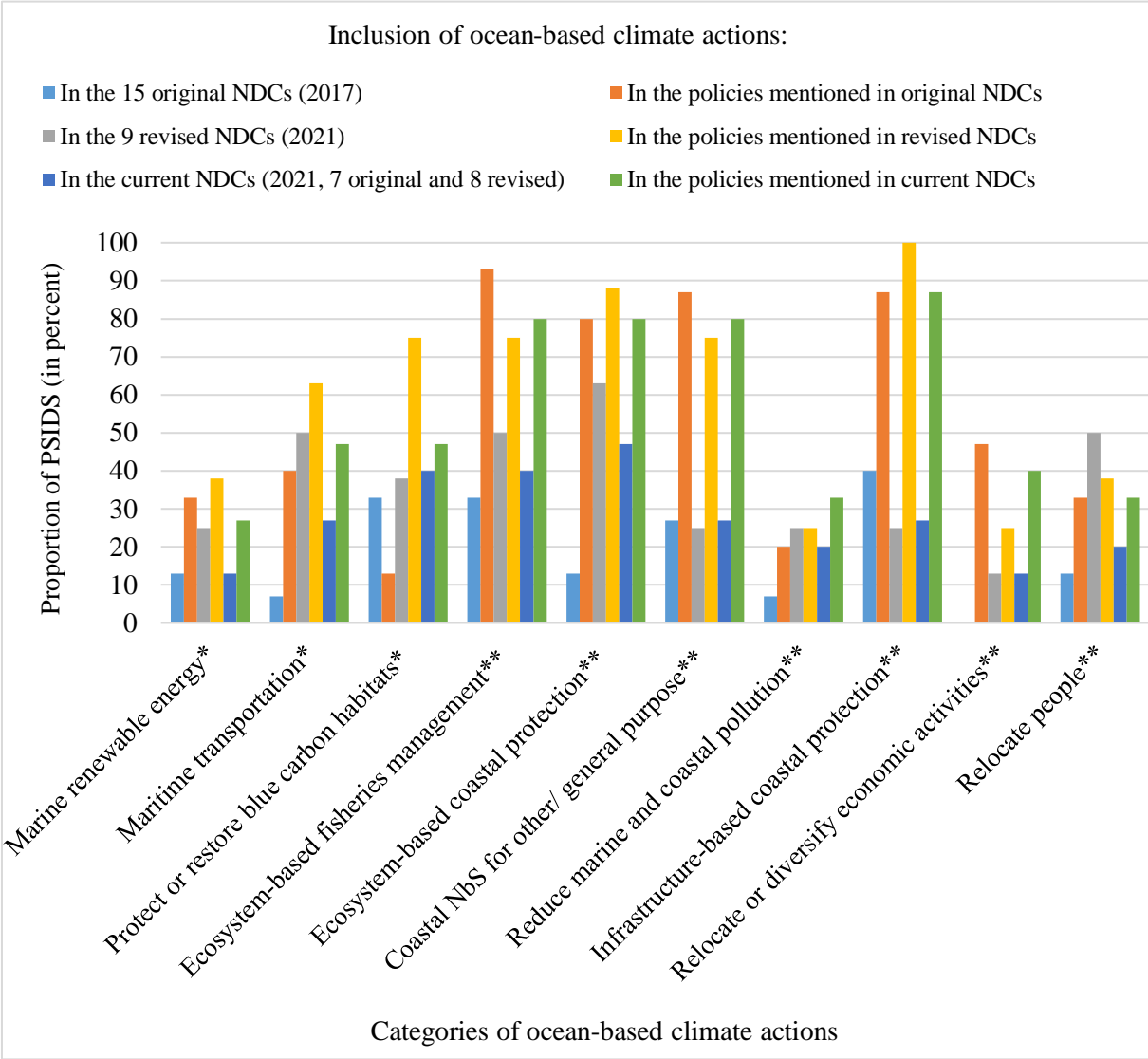


Fig. 1.2: Proportion of Pacific Small Island Developing States (PSIDS) including ocean-based climate actions (OBCA) in their original (light blue), revised (grey) and current (dark blue) Nationally Determined Contributions (NDCs), and in policies referenced in NDCs, for each OBCA category. All the fifteen PSIDS delivered an original NDC, and eight PSIDS revised their NDC (Marshall Islands revised it twice). * refers to a mitigation category. ** refers to an adaptation category.

3.1.2. Categories of OBCAs in other policies than NDCs

We also investigated how PSIDS have incorporated OBCAs in policies other than NDCs, i.e., in the 78 policies referenced in NDCs which include OBCAs (the complete list of policies is available in Table 1.A, in Supplementary Material, Appendix 1.A). The majority (75 out of 78) of the policies referenced in PSIDS’ NDCs that contain OBCAs were public plans, strategies or policies, and few (3 out of 78) were legal sources such as acts (Table 1.A in Appendix 1.A). We found fairly similar patterns of OBCA categories, whether the policies were referenced in the original (orange bars), revised (yellow), or current (green) NDCs (Fig. 1.2). This can be explained by the large number of policies, some of which

being referenced in both original and revised NDCs. The categories that were most increasingly considered over time in the “other policies” were “**Protect or restore blue carbon habitats**” (from 13% of PSIDS for policies mentioned in original NDCs to 75% of PSIDS⁴⁴ for policies mentioned in revised NDCs) and “**maritime transportation**” (from 40% to 63%) (Fig. 1.2).

When comparing NDCs and other policies by period of time (i.e., corresponding to original, revised or current NDCs), we found that the proportion of PSIDS including OBCAs is in general lower regarding the inclusion in NDCs than in other policies (Fig. 1.2). This may be because for each OBCA category we compared a single policy document (i.e., an NDC) with in general several policy documents. Indeed, there were in average around three or four different policies referenced in a given NDC, with strong variability among countries (up to nine policies mentioned in the revised NDC of Samoa) (Fig. 1.3). This was the case for the three periods of time (original, current, revised) and for all the OBCA categories (in particular for infrastructure-based coastal protection and for categories based on coastal ecosystems for adaptation), except for two categories (Fig. 1.2). The first exception concerned the category on the relocation of populations, which was on average more frequently considered in proportion of PSIDS in revised NDCs (50% of PSIDS that submitted a revised NDC) than in the other policies mentioned in revised NDCs (38% of PSIDS that submitted a revised NDC). The second exception concerned the category on blue carbon mitigation, which was on average greatly considered in proportion of PSIDS in their original NDCs (33% of PSIDS) rather than in other policies mentioned in their original NDCs (13% of PSIDS).

3.1.3. *In NDCs and other policies together: policy frameworks*

We sought to understand how PSIDS incorporated OBCAs in their general policy frameworks. In the following, we will call “policy framework” the combination of NDC plus policies mentioned in the NDC. Our results showed that Tuvalu was the only country that did not consider OBCA for mitigation, either in NDCs and other associated policies. In their policy frameworks, all PSIDS have considered OBCAs for climate adaptation. Four OBCA categories were considered by more than 75% of PSIDS, and these four categories refer to climate adaptation. These are: (i) “**Ecosystem-based coastal protection**” (80% of PSIDS for original policy frameworks⁴⁵ then 100% of PSIDS’ revised policy frameworks), (ii) “**Ecosystem-based fisheries management**” (93% for original then 88% for revised), (iii) “**Infrastructure-based coastal protection**” (87% then 100%), and (iv) “**Coastal NbS for other or general adaptation purpose**” (87% then 75%) (Table 1.7, first line in blue). Three of these four

⁴⁴ The percentages are in proportion of PSIDS: for other policies referenced in original NDCs, we consider all fifteen PSIDS as they all have submitted an original NDC, but for policies referenced in revised NDCs, we consider only the PSIDS that have submitted a revised NDC (i.e., eight PSIDS). Thus, here, 75% of PSIDS correspond to six PSIDS of the eight that have revised their NDCs.

⁴⁵ “Original policy framework” refer to the ensemble [original NDC + policies mentioned in the original NDC]. Similarly, “current policy framework” and “revised policy framework” refer to the ensembles [current NDC + policies mentioned in the current NDC] and [revised NDC + policies mentioned in the revised NDC] respectively.

categories are based on coastal ecosystems; only one is focused on human-induced structures (“Infrastructure-based coastal protection”). Moreover, on average for all PSIDS, three categories showed increased consideration in the policy frameworks over time. These are: (i) maritime transportation (in 88% of revised policy frameworks vs. 47% of original ones); (ii) blue carbon for mitigation (75% vs. 47%); and (iii) relocation of people to higher grounds or other countries (63% vs. 40%) (Table 1.7, first line in blue).

3.2. Examining OBCAs’ precision and integration: an indicator-based analysis

Table 1.8 shows a graphical illustration of how OBCAs are characterized (precision, integration) in each PSIDS. The pictograms (🎯 ■ ■ 🤖 \$ Δ) represent the indicators informing the level of precision, while the pictograms (M; ●●●●●●●●) inform the level of integration. Each colored dot correspond to one policy document. The color indicates the sub-sector or sector to which the policy document most relate, in accordance with colors in Table 1.3. For an easier understanding of Table 1.8, we invite the reader to refer to Table 1.6 that shows how we translated policy content of interest into synthetic and graphical information.

Indicators informing the level of precision of OBCA categories (i.e., targeted OBCA, supporting OBCA, quantitative objective, cost, date) and integration (i.e., multi-purpose, presence of policy documents) vary over time, across countries, and across OBCA categories (Table 1.8). As opposed to Table 1.8, Table 1.7 on OBCA precision and Table 1.9 on OBCA integration allow for a more detailed analysis for each of the eight indicators that are part of our scope, but do not make visible the distinction between countries because they focus on the regional scale.

Table 1.7: Count and proportion of PSIDS for indicators informing the level of precision for each category of ocean-based climate actions (OBCAs) in the policy frameworks (NDCs + associated policies referenced in NDCs) of the Pacific Small Island Developing States (PSIDS). Absolute proportion: in comparison to the number of PSIDS (15 PSIDS for original NDCs and 8 PSIDS for revised NDCs). The two versions of the revised NDCs of Marshall Islands were considered as a unique revised NDC. Relative proportion: in comparison with the number of PSIDS including OBCAs in their NDC and associated policies (counts in blue in line 1). In bold, proportion is $\geq 50\%$. OBCA categories in green are those based on coastal ecosystems.

				Categories of ocean-based climate actions (adapted from Gattuso et al., 2018)									
				MITIGATION			ADAPTATION						
				Energy	Transport	Blue carbon	Ecosystem-based fisheries management	Ecosystem-based coastal protection	Coastal NbS for other or general purpose	Pollution reduction	Infrastructure-based coastal protection	Relocation/diversification of activities	Relocation of people
Line 1	Count and proportion of PSIDS including OBCA (targeted or supporting)	In original NDCs and associated policies	Count	5	7	7	14	12	13	4	13	7	6
			Absolute	33%	47%	47%	93%	80%	87%	27%	87%	47%	40%
		In revised NDCs and associated policies	Count	4	7	6	7	8	6	4	8	3	5
			Absolute	50%	88%	75%	88%	100%	75%	50%	100%	38%	63%
Line 2	Count and proportion of PSIDS including targeted OBCA	In original NDCs and associated policies	Count	4	7	7	14	12	12	3	11	7	5
			Relative	80%	100%	100%	100%	100%	92%	75%	85%	100%	83%
		Absolute	27%	47%	47%	93%	80%	80%	20%	73%	47%	33%	
		In revised NDCs and associated policies	Count	4	6	6	6	7	5	4	7	3	5
Relative	100%	86%	86%	86%	88%	83%	100%	88%	100%	100%	100%		
Absolute	50%	75%	75%	75%	88%	63%	50%	88%	38%	63%			
Line 3	Count and proportion of PSIDS including quantitative OBCA objectives	In original NDCs and associated policies	Count	1	1	3	1	0	3	0	1	0	0
			Relative	20%	14%	43%	7%	0%	23%	0%	33%	0%	0%
		Absolute	7%	7%	20%	7%	0%	20%	0%	7%	0%	0%	
		In revised NDCs and associated policies	Count	3	4	4	3	2	2	1	1	0	0
Relative	75%	57%	66%	42%	25%	33%	25%	13%	13%	0%	0%		
Absolute	38%	50%	50%	38%	25%	25%	13%	13%	0%	0%			
Line 4	Count and proportion of PSIDS including supporting OBCA	In original NDCs and associated policies	Count	4	1	1	10	7	7	1	8	3	1
			Relative	80%	14%	14%	71%	58%	54%	25%	62%	43%	17%
		Absolute	27%	7%	7%	67%	47%	47%	7%	53%	20%	7%	
		In revised NDCs and associated policies	Count	0	4	4	5	7	4	1	8	0	2
Relative	0%	57%	67%	71%	88%	67%	25%	100%	0%	40%			
Absolute	0%	50%	50%	63%	88%	50%	13%	100%	0%	25%			
Line 5	Count and proportion of PSIDS including costed OBCA	In original NDCs and associated policies	Count	0	0	1	3	2	2	0	2	0	0
			Relative	0%	0%	14%	21%	17%	15%	0%	15%	0%	0%
		Absolute	0%	0%	7%	20%	13%	13%	0%	13%	0%	0%	
		In revised NDCs and associated policies	Count	0	0	0	2	0	0	0	0	0	0
Relative	0%	0%	0%	29%	0%	0%	0%	0%	0%	0%	0%		
Absolute	0%	0%	0%	25%	0%	0%	0%	0%	0%	0%			
Line 6	Count and proportion of PSIDS including dated (or timeframed) OBCA	In original NDCs and associated policies	Count	1	2	2	1	2	2	0	1	1	1
			Relative	20%	29%	29%	7%	17%	15%	0%	8%	14%	17%
		Absolute	7%	13%	13%	7%	13%	13%	0%	7%	7%	7%	
		In revised NDCs and associated policies	Count	1	2	4	2	1	3	1	0	0	0
Relative	25%	29%	67%	29%	13%	50%	25%	0%	0%	0%			
Absolute	13%	25%	50%	25%	7%	38%	13%	0%	0%	0%			

3.2.1. *Quantitative objectives: a focus on mitigation*

OBCAs have often been formulated as objectives to be achieved (e.g., “*Expand the area covered by marine protected areas and spatial management areas to 30% of the Tonga’s exclusive economic zone*”, in the revised NDC of Tonga). On average, when taking into account both NDCs and other policies (i.e., policy frameworks), categories in which there were at least one OBCA with a quantitative objective mostly related to mitigation, in particular for revised policy frameworks as compared to original ones (Table 1.7, line 3 in bold). Indeed, for more than half of PSIDS that have revised their NDCs, all three mitigation categories contained quantitative OBCA objectives (Table 1.7, line 3). This was particularly the case for actions referring to marine renewable energy, for which we found associated quantitative objectives to reduce CO₂ emissions or increase energy efficiency. For example, the Vanuatu’s National Energy Roadmap Implementation Plan of 2019 mentions the objective to “*improve marine transport efficiency by 2% in 2020, and 10% in 2030 compared to a business as usual projection*” (Working Table #24 in Supplementary Material, Appendix 1.C). Quantitative objectives for coastal NbS generally referred to an area or a proportion of the country’s maritime space that will be converted into a marine protected area. For instance, the Sustainable Development Goal 13 Roadmap of Papua New Guinea includes the following statement: “*Increased percentage of marine area protected to maintain and improve biological diversity from 0.21% (2017) to 9% (2022) [...] conserving and rehabilitating these areas will play an important role in increasing PNG’s resilience to climate change, as well as enhancing emissions reductions, with opportunities to develop approaches to registered blue carbon approaches*”. On the opposite, OBCAs referring to the relocation of people or to the relocation and diversification of economic activities were never associated with a quantitative objective, neither in NDCs explicitly nor in other policies (Tables 1.6 and 1.7). We also found great variability across countries. Some countries (e.g., Fiji) tend to explicitly increasingly include quantitative objectives over time (i.e., more directly in their revised NDCs than in the associated other policies). Yet, all policies referenced in the revised NDC of Fiji are all very recent (published in 2018 and after) (Table 1.A in Supplementary Material, Appendix 1.A). On the contrary, other countries (e.g., Papua New Guinea) tend to increasingly include quantitative objectives more in their other policies than directly in their revised NDCs (Table 1.8).

3.2.2. *Supporting OBCAs: a focus on coastal protection*

“Supporting OBCAs” were on average mostly found in categories referring to coastal protection (either infrastructure-based or ecosystem-based), and in categories based on coastal ecosystems more generally, both in the original and revised policy frameworks (Table 1.7, line 4). To a lesser extent, supporting actions were foreseen for the relocation of people to safer places. Supporting actions typically referred to improving investments in climate-resilient infrastructure (e.g., in Papua New Guinea’s Sustainable Development Goal 13 roadmap (2020), and in Samoa’s Second National Communication to the UNFCCC (2009)), as well as to the development of coastal vulnerability maps and assessments to strengthen coastal risk prediction (e.g., in Fiji’s National Adaptation Plan, 2018).

3.2.3. *Date and cost: often neglected aspects*

OBCAs were rarely costed on average in PSIDS' policy frameworks (Table 1.7, line 5). The only category that contained costed actions in PSIDS' revised policy frameworks was "Ecosystem-based fisheries management" (Table 1.7, line 5). On average in PSIDS, OBCAs were more frequently dated than costed, either for original policy frameworks or revised ones (Table 1.7, lines 5 and 6). However, the proportion of PSIDS mentioning dates associated with OBCAs never exceeded 50%, except for the category related to the protection or restoration of blue carbon ecosystems in the revised policy frameworks. More precisely, 50% of PSIDS that submitted a revised NDC have included dated OBCAs with regard to the protection or restoration of blue carbon ecosystems for climate mitigation (Table 1.7, line 6).

3.2.4. *Differences between NDCs and other policies*

By crossing the data from Table 1.7 on indicators of precision, Fig. 1.3 on policies and Table 1.8 with country details, we revealed great differences (i) across countries, and (ii) between the NDCs and the other policies. In some countries such as Nauru, the NDCs included OBCAs more explicitly than implicitly, mainly because very few policies were mentioned in NDCs (only one in the case of Nauru, entitled "Republic of Nauru Environmental Management and Climate Change Act 2020"). For instance, in Nauru's revised NDC, 8 categories out of 11 were explicitly covered, whereas only one category ("multiple") was considered in Nauru's Environmental Management and Climate Change Act 2020 (see Table 1.8 and Working Table #10 in Supplementary Material, Appendix 1.C). On the other hand, countries that mentioned many policies in their NDCs, such as Fiji, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu (Fig. 1.3) were more likely to cover many categories of OBCAs (Table 1.8).

Table 1.8: Synthesized graphical illustration of how the categories of ocean-based climate actions (OBCAs) are characterized (precision, integration) in each Pacific Small Island Developing State. “Other policies” correspond to the policies referenced in the Nationally Determined Contributions (NDCs). OBCA categories in green are those based on coastal ecosystems. In bold: current policy framework (i.e., the country’s most recent NDC and policies mentioned in it).

🎯: Targeted action; 🌿: Supporting action; ■: Presence of a quantitative objective; ■: Absence of a quantitative objective; \$: Costed action; Δ: Dated action; M: Multi-purpose; • Climate change policy; • Energy/transport policy; • Environment-climate policy • Environmental policy; • Biodiversity policy; • Ocean policy; • Agriculture policy; • Forest policy; • Climate – Development policy; • General development policy; • Community/gender policy (social). Each colored dot corresponds to one distinct policy document.

	Categories of OBCAs (adapted from Gattuso et al., 2018)	Climate mitigation			Climate adaptation								
		Marine Renewable Energy	Maritime Transport	Protect/restore blue carbon habitats	Ecosystem-based fisheries management	Ecosystem-based coastal protection	Protect, restore, sustainably manage coastal ecosystems for other or general purpose	Reduction of marine and coastal pollution	Infrastructure-based coastal protection	Relocate/diversify coastal and marine economic activities	Relocate people	Multiple	
Cook Islands	Original NDC			🎯 M ■		🎯 M ■	🎯 M ■						
	Other policies				🎯 ■ •	🎯 ■ •	🎯 ■ • •		🎯 ■	🎯 ■		🌿 •	
Fiji	Original NDC	🌿			🎯 ■		🎯 ■		🎯 ■		🎯 ■	🌿 Δ	
	Other policies	🎯 ■ • 🌿 • • •	🎯 ■ Δ • • • 🌿 Δ •		🎯 ■ •	🎯 ■ •	🎯 ■ •		🌿 • •	🎯 ■ •			
	Revised NDC		🎯 ■ ■ Δ	🎯 M ■ Δ	🎯 M ■	🎯 M ■	🎯 M ■ Δ				🎯 ■		
	Other policies		🎯 ■ • •	🎯 ■ Δ • • • 🌿 • •	🎯 ■ •	🎯 ■ •	🎯 ■ •	🎯 ■	🎯 ■ •	🎯 ■ •	🎯 ■ •	🎯 ■ •	🌿 • •
Kiribati	Original NDC			🎯 ■				🎯 ■					
	Other policies		🎯 ■ • •		🎯 ■ M • • •	🎯 ■ •	🎯 ■ • •	•	🎯 ■ • • •	🎯 ■ •		🌿 • • •	
Marshall Islands	Original NDC	🎯 ■ 🌿	🎯 ■ Δ	🎯 ■ M								🎯 ■ M	
	Other policies	🎯 ■ Δ • 🌿 Δ •			🎯 ■ •							🎯 ■ •	
	Revised NDC 2018										🎯 ■	🌿	
	Other policies	🎯 ■ •	🎯 ■ • 🌿 •			🎯 ■ M			🎯 ■			🎯 ■ M • (risks)	

	Revised NDC 2020											
	Other policies											
	Climate mitigation			Climate adaptation								
	Categories of OBCAs (adapted from Gattuso et al., 2018)	Marine Renewable Energy	Maritime Transport	Protect/restore blue carbon habitats	Ecosystem-based fisheries management	Ecosystem-based coastal protection	Protect, restore, sustainably manage coastal ecosystems for other or general purpose	Reduction of marine and coastal pollution	Infrastructure-based coastal protection	Relocate/diversify coastal and marine economic activities	Relocate people	Multiple
Micronesia	Original NDC											
	Other policies											
Nauru	Original NDC											
	Other policies											
	Revised NDC											
	Other policies											
Niue	Original NDC											
	Other policies											
Palau	Original NDC											
	Other policies											
Papua New Guinea	Original NDC											
	Other policies											
	Revised NDC											
	Other policies											
Samoa	Original NDC											
	Other policies											
	Revised NDC											
	Other policies											

		Climate mitigation			Climate adaptation							
	Categories of OBCAs (adapted from Gattuso et al., 2018)	Marine Renewable Energy	Maritime Transport	Protect/restore blue carbon habitats	Ecosystem-based fisheries management	Ecosystem-based coastal protection	Protect, restore, sustainably manage coastal ecosystems for other or general purpose	Reduction of marine and coastal pollution	Infrastructure-based coastal protection	Relocate/diversify coastal and marine economic activities	Relocate people	Multiple
Solomon Islands	Original NDC											
	Other policies											
	Revised NDC											
	Other policies											
Timor-Leste	Original NDC											
	Other policies											
Tonga	Original NDC											
	Other policies											
	Revised NDC											
	Other policies											
Tuvalu	Original NDC											
	Other policies											
Vanuatu	Original NDC											
	Other policies											
	Revised NDC											
	Other policies											

Table 1.9: Count and proportion of PSIDS for indicators informing the level of integration for each category of ocean-based climate actions (OBCAs) in the policy frameworks (NDCs + associated policies referenced in NDCs) of the Pacific Small Island Developing States (PSIDS). Absolute proportion: in comparison to the number of PSIDS (15 PSIDS for original NDCs and 8 PSIDS for revised NDCs). The two versions of the revised NDCs of Marshall Islands were considered as a unique revised NDC. Relative proportion: in comparison with the number of PSIDS including OBCAs in their NDC and associated policies (counts in blue on line 1). In bold, proportion is $\geq 50\%$. *sector refers to the main sectors of the policies reviewed: climate change, development, environment. OBCA categories in green are those based on coastal ecosystems.

				Categories of ocean-based climate actions (adapted from Gattuso et al., 2018)									
				MITIGATION			ADAPTATION						
				Energy	Transport	Blue carbon	Ecosystem-based fisheries management	Ecosystem-based coastal protection	Coastal NbS for other or general purpose	Pollution reduction	Infrastructure-based coastal protection	Relocation/diversification of activities	Relocation of people
Line 1	Count and proportion of PSIDS including OBCA (targeted or supporting)	In original NDCs and associated policies	Count	5	7	7	14	12	13	4	13	7	6
			Absolute	33%	47%	47%	93%	80%	87%	27%	87%	47%	40%
		In revised NDCs and associated policies	Count	4	7	6	7	8	6	4	8	3	5
			Absolute	50%	88%	75%	88%	100%	75%	50%	100%	38%	63%
Line 2	Count and proportion of PSIDS including multi-purpose OBCA	In original NDCs and associated policies	Count	0	0	3	5	5	6	1	4	0	1
			Relative	0%	0%	43%	36%	42%	46%	25%	31%	0%	17%
			Absolute	0%	0%	20%	33%	33%	40%	7%	27%	0%	7%
			Count	0	0	3	5	6	4	2	3	0	0
		In revised NDCs and associated policies	Relative	0%	0%	50%	71%	75%	67%	50%	38%	0%	0%
			Absolute	0%	0%	38%	63%	75%	50%	25%	38%	0%	0%
			Count	0	1	5	0	0	0	1	0	0	1
Line 3	Count and proportion of PSIDS including OBCA in NDCs only	In original NDCs only	Relative	0%	14%	71%	0%	0%	0%	25%	0%	0%	17%
			Absolute	0%	7%	33%	0%	0%	0%	7%	0%	0%	7%
			Count	1	2	0	1	1	0	1	1	1	3
		In revised NDCs only	Relative	25%	29%	0%	14%	13%	0%	25%	13%	33%	60%
			Absolute	13%	25%	0%	13%	13%	0%	13%	13%	13%	38%
			Count	3	6	2	9	10	8	3	7	7	4
Line 4	Count and proportion of PSIDS including OBCA only in other policies than NDCs	In policies referenced in original NDCs but not in original NDCs	Relative	60%	86%	29%	64%	83%	62%	75%	54%	100%	67%
			Absolute	20%	40%	13%	60%	67%	53%	20%	47%	47%	27%
			Count	2	2	3	3	2	4	3	6	2	2
		In policies referenced in revised NDCs but not in revised NDCs	Relative	50%	29%	50%	43%	25%	67%	75%	75%	67%	40%
			Absolute	25%	25%	38%	38%	25%	50%	38%	75%	25%	25%
			Count	2	0	0	5	2	4	0	6	0	1
Line 5	Count and proportion of PSIDS including OBCA in both NDCs and other policies	In original NDCs and associated policies	Relative	40%	0%	0%	36%	17%	31%	0%	46%	0%	17%
			Absolute	13%	0%	0%	33%	13%	27%	0%	40%	0%	7%
			Count	0	2	3	3	4	2	1	1	0	1
		In revised NDCs and associated policies	Relative	0%	29%	50%	43%	50%	33%	25%	13%	0%	20%
			Absolute	0%	25%	38%	38%	50%	25%	13%	13%	0%	13%
			Count	0	1	0	3	5	5	0	1	1	0
Line 6	Count and proportion of PSIDS including OBCA only in other policies than NDCs, of different sectors*	In original NDCs but not in original NDCs	Relative	0%	14%	0%	21%	42%	38%	0%	8%	14%	0%
			Absolute	0%	7%	0%	20%	33%	33%	0%	7%	7%	0%
			Count	0	1	1	1	1	1	0	1	1	0
		In policies referenced in revised NDCs but not in revised NDCs	Relative	0%	14%	17%	14%	13%	17%	0%	13%	33%	0%
			Absolute	0%	13%	13%	13%	13%	13%	0%	13%	13%	0%

Line 7	Count and proportion of PSIDS including OBCA in both NDCs and other policies of different sectors*	In original NDCs and associated policies	Count	1	0	0	2	0	2	0	3	0	0
			Relative	20%	0%	0%	14%	0%	15%	0%	23%	0%	0%
			Absolute	7%	0%	0%	13%	0%	13%	0%	20%	0%	0%
		In revised NDCs and associated policies	Count	0	1	3	2	2	2	0	1	0	1
			Relative	0%	14%	50%	29%	25%	33%	0%	13%	0%	20%
			Absolute	0%	13%	38%	25%	25%	25%	0%	13%	0%	13%

3.2.5. Multi-purpose: increased recognized aspect over time

Table 1.9 presents an analysis of the extent to which we found the indicators of integration (i.e., indicators (f) on multi-purpose aspect, (g) on the presence of several policies from the same sector, and (h) on the presence of policies from different sectors) in the policy frameworks of PSIDS, for each OBCA category, in count and in proportion of PSIDS. The multi-purpose aspect was increasingly considered over time on average in PSIDS, for all categories except for “Relocation of people” (Table 1.9, line 2). In addition, Table 1.9 (line 2) shows that coastal NbS categories were more likely to contain actions that are multi-purpose compared to categories not based on coastal ecosystems. Multi-purpose OBCAs in PSIDS’ policies could refer for example to both mitigation and adaptation. This was for instance the case in the Palau’s Climate Change Policy 2015 and in the Samoa Ocean Strategy 2020-2030, which included coastal NbS that are described to both respond to climate adaptation and mitigation challenges. The Palau’s Climate Change Policy 2015 mentions that “MPAs in Palau Protected area network are ecologically connected (baseline assessments, nationwide management frameworks), 5-year action plan, cost: \$1,000,000. Objective: by 2020, the enabling framework is established to build ecosystem resilience and sustainably manage carbon sinks using holistic and synergistic management approaches”. Co-benefits for mitigation and adaptation are highlighted in the Ocean Strategy 2020-2030 of Samoa as followed: “By 2030, mangrove forests are effectively protected or restored through national policy and through ecosystem-based approaches to maximize climate change adaptation and mitigation benefits for coastal communities”. OBCAs referring to coastal protection were also frequently multi-purpose. More precisely, we frequently observed that, in the same sentence of a policy document, certain OBCAs referred to coastal risks reduction through both infrastructure-based actions (e.g., construction of seawalls) and ecosystem-based actions (e.g., mangrove protection). This was for instance the case in the First National Communication to the UNFCCC (2000) of Papua New Guinea, which calls for “considering seawalls and soft measures for coastal protection”.

3.2.6. Policy sectors: a greater variety over time and associated with coastal NbS categories

Both Table 1.8, Table 1.9 and Fig. 1.3 inform the level of integration with regards to indicators (g) and (h) on the presence of policies containing OBCAs. Figure 1.3 shows that, in general for all PSIDS, the most common sector of policies containing OBCAs was climate change, with policy documents either addressing it generally (dark grey) or focusing on one specific aspect, such as energy or transport (light grey). All PSIDS’ NDCs mentioned climate policies, except Nauru’s revised NDC. Development-

related policies containing OBCAs were also frequently mentioned in PSIDS' NDCs, since 13 NDCs out of 24 included some (orange, pink and purple in Fig. 1.3). The NDCs that did not mention development policies containing OBCAs were for instance those of Marshall Islands and Nauru (Fig. 1.3). This does not mean that these countries did not mention a development policy in their NDC; they may have mentioned a development policy that does not include any OBCAs. This is the case, for example, of the original NDC of Marshall Islands, which mentions a development policy (National Strategic Development Plan: Vision 2018 (2001)) that does not include any OBCA and only refers to the ocean in a contextual manner (*“Our lagoons and oceans were rich in marine and fisheries resources”*).

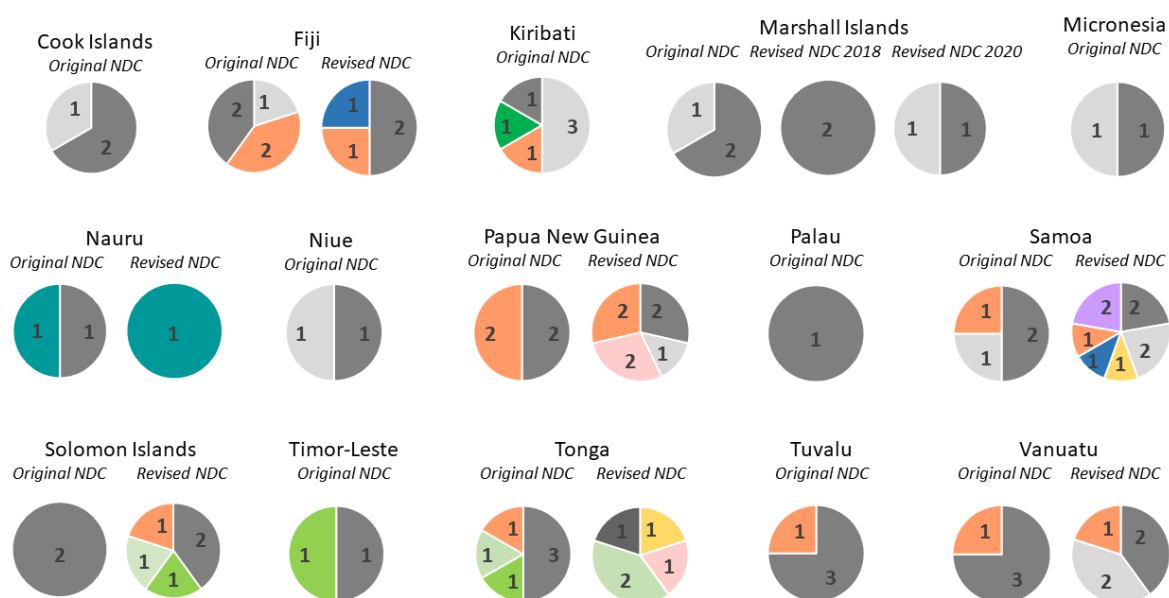


Fig. 1.3: Proportion of policy sectors for all the policies referenced in the original and revised Nationally Determined Contributions of each Pacific Small Island Developing States. Numbers indicate the number of different policies. Policy sectors: ● Climate change (general); ● Energy-Transport; ● Climate change – Environment; ● Environment (general); ● Biodiversity; ● Forestry; ● Agriculture; ● Ocean; ● Climate – Development; ● Development (general); ● Community-Gender.

The NDCs of countries with small human populations such as Niue (1620 inhabitants in 2018), Nauru (12,511 inhabitants in 2021), and Marshall Islands (42,050 inhabitants in 2021) generally mentioned fewer other policies containing OBCAs than bigger countries, such as Papua New Guinea (14,800,000 inhabitants in 2020), Fiji (924,610 inhabitants in 2021), Solomon Islands (707,851 inhabitants in 2021) or Samoa (218,764 inhabitants in 2021) (Table 1.A in Supplementary Material Appendix 1.A shows the complete list of the policies mentioned in PSIDS' NDCs). The most notable exception was Timor-Leste (1,321,000 inhabitants in 2021), which only mentioned two policies containing OBCAs in its NDC.

On average, PSIDS included more policies containing OBCAs in their revised NDCs than in original ones (Fig. 1.3). This was particularly the case for Samoa, Solomon Islands and Papua New Guinea. This increased number was also accompanied by a greater variety of policy sectors represented, in particular policies focusing on specific aspects such as the ocean (in the revised NDC of Fiji and Samoa), forestry through mangrove-based OBCAs (in the revised NDC of Solomon Islands and Tonga) or agriculture (in the revised NDC of Samoa and Tonga) (Fig. 3).

At the regional PSIDS scale, coastal NbS categories were generally covered by a greater variety of policies from different sectors (i.e., climate change, environment and development) than OBCA categories not based on coastal ecosystems (Table 1.9, lines 6 and 7). This was especially the case for revised policy frameworks, especially those of Samoa, Papua New Guinea, Solomon Islands and Tonga (see the numerous colored dots in rows corresponding to the countries in Table 1.8). Coastal NbS were rarely found in biodiversity policies, but rather in climate-related policies such as in the National Adaptation Programmes of Actions. To sum up, coastal NbS categories were on average both more likely to contain multi-purpose OBCAs (indicator f), and to contain actions from various policies (indicator g), which focus on different sectors (indicator h), compared to OBCA categories not based on coastal ecosystems. Finally, OBCAs were also included more explicitly in NDCs over time, meaning that the proportion of PSIDS that have only considered OBCAs in their other policies and not in NDCs has decreased over time (Table 1.9, line 4).

4. Discussion

4.1. An increased consideration of OBCAs in PSIDS' NDCs, with a focus on coastal NbS and adaptation

Our results highlight an increased explicit consideration of OBCAs over time in PSIDS' NDCs. This is particularly the case for coastal NbS in PSIDS' NDCs, especially concerning (i) ecosystem-based coastal protection for adaptation, (ii) ecosystem-based fisheries management for adaptation, and (iii) the protection and restoration of blue carbon ecosystems for mitigation. The NDCs of PSIDS also increasingly refer to other policies containing OBCAs. This increase cannot be explained by the number of policies, since there are on average similar numbers⁴⁶ of policies references in revised NDCs compared to the original ones. Thus, we can conclude from this result that, alike NDCs, other policies have also increasingly include OBCAs.

Adaptation categories containing OBCAs in NDCs are multiple, while there are few mitigation OBCA categories. No PSIDS have considered the following mitigation OBCA categories from the classification

⁴⁶ Among the countries with the highest numbers of policies referenced in NDCs, the Solomon Islands, Samoa and Papua New Guinea have more referenced policies in their revised NDCs compared to their original ones, while it is the contrary for Fiji, Nauru and Tonga (Fig. 1.3).

of Gattuso et al. (2018, refined in 2022): “Carbon capture and storage”, “Marine bioenergy with carbon capture and storage”, “Enhancing open-ocean productivity”, “Enhancing weathering alkalisation”, “Cloud brightening”, and “Surface albedo enhancement”. However, all OBCA categories for adaptation referenced by Gattuso et al. have been considered. This result underlines the fact that highlighting adaptation actions in NDCs is of importance for PSIDS. This is interesting since the adaptation component in NDCs is not mandatory and serves as a mean to communicate internationally a country’s contribution, while other policies elaborated under the UNFCCC, such as the National Adaptation Plans, are domestic planning processes specifically dedicated to adaptation (Hammil et al., 2017). The importance of climate adaptation, notably regarding coastal protection and the sustainable management of coastal fisheries, is also highlighted as a key priority in the other policies mentioned in NDCs, especially in National Adaptation Programmes of Actions and in Joint National Plans for Climate Change and Disaster risk reduction.

Moreover, our results underscore the recognition by PSIDS of the important role that coastal ecosystems play in climate adaptation with mitigation co-benefits. Northrop et al. (2020) consider that the restoration and protection of coastal and marine ecosystems has the greatest mitigation potential while providing significant co-benefits, among all OBCAs. Recognition of coastal NbS’ co-benefits for adaptation and mitigation, and for nature and people, is also more frequent in revised NDCs than in original NDCs, suggesting a better awareness of the wide range of ecosystem services from mangrove, coral reefs and seagrasses by PSIDS (Brodie et al., 2020; Selig et al., 2019). This is particularly true for seagrasses, echoing the development of policies on seagrass protection, which is one of the six priorities for seagrass protection in PSIDS highlighted by Brodie et al. (2020). The importance of protecting coastal zones and ecosystems in PSIDS is also highlighted by Crumpler & Bernoux (2020) in their review of agricultural ecosystems in PSIDS’ NDCs. They showed that oceans and coastal zones are considered the second most vulnerable ecosystems in PSIDS after agro-ecosystems, and that the most vulnerable agro-ecosystem to changes is marine fisheries, followed by crops, livestock, and forestry. In addition, the explicit information in the NDCs shows a shift over time from infrastructure-based options to protect coasts from climate impacts towards ecosystem-based actions to protect coasts, especially through mangrove protection and restoration. This corroborates the growing scientific literature that considers seawalls as maladaptation options to protect coasts, as they have failed to resolve coastal erosion in PSIDS, particularly in small islands and rural areas (Nunn et al., 2021). Seawalls are more likely to cause unintended negative effects on people and natural ecosystems than coastal NbS (Nunn et al., 2021; Schoonees et al., 2019). For example, a study examining two seawall projects in Fiji found that seawalls failed to protect coastal communities from coastal climate pressures and instead resulted in unintended negative outcomes for land and livelihood security (Piggot-McKellar et al., 2020). However, in some cases, local conditions hinder the use of soft solutions such as NbS (Schoonees et al., 2019). Local preferences for seawalls can also dominate despite potential negative effects (Hills et al., 2013), as

shown by Narayan et al. (2020) for some coastal communities in Papua New Guinea, Solomon Islands and Samoa. Finally, we found that the infrastructure-based coastal protection actions that are implicitly included in other policies referenced in revised NDCs are generally published in the last five years (2017-2022) and do not generally refer to seawalls but rather to the reconstruction or consolidation of houses, roads and other infrastructures.

4.2. Despite greater details on OBCA quantitative objectives in NDCs, a gap of information still remains

On the one hand, NDCs increasingly explicitly include quantitative OBCA objectives. Quantitative objectives are more frequently associated with mitigation OBCAs than adaptation OBCAs, which is not surprising since setting adaptation targets can be particularly difficult, as adaptation progress remains difficult to measure (UNEP, 2022b). This increase is in line with the requirements of the Paris Agreement Work Programme of 2018 to provide detailed and transparent information in NDCs to facilitate clarity and progress tracking. This greater level of detail may facilitate the global stocktake that will be conducted in 2023 under the Paris Agreement to take stock of global climate progress. It may also enhance policy coherence among instruments and sectors, thereby increasing the implementability of actions (Coscieme et al., 2021). On the other hand, our analysis reveals that PSIDS' NDCs still lack clarity to allow a fine understanding of how and when actions will be implemented. Indeed, most PSIDS' NDCs explicitly mention the need to foster climate finance but they rarely mention finance sources or potential finance channels they could use for OBCA implementation. In addition, the feasibility and sufficiency of the budget are not described. Similarly, dates and timeframes are often found in NDCs but not at the OBCA scale, and it is difficult to know if there is a long-term vision on OBCA implementation planning by analyzing NDCs. This echoes the findings of Scobie et al. (2016) on their review of climate policies in the Caribbean SIDS, which demonstrated that the mechanics involved in climate coherence such as “setting and prioritizing objectives” have not translated to policy coherence at national levels, and that policies do not adequately address timelines nor sources of finance. Greater levels of details regarding dates, costs, supporting actions and quantitative objectives associated with OBCAs would be useful to understand how PSIDS envision the implementation of OBCAs included in their NDCs. Nonetheless, PSIDS made their need for external financial, capacity-building or technical support explicit as a prerequisite to achieve their NDC targets (Crumpler & Bernoux, 2020). In particular, all PSIDS communicate either full or partial conditionality of NDC implementation to external financial support – but not all quantify the respective conditional or unconditional shares (Crumpler & Bernoux, 2020).

4.3. The importance of reviewing the policies referenced in NDCs to address information gaps

The importance of reviewing policies other than NDCs (i.e., the policies mentioned in NDCs) is particularly important to address information gaps. This additional review is particularly valuable to

understand how PSIDS integrated (i) blue carbon mitigation actions and (ii) coastal infrastructure-based actions in their policy frameworks. Indeed, when analyzing the explicit inclusion of blue carbon actions in NDCs only (category “Protect blue carbon ecosystems”), we observe a slight increase of consideration over time between original and revised PSIDS’ NDCs (33% to 38% of PSIDS respectively for original and revised NDCs), while the analysis of other policies shows a strong rise of consideration from 13% to 75% of PSIDS over time (Fig. 1.2). This result suggests a recent, sudden and very marked increase of political consideration in a wide range of policies regarding blue carbon related actions. We would have missed this result if we had only looked at the NDCs without examining the policies to which the NDCs refer to. This result also suggests that NDCs do not always represent the highest ambition of the country regarding its OBCAs, as NDCs often do not explicitly express critical information that are contained in other policies. For instance, the revised NDC of Samoa (published in July 2021) does not explicitly include OBCAs for climate mitigation, but it mentions Samoa’s National Ocean Policy (published in 2020), in which we found the following OBCAs for mitigation: (i) *“by 2030, mangrove forests are effectively protected or restored through national policy and through EBAs to maximize climate change adaptation and mitigation benefits for coastal communities”* and (ii) *“By 2030, air and marine pollution from ships and ports are reduced by 50% compared with 2020 levels of carbon emissions levels”*. We found similar patterns regarding the category “Infrastructure-based action for coastal protection”, since corresponding OBCAs were largely included implicitly in NDCs rather than explicitly (i.e., they are more often included in other policies than in NDCs), as shown in Fig. 1.2. For instance, while Papua New Guinea only mentions “coastal defense structures” in its revised NDCs, without complementary information, more details are incorporated in its Medium Term Development Plan III (2018) (*“Goal: 2.1: Improve infrastructure with sustainable and disaster resilient quality - Strategy 3: Rehabilitate and upgrade major ports and strategic wharves and jetties along the coast and waterways.”*) and in its First National Communication to the UNFCCC 2000 (*“Consider seawall and soft measures for coastal protection”*). Including OBCAs in NDCs in an explicit manner could help PSIDS make climate action more visible and increase policy integration, in a context where the majority of PSIDS’ NDCs promote policy mainstreaming and coherence (Crumpler & Bernoux, 2020). Thus, our study highlights specific areas (i.e., blue carbon protection and infrastructure-based coastal protection) where actions could be more integrated between NDCs and the policies they mention.

We found that PSIDS increasingly include OBCAs in various policies that focus on different sectors (development, climate, environment) and sub-sectors (such as ocean, biodiversity, energy). This echoes the findings of Schmidt & Fleig (2018) on the rise of the climate policy portfolio worldwide between 1990 and 2018. However, only two PSIDS (Samoa and Fiji) mention their National Ocean Policy (NOP) in their NDCs, whereas other PSIDS released some NOPs earlier than their revised NDCs. This is for example the case of Vanuatu, whose NOP was published in 2016 while its revised NDC was published in 2020. This is also the case of Papua New Guinea, whose NOP was released in July 2020 while its

revised NDC is from December 2020. It could be interesting in future research to systematically review these ocean or coastal policies that are not referenced in PSIDS' NDCs to clarify the information gap between NDCs and other policies in terms of OBCAs, and better inform the upcoming NDCs that should be updated in 2025.

4.4. Limitations and research perspectives

While we believe this work provides important insights into how NDCs include OBCAs explicitly and implicitly, several limitations should be pointed out. First, NDCs differ widely across countries in terms of content but also in terms of format, with relevant information for analysis scattered throughout NDC documents, which makes it difficult to identify relevant information and priorities. The analysis of NDCs and of the other policy documents remains a complex task, as these policies often lack clarity on the concrete actions that will be implemented and expected results. Moreover, it was not always made clear in the policy documents that an OBCA was designed with a clear climate objective. We selected only those OBCAs that clearly had a climate purpose, which may eliminate a substantial proportion of OBCAs that may play a role for climate adaptation and mitigation, but were not developed for that purpose according to the text of the policy document.

Second, while several aspects such as quantitative targets and policy sectors were relatively easy to identify and qualify, others were less so. For example, the level of detail in dates or costs was sometimes too low to understand whether the dates or costs referred to an OBCA or to a broader set of actions; often, programs or policies are dated or costed but without details about specific actions, making it difficult to accurately qualify OBCAs.

Thirdly, interpreting the presence or absence of OBCAs is not straightforward. Indeed, our analysis does not allow us to know whether a country has not included certain OBCAs because it does not consider them a priority or because it has already implemented them (e.g., in the case where natural ecosystems are already protected and the country has not considered it important to mention this in its NDC and related policies). Further knowledge of what has already been done by PSIDS would be needed to refine our interpretations of the absence or presence of OBCAs in policy documents.

In relation to the previous point, our approach focuses only on policy design, but integration must occur across all stages of the policy process (e.g., policy formulation, decision-making, implementation, evaluation) for action to be effective (UNEP, 2022b). Further research on how NDCs are integrated into other critical stages (e.g., decision-making, implementation, evaluation) and how stakeholders cooperate (e.g., government agencies, industry partners, communities) would also be worth investigating in order to gain a broader overview of NDC integration and inform coastal management.

5. Conclusion

Although NDCs mainly show what countries intend to do and not what they actually do, the analysis of these policy documents has revealed interesting features. First, 80% of PSIDS included OBCAs directly in their NDCs, and when taking into account policies referenced in NDCs, 100% of PSIDS included OBCAs in their policy frameworks. This suggests a strong awareness among PSIDS of the role of the ocean in tackling climate change. Patterns of OBCA inclusion in PSIDS' national policies differ widely across countries, which is not surprising given the different national socio-ecological contexts and circumstances. Second, our results highlight a great recognition of the role of coastal ecosystems for climate adaptation and mitigation, since the three OBCA categories most considered in the current NDCs of PSIDS referred to coastal ecosystems. These are (i) ecosystem-based coastal protection for climate adaptation (47% of PSIDS' current NDCs), (ii) ecosystem-based fisheries management for climate adaptation (40%), and (iii) protection/restoration of blue carbon ecosystems for climate mitigation (co-benefits for adaptation being often recognized) (40%). Least considered OBCA categories referred to marine renewable energy (13% of PSIDS' current NDCs), relocation and diversification of marine and coastal economic activities (13%), reduction of pollution for preserving coastal ecosystems (20%) and the relocation of people to safer places (20%). However, the development of marine renewable energy and the relocation of populations to safer locations were increasingly being considered as options, with explicit inclusion in 25% and 50% of the revised NDCs respectively.

OBCAs were increasingly considered over time by PSIDS in their NDCs, and more generally in their policy frameworks, in particular regarding (i) maritime transportation, (ii) relocation of people, and (iii) the four coastal NbS categories. One salient result was the switch over time from infrastructure-based coastal protection towards ecosystem-based coastal protection to reduce climate impacts on coastal areas. In addition, OBCAs in NDCs were also increasingly precise and integrated across different OBCA categories and across various policies from different sectors. More specifically, OBCAs were increasingly associated with quantitative objectives over time, especially coastal NbS. Also, OBCA categories were more integrated in various policies from different sectors or sub-sectors over time, and co-benefits across OBCA categories were increasingly highlighted, including between (i) nature-based and non-nature based actions, (ii) between development, climate and general environmental challenges, and (iii) between climate mitigation and adaptation components. However, the information provided in the NDCs in general still lacks important indications about when and how OBCAs will be concretely implemented and monitored. In particular, costs and dates on their future implementation currently lack in PSIDS' NDCs and could be more systematically incorporated.

The importance of reviewing not only NDCs but also the policies they refer to was particularly useful to better understand how PSIDS integrate OBCAs in their policy frameworks. This was particularly the case regarding blue carbon activities and targets, for which we found relevant information in other

policies referenced in revised NDCs that was not made explicit in revised NDCs. We therefore argue that the NDCs do not necessarily adequately express the actual level of ambition of PSIDS in terms of OBCAs, notably concerning blue carbon activities and infrastructure-based adaptation. We recommend that these actions and targets implicitly included in NDCs be explicitly included in NDCs to make PSIDS' climate actions and needs more transparent and visible on the international stage, as required by the Paris Agreement. This practice would also improve climate policy mainstreaming and coherence between policies and sectors, as recommended by the OECD, the Ocean and Climate Change Dialogue of the UNFCCC, and the scientific literature (see for example Dencer-Brown et al., 2022; Dobush et al., 2022; Strauß et al., 2022; Coscieme et al., 2021). As such, this work serves as an initial inventory of policy coverage regarding OBCAs in PSIDS' NDCs, and does not indicate policy effectiveness. This work does not aim to cover all OBCAs in PSIDS' policies. Instead, it focuses on how NDCs include OBCAs both directly and indirectly, revealing the linkages between NDCs and other national policies, in order to inform the next round of NDC update in 2025 and the upcoming global climate stocktake in 2023.

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Chapter 2

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

Chapter 2 has been published in *Nature-based Solutions*.

Châles, F., Bellanger, M., Bailly, D., Dutra, L. X., & Pendleton, L. (2023). Using standards for coastal nature-based solutions in climate commitments: Applying the IUCN Global Standard to the case of Pacific Small Island Developing States. *Nature-Based Solutions*, 3, 100034.

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.

Keywords: Climate; Nationally Determined Contributions; Coastal ecosystems; IUCN Global Standard for Nature-based Solutions; Pacific; Small Island Developing States.

1. Introduction

Climate change and environmental degradation are two main challenges of our time, threatening human health and exacerbating development inequalities (Pörtner et al., 2021). 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 (Deprez et al., 2021; IPCC, 2021; Pörtner et al., 2021; IPBES, 2019; Romanelli et al., 2015).

Nature-based solutions (NbS) have been recognized as a valuable tool to jointly tackle these challenges (IPBES, 2019). 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” (Cohen-Shacham et al., 2016). Well-designed NbS help to reinforce synergies between the 17 Sustainable Development Goals of the United Nations (Cohen-Shacham et al., 2019), while being in many contexts low-cost options compared to engineered solutions (Gattuso et al., 2021; Seddon et al., 2020a; Hoegh-Guldberg et al., 2019; Jones et al., 2012). 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 (IPBES, 2019). For example, carbon sequestration rates in the sediments of coastal ecosystems such as mangroves and seagrasses can be up to ten times higher than those of terrestrial ecosystems (Duarte et al., 2013).

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 (Lecerf et al., 2021; UNFCCC, 2021; Seddon et al., 2020b; Seddon et al., 2019).

However, the growing use of the NbS concept by scientists and practitioners raises concerns about its potential misuses and implementation constraints (Chausson et al., 2020; Seddon et al., 2020a). For instance, Gann et al. (2019) 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 (Seddon et al., 2020a). 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 (IUCN, 2020). 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 (IUCN, 2020).

As a global standard, it is important to ensure that coastal NbS are appropriately considered in climate commitments such as NDCs (Gallo et al. 2017). However, there is currently no NDC⁴⁷ 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 (Hellio, 2017). Previous studies have also focused on assessing the presence of ocean-related issues in climate plans through quantitative analysis (e.g., Gallo et al., 2017), 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 (CDKN, 2014). Second, the potential of coastal NbS is still largely under-exploited in national climate strategies (Gattuso et al., 2018). Lastly, PSIDS are among the most vulnerable countries to the impacts of climate change (CDKN, 2014), and highly dependent on coastal ecosystems for livelihoods and income (Buckwell et al., 2020; Grantham et al., 2020; Smallhorn-West et al., 2020; Selig et al., 2019; Veron et al., 2019; Hills et al., 2013).

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. (2020b) 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.

⁴⁷ 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

1.1. 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 (Calliari et al., 2019) (e.g., in Narayan et al., 2017), but robust frameworks that assess NbS multifunctionality are lacking (Dumitru et al., 2020). 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 Narayan et al., 2017).

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 (Himes-Cornell et al., 2018; Gilman et al., 2006), as well as to the community-based sustainable management of coastal fisheries.

In this chapter, PSIDS refer to the fifteen independent countries of the South Pacific Ocean, in Melanesia (Fiji, Papua New Guinea, Solomon Islands, Timor-Leste and Vanuatu), Micronesia (Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau) and Polynesia (Cook Islands, Niue, Samoa, Tonga and Tuvalu). Their geographical location is available on Fig. 0.5 of the General Introduction).

While NbS for climate adaptation and mitigation are typically addressed by PSIDS in a wide range of national policy instruments (e.g., National Ocean Policies, National Biodiversity Strategies, or 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 (Paris Agreement, 2015). The 31st of October 2021 was the deadline for countries to submit their revised⁴⁸ 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

⁴⁸ 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.

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).

1.2. Method description

The methodology is composed of three related steps (Fig. 2.1): 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.

1.2.1. 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. (2018) (refined in 2019 and 2022), 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 2.1). Category A refers to the conservation, restoration, and sustainable management of coastal vegetation for mitigation, with coastal vegetation referring to seagrasses and 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.

Table 2.1: Classification of coastal nature-based solutions, adapted from the classification of ocean-based climate solutions by Gattuso et al. (2018).

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.

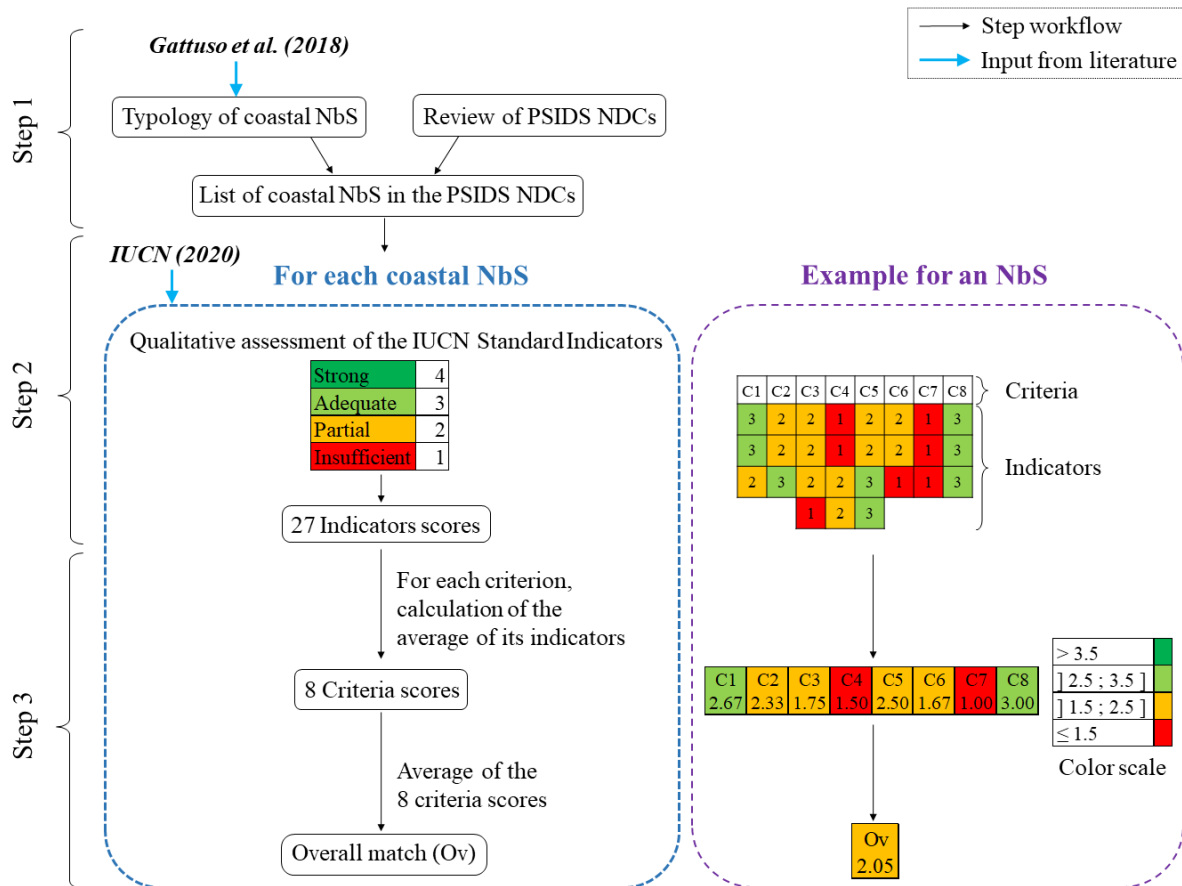


Fig. 2.1: Overview of method steps. NbS: nature-based solution. NDCs: Nationally Determined Contributions. PSIDS: Pacific Small Island Developing States.

1.2.2. Step 2: Assessment of indicators' alignment with the Standard

The IUCN Global Standard for NbS is composed of eight criteria (Table 2.2). Twenty-eight indicators are used to assess the criteria. Supplementary Material, Appendix 2.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 (2020) 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 (2020). For the assessment, we developed and used the assessment scale described in Fig. 2.2, 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. 2.2). 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 2.E can be found in the online version, at doi:10.1016/j.nbsj.2022.100034) to ensure that each indicator was evaluated consistently across all countries and coastal NbS.

Table 2.2: Criteria of the IUCN Global Standard for NbS. Adapted from IUCN (2020).

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.

	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. 2.2: Scale used to assess the alignment of the NbS with the indicators of the IUCN Global Standard for NbS as defined by IUCN (2020). *The rationale for assessment was developed by the authors of the current paper.

1.2.3. 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” (IUCN, 2020). Each criterion score was obtained by calculating the average value across the scores of the indicators composing the criterion (Fig. 2.1). 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 2.B.1 in Supplementary Material, Appendix 2.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. 2.3). Further details on these 22 NbS (Table 2.C.1) as well as two examples of how NbS are described in NDCs (Table 2.C.2) are available in Supplementary Material, Appendix 2.C.

The results of the full assessment of the 22 coastal NbS are presented in Fig. 2.4. 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. 2.5). 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. 2.5).

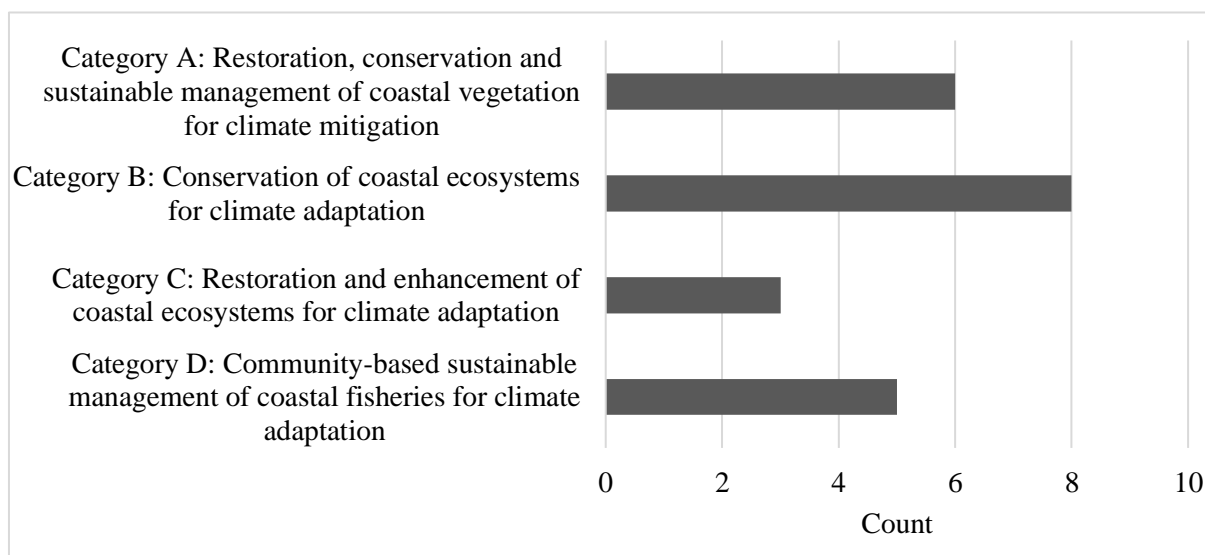


Fig. 2.3: Number of coastal nature-based solutions in the Nationally Determined Contributions of Pacific Small Island Developing States, for the four categories of solutions.

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’

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 insufficient (Fig. 2.5). The three criteria rated insufficient corresponded to economic feasibility (C4), balancing trade-offs (C6), and adaptive management (C7) (Fig. 2.5). 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. 2.4). Heterogeneity across coastal NbS for a given indicator is the highest for indicator on risk identification and risk management (indicator 2.3) (Fig. 2.4). 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. 2.5), with no significant difference except for criterion C7 (see Table 2.B.1 in Supplementary Material, Appendix 2.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. 2.5). 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. 2.5), 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 2.B.2 in Supplementary Material, Appendix 2.B). This is particularly significant regarding criteria C1, C2 and C3 (see *t*-test in Table 2.B.1 in Supplementary Material, Appendix 2.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 < 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 2.E).

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. 2.5: Criteria (C1 to C8) scores and overall match (Ov) for each coastal nature-based solution in the Nationally Determined Contributions (NDCs) of Pacific Small Island Developing States (PSIDS). 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.

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) (Swann et al., 2021). 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 Fig. 2.D in Supplementary Material, Appendix 2.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. (2021) 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 (McLeod et al., 2011). In addition, Hills et al. (2013) 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 (2017). 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 (Schindler Murray et al., 2021). In 2018, the sources of inputs required for the global stocktake were defined (UNFCCC, 2018). 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 2.A.2 in Appendix 2.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. 2.4). This echoes the conclusions of Craft & Fisher (2018) and Jeffery et al. (2021) 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 (2022) 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 (Schindler Murray et al., 2021). 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 (Schindler Murray et al., 2021). For Craft & Fisher (2018), 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 (Arkema et al., 2017; Mcleod et al., 2011). For example, the preference of some PSIDS for seawalls instead of NbS to protect coasts against climate hazards (Hills et al., 2013; Narayan et al., 2020), 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 (Dutra et al., 2015; Nesshöver et al., 2017). 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 (SPREP, 2020). 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 (Pramova et al., 2012). 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 Strategies, 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 (Wells et al., 2016). 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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Chapter 3

A systematic review of coastal ecosystem services in the Pacific Small Island Developing States

Chapter 3 has been accepted for publication in *Mondes en développement*.

Châles, F. (forthcoming). A systematic review of coastal ecosystem services in the Pacific Small Island Developing States. *Mondes en développement*.

Abstract

Coastal ecosystems, such as coral reefs, mangroves, and seagrasses, are critical habitats for many species and provide numerous essential services to humans. This is particularly the case in the Pacific Small Island Developing states (PSIDS), whose populations highly rely on coastal ecosystems for their livelihoods and income. The loss and degradation of coastal ecosystem in PSIDS enhances the vulnerability of marine species and people who directly or indirectly benefit from these ecosystems. By highlighting the various ways in which human populations benefit from natural ecosystems, the assessment of ecosystem services is recognized as a valuable tool to support the protection and sustainable management of ecosystems. We reviewed and analyzed the current literature on coastal ecosystem services in PSIDS to understand how the contributions of coral reefs, mangroves and searasses to human populations are described in the literature. Our findings highlight geographical and methodological literature gaps and provide new insight for future research. In particular, we found a lack of coral reef assessments in Papua New Guinea, and an absence of water purification assessments while it is the second most frequently assessed regulating service from coastal ecosystems globally. Our results also point out an overuse of benefit transfer valuations, and a higher proportion of policy recommendations in reports than in peer-reviewed publications. We discuss the key implications of these results and provide recommendations for future ecosystem services assessments and literature reviews to support the sustainable management of coastal ecosystems.

Keywords: Systematic literature review, Pacific Small Island Developing States, coastal, ecosystem services.

1. Introduction

Healthy coastal ecosystems such as mangroves, coral reefs and seagrasses help support life and human well-being worldwide (Barbier et al., 2017). Coastal ecosystems provide multiple benefits to people through the provision of seafood, the regulation of the global climate and biogeochemical cycles, coastal protection and support for cultural, tourism and recreational uses (Börger et al., 2014; Barbier et al., 2011). This is particularly true in the Pacific Small Island Developing States (PSIDS), which rely heavily on coastal ecosystems for livelihoods, income and culture (Selig et al., 2019; Cullen-Unsworth & Unsworth, 2018; Hilmi et al., 2014; Hills et al., 2013).

However, key coastal ecosystems, such as mangroves, coral reefs and seagrasses are in decline in PSIDS (Devlin et al., 2021; Brodie et al., 2020; Lovelock et al., 2015) due to the combined effects of climate change and other anthropogenic stressors such as overfishing, pollution and clearing (Devlin et al., 2021; Pendleton et al., 2016a). This decline is reducing the ability of these ecosystems to cope and adapt to climate and population-driven changes, and to sustain livelihoods (IPBES, 2018; Pendleton et al., 2016b). The loss and degradation of coastal ecosystems exacerbates the high vulnerability of PSIDS to environmental change (Ruckelshaus et al., 2015; Nurse et al., 2014; Campbell and Barnett, 2010), further threatening human health in the region (IPBES, 2018; Mciver et al., 2016). In this context, the preservation of coastal ecosystems in PSIDS should be a priority goal to reduce the poverty and vulnerability of coastal populations (Hilmi et al., 2014).

Some of the threats and pressures on coastal ecosystems are economically-induced, such as through the tragedy of commons and market externalities (Hilmi et al., 2014). The tragedy of the commons was first defined by Garrett Hardin in 1968 to describe a situation in which individuals, acting independently and rationally according to each one's self-interest, ultimately destroy a shared limited resource even when it is clear that it is not in anyone's long-term interest for this to happen. Market externalities are external effects that are not taken into account in the price of a product or service. These effects can be positive or negative and can have an impact on society, the environment, or the economy. As some of the central issues affecting sustainable and equitable management of coastal ecosystems (i.e., inequitable distribution of ecosystem goods and services, overexploitation of coastal resources) are economic, some economic tools can be relevant to address these issues (Hilmi et al., 2014). These tools include the assessment of ecosystem services (ES). In this study, by the term "ES assessments" we refer to both monetary and non-monetary assessments.

ES assessments are recognized as valuable tools to improve coastal management (Börger et al., 2014; Laurans et al., 2013a) for the following reasons. Firstly, ES assessments can highlight ecosystem benefits and costs that might have been missed if only commercial revenues and costs were considered. They can also improve understanding of trade-offs among multiple management options (Börger et al., 2014). This is particularly relevant for PSIDS, where the imperative to simultaneously increase

development, nature protection and climate adaptation implies making choices among various management scenarios. Thus, ES assessments could help prioritize and implement action in the context of PSIDS, which face financial, human, and technical constraints to rapidly implement much needed effective resilience actions (IPCC, 2022; Nurse, 2014).

Although the types of services provided by coastal ecosystems are well-known (Barbier et al., 2011), the contributions of these ecosystems to people remains poorly understood at the local scale (Blythe et al., 2020). Coastal ES are studied in a spatially heterogeneous manner, with European, North American and Australian case studies being overrepresented in the literature compared to other regions (Comte & Pendleton, 2018; Ruiz-Frau et al., 2017; Liqueste et al., 2013). To date, systematic literature reviews of coastal ES have mainly focused on the global scale (e.g., Liqueste et al., 2013), with no systematic review as far as the author is aware focusing on the Pacific region, except regarding seagrasses specifically (in McKenzie et al., 2021a). Furthermore, evidence of the practical use of ES assessments in policy and decision-making is still expected (Bitoun et al., 2022; Marre et al., 2016), despite on-going and increasing efforts worldwide to include ES assessments in policies design, implementation and monitoring (Ruckelshaus et al., 2015). ES assessments are rarely associated with policy recommendations in literature, and do not necessarily respond to ongoing policy needs and concerns (Bitoun et al., 2022). These aspects questions the relevance of ES assessments for policy use (Scemama et al., 2022; Marre et al., 2016; Pendleton et al., 2015; Laurans et al., 2013b). Further research on ES assessments is therefore needed to fill geographical, methodological and practical gaps (Hilmi et al., 2014).

In this context, we conducted a systematic review of existing peer-reviewed and grey literature on coastal ES assessments in PSIDS to investigate how coastal ES are assessed and identify gaps in research. We have not limited our scope to studies based on ES monetary valuations, but have extended it to studies involving non-monetary valuations in order to better understand how non-monetary indicators contribute to the understanding of coastal ES in PSIDS. Indeed, at the global scale, the majority of marine and coastal ES are not marketed (Pendleton et al., 2007). Moreover, the widely used monetary valuation techniques are often inappropriate in PSIDS due to the common use of non-monetary systems for exchanging products, and culturally specific value attributions (Laurans et al., 2013a). Following the recommendation of Blythe et al. (2020), we considered both peer-reviewed and grey literature in order to obtain a more comprehensive overview of coastal ES in PSIDS. We sought to:

- (1) provide an overview of the current state of the literature regarding coastal ES in PSIDS,
- (2) categorize the methodologies used in the literature to assess ES, and
- (3) deepen the understanding of cultural ES in PSIDS.

Although the definition of cultural ES is under debate within the research community, a common definition is that these services “combine with built, human, and social capital to produce recreation,

aesthetic, scientific, cultural identity, or other “cultural” benefits” (Costanza et al., 2011). We were interested in examining cultural ES specifically because they are generally difficult to assess monetarily as many of them are not marketed and their value is context specific (Lau et al., 2019; Díaz et al., 2018). It is particularly challenging to monetize cultural services associated to reefs in the PSIDS since the cultural function of the reefs is sacred for Pacific people (Hilmi et al., 2014). We also aimed at (4) understanding the context in which the coastal ES assessments in the reviewed studies were conducted. To do so, we reviewed author affiliations to analyze by who and where the studies were conducted, and we explored the extent to which the literature included recommendations for coastal ecosystem management in PSIDS. Finally, based on our literature analysis, we highlighted opportunities to increase the comprehensiveness of ES assessments, and their use for coastal management.

2. Materials and method

2.1. Scope of the analysis: inclusion criteria

We built the scope of our systematic literature review on three inclusion criteria. The first inclusion criterion concerns the type of ecosystem. We selected only papers that included assessments of services from mangroves, coral reefs, seagrasses, or a combination of them. The distribution of coral reefs (Chin et al., 2011), mangroves (Bhattarai & Giri., 2011) and seagrasses (McKenzie et al., 2021b) varies among PSIDS, with volume and diversity decreasing from west to east (i.e., from Melanesia to Polynesia) (Table 3.1).

The second inclusion criterion refers to the geographical scope of the study. As in Chapters 1 and 2, PSIDS here correspond to the fifteen independent countries of the South Pacific Ocean, in Melanesia (Fiji, Papua New Guinea, Solomon Islands, Timor-Leste and Vanuatu), Micronesia (Federated States of Micronesia, Kiribati, Marshall Islands, Nauru, Palau) and Polynesia (Cook Islands, Niue, Samoa, Tonga and Tuvalu). Their geographical location is available on Fig. 0.5 of the General Introduction. We considered both studies that focused on the whole region, and those that focused on a portion of that region (such as a country, village or a portion of coastline).

The third inclusion criterion relates to the definition of an ecosystem service. Ecosystems services are commonly defined as “ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being” (Costanza et al., 2017; Millennium Ecosystem Assessment (MEA), 2005; Costanza et al., 1997). Although there are numerous ways to understand and categorize the connections between people and nature (Blythe et al., 2020; Díaz et al.), there is a consensus that humans benefit from nature and that ES must be measured in relation to human welfare (Himes-Cornell et al., 2018a). How best to define this relationship is still under debate (Himes-Cornell et al., 2018a). We identified an ES if it met the three following conditions:

- (i) Firstly, it must be the contribution of an ecosystem to human welfare, including direct and indirect contributions such as the regulation of natural cycles. We considered it important to take into account these indirect contributions, as they are generally not considered within policy evaluation and represent an area where a greater and more systematic attention would be very useful (Defra, 2007). Our definition of an ES includes the positive “nature’s contributions to people”, a concept developed in 2017 by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) to better take into account the multiple perspectives and stakeholders in ES assessments (Díaz et al., 2018; Pascual et al., 2017).
- (ii) Secondly, this positive contribution, or ES, must be related to an identifiable coastal ecosystem within our scope, i.e., mangroves, coral reefs, seagrasses, or a combination of them. ES from coastal fisheries were considered whereas ES from offshore commercial fisheries were not.
- (iii) Thirdly, this positive contribution must be linked to an identifiable bounded location part of our scope, such as a country, city, or portion of coastline.

Table 3.1: Mangrove, seagrass and coral reef coverage in the Pacific Small Island Developing States, and associated proportion to the countries’ land areas.

	Pacific SIDS	Mangroves		Seagrasses		Coral reefs	
		Coverage (km ²)	% of the country's land area	Coverage (km ²)	% of the country's land area	Coverage (km ²)	% of the country's land area
Melanesia	Fiji	525	3	500	3	6,704	37
	Papua New Guinea	4,801	1	1,091	<1	14,535	3
	Solomon Islands	470	2	506	2	6,743	24
	Timor-Leste	13**	<1	43**	<1	146**	1
	Vanuatu	14	<1	27	<1	1,803	15
Micronesia	Federated States of Micronesia	99	14	67	10	4,925	703
	Kiribati	0.2	<1	N/A	N/A	3,041	375
	Marshall Islands	0.02	<1	N/A	N/A	3,558	1,965
	Nauru	0.04	<1	N/A	N/A	15	71
	Palau	57	13	75	17	966	218
Polynesia	Samoa	3.7	<1	14	<1	402	14
	Cook Islands	0	N/A	N/A	N/A	528	223
	Niue	0	N/A	N/A	N/A	45	17
	Tonga	7.8	1	23	3	1,662	222
	Tuvalu	0.09	<1	0.01	<1	3,175	12,212
Data source:		Bhattarai & Giri (2011), Alongi (2014)		McKenzie et al. (2021a), **Seagrass watch		Chin et al. (2011), **Seagrass watch	

2.2. Identification of literature based on our inclusion criteria

We systematically searched both peer-reviewed publications and reports with search terms including the fifteen PSIDS and the three types of ecosystems, with unlimited timespan until April 2021. For reports identification, we used search equations with keywords in Google Scholar and the Pacific Hub Database (<https://pacificdata.org/>), the latter being a major source of grey literature on environmental issues in the Pacific region. For identification of peer-reviewed literature, we used search equations with keywords in the search engines Google Scholar and Scopus. Supplementary Material Appendix 3.A provides details of the search equations. This first analysis yielded 50 peer-reviewed studies and 35 reports. Next, we screened titles, abstracts and keywords to remove the studies that did not fit our scope. Studies were subject to a full text reading when necessary to confirm their alignment with our three inclusion criteria. It was particularly the case for reports, which often did not include any abstract. Some key reports and articles allowed us to identify other relevant publications that we had missed in our first round of literature identification. After these processes, 57 studies were retained for analysis (the list of the 57 studies is provided in Supplementary Material Appendix 3.B).

2.3. Data reporting, classification and analysis

For each study retained, we first identified the dimensions of interest associated to each ES. We were interested in values but also in uses (i.e., a practice described qualitatively) when they could be considered as ES according to our three inclusion criteria. Dimensions of interest included ecosystem type (i.e., coral, mangrove, seagrass), location, level of assessment (e.g., regional, national), ecosystem coverage (in km²), assessment method (e.g., contingent valuation, market price, benefit transfer), as well as the presence of policy recommendations. To identify policy recommendations, we systematically searched for the words “suggest” and “recommend” in all studies, and we read the studies’ discussions and conclusions, which are the places where recommendations are commonly included. We also reported macro information on publication date and type (i.e., report, peer-reviewed) and author affiliations.

We classified data of interest according to the classification of The Economics of Ecosystems and Biodiversity (TEEB, 2010), which is based on the Millennium Assessment (MEA, 2005), except for coastal protection services, for which the classification proposed by Liqueste et al. (2013) appeared to be more relevant. Indeed, the TEEB includes two distinct types of coastal protection services, i.e., “moderation of extreme events” and “erosion prevention”, but often studies do not consider these two dimensions separately and broadly refer to “coastal protection” services: in these cases, we considered the services as “coastal protection” services in general. We attributed a category and a type to each ES based on the TEEB classification, unless studies’ authors considered the service as part of another category or type. In that case, we followed the original author appreciation. We categorized goods (material contributions) into the cultural category when they explicitly referred to traditional practices, a choice supported by Fish et al. (2016). For instance, as medicinal resources were systematically linked

to traditional uses or values in the papers, we categorized them as cultural services, whereas the TEEB classification considers them as provisioning services (TEEB, 2010). The classification of ES categories and types (i) according to the TEEB and (ii) in this study is provided in Supplementary Material Appendix 3.C.

After data classification, we compared our data with those of the Ecosystem Services Valuation Database (ESVD, 2020), a follow-up to the TEEB database, to ensure that we did not miss or misreport any data. This comparison was possible for monetary values only, because the ESVD contains only monetary ES.

All monetary values were in US\$. We converted them into 2022 prices to allow comparison, using the inflation calculator <https://www.in2013dollars.com/us/inflation/2014?amount=1>. Then, to understand how authors captured the importance of coastal ES beyond economic terms, we proposed to classify ES whether they were assessed (i) monetarily, (ii) quantitatively but non-monetarily, or (iii) qualitatively.

3. Results

3.1. General results

A total of 57 studies were analyzed, including 26 peer-reviewed articles and 31 reports (the complete list of studies analyzed is available in Supplementary Material Appendix 3.B). We identified 292 assessments of coastal ES based on the definition of ES described in the Materials and Methods section. The details on these 292 ES assessments is available in Supplementary Material Appendix 3.D. While some studies focused on a single ES assessment (e.g., seagrass services to humans through their habitat function for emblematic marine species such as green turtles, in Cullen-Unsworth et al., 2014), others contained several assessments (e.g., 20 ES assessments in Buckwell et al., 2020). Reports accounted for 54% of the total number of studies part of our literature review, and contained on average twice as many ES assessments as peer-reviewed studies (Table 3.2).

Table 3.2. Differences between reports and peer-reviewed articles. ES: ecosystem services.

	Number of ES	Number of studies	Average proportion of ES per study	Number of monetary ES	Number of quantitative non-monetary ES	Number of qualitative ES	Number of studies with policy recommendations
Total	292	57	N/A	197 (67% of total ES)	38 (13% of total ES)	59 (20% of total ES)	37 (65% of total studies)
Reports	200 (68% of total ES)	31 (54% of total studies)	6.4 %	154 (77% of ES in reports)	19 (9.5% of ES in reports)	29 (14.5% of ES in reports)	26 (84% of reports)
Peer-reviewed studies	92 (32% of total ES)	26 (46% of total studies)	3.5 %	43 (47% of ES in peer-reviewed stud.)	19 (20.5% of ES in peer-reviewed stud.)	30 (32.6% of ES in peer-reviewed stud.)	11 (42% of peer-reviewed stud.)

3.2. Disparities and research gaps

3.2.1. Disparities across regions: the literature focuses on Melanesia

The number of studies that included at least one assessment of a coastal ES was higher in Melanesia (44 studies) than in Micronesia (8 studies) and Polynesia (6 studies). Similarly, the number of ES assessed was higher for Melanesia specifically (201 ES) than for Polynesia (56 ES) and Micronesia (28 ES). The difference between the sum of ES in the previous sentence (285 ES) and the total ES identified (292) corresponds to interregional ES assessments, for instance at the scale of the Coral Triangle, which spans both Melanesia and Micronesia. Vanuatu and Fiji were the most assessed countries, while we found zero ES assessments for the Marshall Islands, Nauru and Tuvalu.

3.2.2. Disparities across ecosystems: the literature focuses on coral reefs

Mangrove ES were assessed earlier (in 1990, in Lal et al.) than coral reef ES (in 2001, in Mohd-Shahwahid et al. and in Spalding et al.) and seagrass ES (in 2006, in Green et al.) (Fig. 3.1). Seagrass services were increasingly assessed over time in PSIDS, with 2020 being a year where we found more studies including seagrass services assessments as compared to studies involving coral reef or mangrove services assessments (Fig. 3.1). However, coral reefs were the most studied ecosystem, with 146 assessments referring to coral reefs services specifically. In comparison, 87 assessments referred to mangroves and 24 referred to seagrasses (Fig.3.2). In about 10% of the cases, services from several ecosystem types were considered together (column “combined” on Fig. 3.2). This was for instance the case in Buckwell et al. (2020), where the monetary value associated with the “moderation of disturbance” service (188 US\$ per year) referred to mangrove and coral reefs simultaneously.

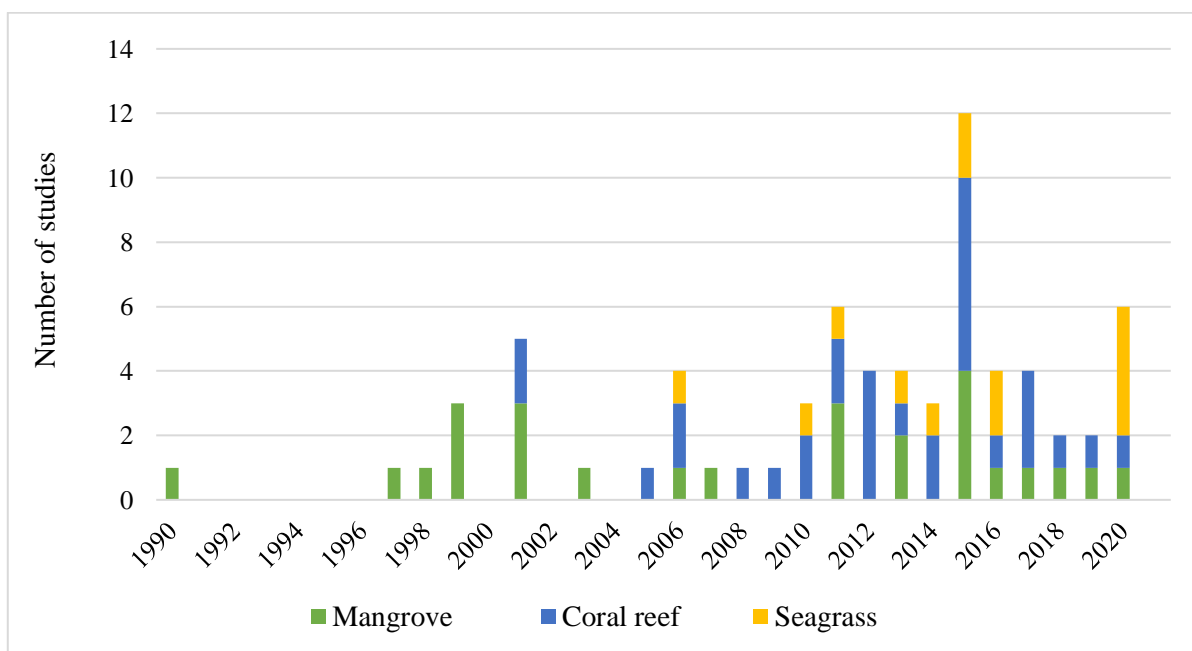


Fig. 3.1: Number of studies including ecosystem services assessments for mangroves (green), coral reefs (blue) and seagrasses (yellow) over time in the Pacific Small Island Developing States.

3.2.3. Disparities across categories and types of service

In Fig. 3.2, we represented the 281 ES referring to a distinct category of services (i.e., provision, regulation and maintenance, culture), removing the 11 other ES which referred to several categories. The proportions of cultural services and provisioning services were similar (35% of total ES in each case), while fewer services (27%) referred to the “regulating and maintenance” category (Fig. 3.2). In terms of categories of services, seagrasses and coral reefs show opposite patterns (Fig. 3.2). Seagrass services were mostly “regulating and maintenance” services (62.5%), whereas coral reef services mainly referred to provisioning services through food provision, and to cultural services through the opportunities for recreation and tourism (Fig. 3.3).

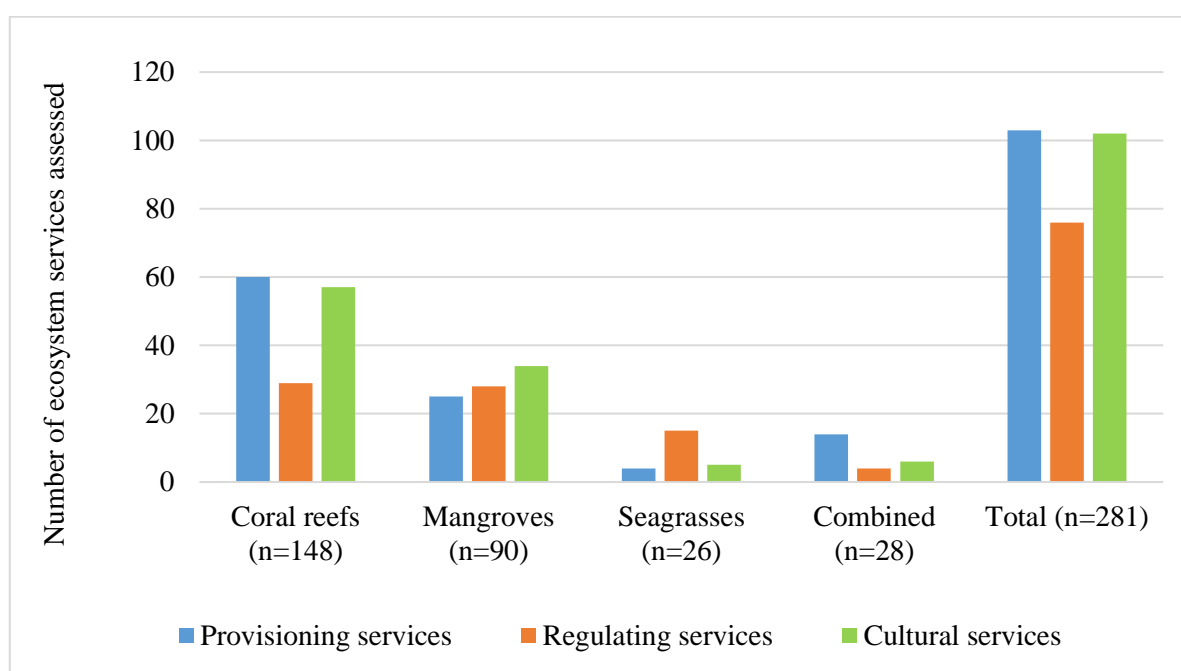


Fig. 3.2: Number of coastal ecosystem services by category of service (based on the TEEB, 2010) and by type of ecosystems (coral reef, mangrove, seagrass), in the Pacific Small Island Developing States.

Our results show a great variety of ES types, since 19 ES types are represented, out of the 23 ES types of the TEEB classification (the detail of the TEEB classification is provided in Supplementary Material Appendix 3.C). The four types not represented in our review are “regulation of water flows”, “maintenance of genetic diversity”, “pollination” and “water purification”. Three ES types covered almost half of the total 292 ES. These relate to the provision of seafood (representing 27% of all ES), opportunities for recreation and tourism (12%) and raw materials from mangroves (10%) (Fig. 3.3).

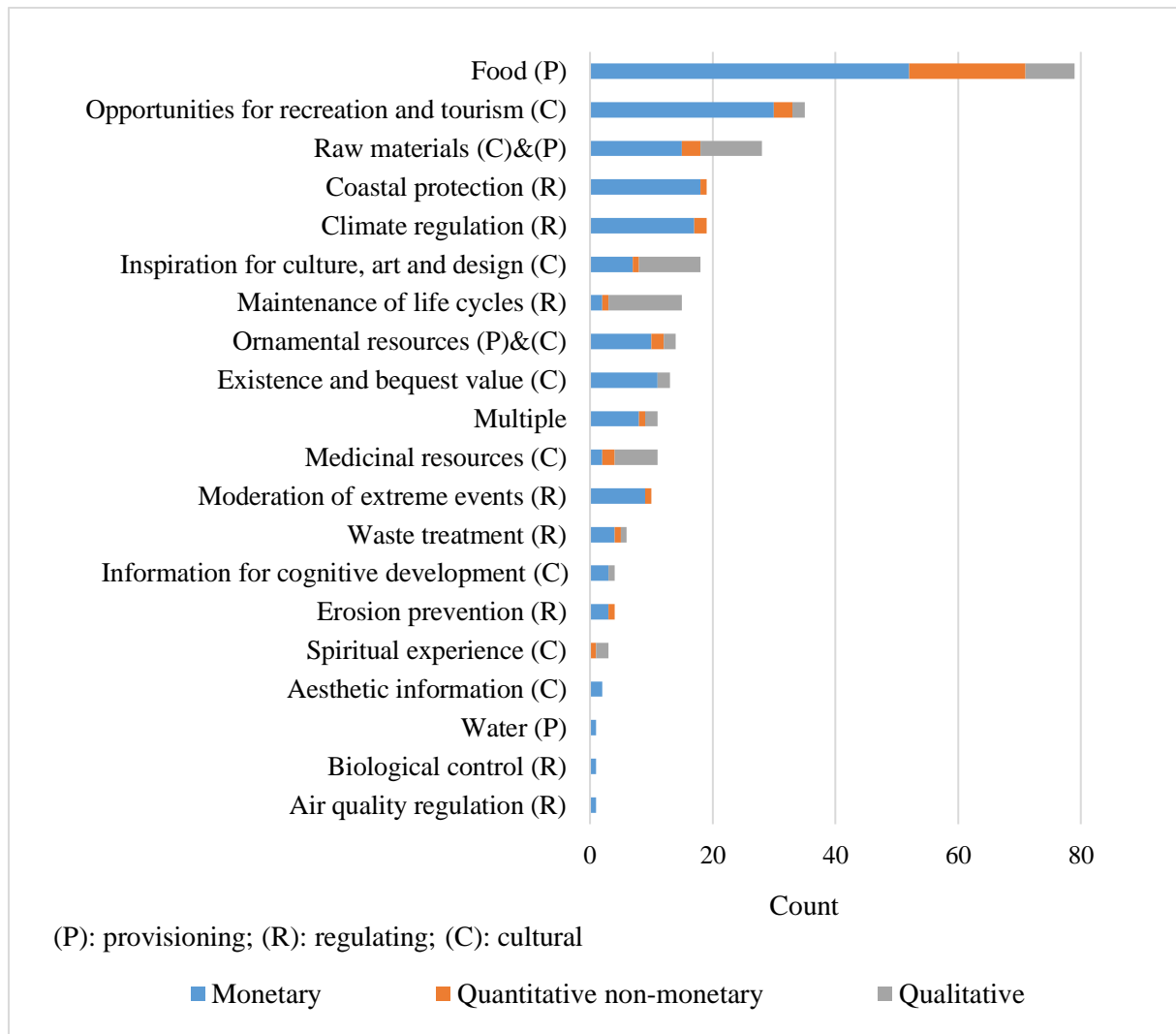


Fig. 3.3: Number of coastal ecosystem services in the Pacific Small Island Developing States, assessed (i) monetarily (blue), (ii) quantitatively non-monetarily (orange), and (iii) qualitatively (gray), by type of service according to the TEEB (2010) classification. “Multiple” is for services referring to several types. “Coastal protection” is not a TEEB type, but we created it for services that referred to coastal protection in general, as recommended by Liqueste et al. (2013).

One quarter of coastal services were directly linked to climate services, through (i) coastal protection from climate impacts (34 ES) and (ii) carbon sequestration (“climate regulation”) from mangroves and seagrasses (19 ES) (Fig. 3.3). Eighteen out of the 19 assessments on climate mitigation were included in studies published after 2011. We found similarities in the profiles of seagrasses and mangroves, which were often recognized for their role in carbon sequestration and in the reduction of coastal risks related to erosion and extreme events. In addition to their contribution to climate mitigation and adaptation, seagrass services were also often assessed in relation to “maintenance of life cycle” services for being essential habitats for fish, invertebrates and endangered species (such as the Green turtle and Dudongs). Mangroves were also frequently mentioned for their traditional uses related to raw materials (e.g., mangrove timber for cooking or building houses) and medicinal resources (e.g., to treat ulcers, itching, acne or insect bites).

3.3. Indicators and assessment methods used in the literature

3.3.1. Monetary, quantitative non-monetary and qualitative indicators

The majority (65%) of coastal ES identified in our literature review were assessed using monetary indicators by the authors of the 57 studies examined (Fig. 3.4a). This was particularly the case in reports, in which 77% of ES had been assessed in monetary units, compared to 47% of ES in peer-reviewed studies (Table 3.2). Mangrove and seagrass services have been increasingly valued in monetary terms over time. “Regulating and maintenance” services were more frequently assessed in monetary terms than provisioning and cultural services, with the exception of services referring to “maintenance of life cycles” which were mostly expressed in qualitative terms (Fig. 3.3). In contrast, ES part of the cultural category were more frequently assessed qualitatively than ES part of the categories on “regulating and maintenance” and “provision” (Fig. 3.3). Moreover, ES referring to the most frequent ES types (i.e., “food” and “opportunities for recreation and tourism”) were also those that were assessed more frequently monetarily (Fig. 3.3). Finally, ES assessed quantitatively but non-monetarily were expressed through a variety of indicators, such as the proportion of local people feeding on coastal fisheries supported by coral reefs, or the number of visitors per year coming to dive at a coral site.

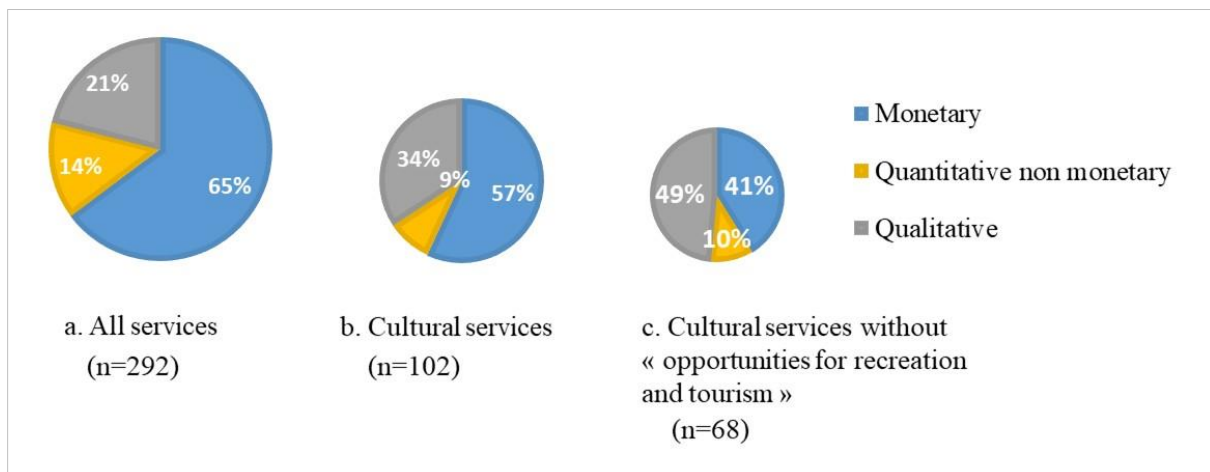


Fig. 3.4: Proportion of coastal ecosystem services that were assessed monetarily (blue), quantitatively non-monetarily (orange), and qualitatively (grey) by the authors of the 57 studies.

We found great variability in monetary values between the different ES types. Climate regulation was the type that was valued highest on average per hectare per year, at 3,629 US\$/ ha/year (Table 3.3). Next, other regulating services including maintenance of life cycles, air quality regulation and waste treatment were valued on average at 3,566 US\$/ha/year. The opportunities for tourism and recreation offered by coastal ecosystems were valued on average 863 US\$/ha/year, while food provision (370 US\$/ha/year) and coastal protection services (370 US\$/ha/year) were valued much lower on average (Table 3.3). The values on climate regulation should nevertheless be interpreted with caution because of the low number of climate regulation assessments (19 out of 292). Although monetary values for

climate regulation are on average higher per ha/year than for the other types of services, climate regulation services represent only a small fraction of all the services assessed. Thirteen out of 89 mangrove assessments are related to mangroves' contribution to climate regulation; and five out of 27 seagrass assessments are related to seagrasses' contribution to climate regulation. Conversely, the provision of seafood, which is the most frequently cited type of service in the studies reviewed (Fig. 3.3), is also the type with the lowest average monetary value (Table 3.3).

3.3.2. Assessment methods: the literature focuses on a few methods

We found an important variety of methods (14 different methods) used to assess coastal ES in PSIDS (the details on valuation methods is available in Supplementary Material, Appendix 3.D). However, only three methods account for almost half of the total ES assessments. These are market prices (60 ES), benefit transfer (59 ES) and contingent valuation (29 ES). Provisioning services were mostly assessed using the market price method, whereas “regulation and maintenance” services were mostly assessed using benefit transfers. Cultural services were mostly assessed using contingent valuation (18% of all cultural ES) and benefit transfer (18%), with five studies (out of 37 involving cultural ES) using benefit transfers.

We found that, when ES were assessed using the benefit transfer method, they were valued lower than when they were valued without benefit transfers for all types of services except for food provision (Table 3.3). This is particularly the case for (i) regulating services on “maintenance of life cycles” (average value of 148 US\$/ha/year with benefit transfers compared to 7,026 US\$/ha/year with methods that do not involve benefit transfers) and on “climate regulation” (1,919 US\$/ha/year compared to 6,865 US\$/ha/year). This is also the case for (ii) cultural services on “existence and bequest” (57 US\$/ha/year compared to 675 US\$/ha/year), and on “aesthetic information and inspiration for cognitive development, culture, art and design” (2 US\$/ha/year compared to 171 US\$/ha/year) (Table 3.3). These results on cultural services should nevertheless interpreted with caution due to the low number of studies involving benefit transfers for assessing these cultural services.

Table 3.3. Monetary values (in hectare per year, adjusted in 2022 prices) of different types of coastal ecosystem services in Pacific Small Island Developing States, with values for studies where authors had used benefit transfers and for studies where authors had not used benefit transfers.

Categories of ecosystem services	Types of ecosystem services	Values for all monetary valuation methods		Values obtained via benefit transfers only		Values obtained via methods which did not involve benefit transfers	
		Average value (US\$/ha/year)	Standard deviation	Average value (US\$/ha/year)	Standard deviation	Average value (US\$/ha/year)	Standard deviation
Provisioning	Food provision (seafood)	370	373	481	743	362	346
Regulating and maintenance	Coastal protection, Erosion prevention, Moderation of extreme events	370	629	300	164	256	489
	Climate regulation (i.e., carbon sequestration)	3,629	6,073	1,919	2,635	6,865	8,103
	Maintenance of life cycle, Waste treatment, Air quality regulation	3,566	6,768	148	203	7,026	9,490
Cultural	Opportunities for recreation and tourism	863	1,082	348	N/A	909	1,141
	Aesthetic information, Information for cognitive development, Inspiration for culture, art and design	108	93	2	2	171	40
	Raw materials (e.g., timber, tannins)	229	258	138	239	284	280
	Existence and bequest (i.e., non-use values linked to the value placed on conserving resource for future generation (bequest) and arising from knowledge that resource exists and/or is protected (existence))	234	493	57	33	675	964

3.4. Cultural ecosystem services: more frequently assessed qualitatively compared to “provisioning” and “regulating” services

We found that cultural ES were assessed in 37 out of 57 studies (65%), and accounted for 35% of the total ES identified in our literature review (102 out of 292). Cultural ES mainly referred to (i) opportunities for recreation and tourism (33%), (ii) inspiration for culture, art and design (17%), (iii) raw materials (16%), (iv) existence and bequest value (13%) and (v) medicinal resources (11%). Information for cognitive development (4%), aesthetic information (2%) and ornamental resources (1%) were less frequently assessed cultural services.

As for all ES, cultural ES were on average more frequently assessed monetarily (57% of all cultural ES) than qualitatively (34%) and quantitatively non-monetarily (9%) (Fig. 3.4b). Compared to all ES, however, cultural ES were more frequently assessed qualitatively (Fig. 3.4). This trend is even more

pronounced for cultural ES that do not refer to “opportunities for recreation and tourism” (Fig. 3.4c), in particular regarding “inspiration for culture, art and design”, “raw materials”, “medicinal resources” and “spiritual experience” (Fig. 3.3).

When it was possible to compare values of cultural ES to those of provisioning or “regulating and maintenance” ES, we found that cultural ES (with the exception of recreation and tourism services) were systematically valued lower when assessed in monetary terms, except in Naylor and Drew (1998), where the existence value of mangroves was valued more than the provision of food by mangroves. However, when the studies’ authors used ranking methods, cultural ES were more frequently ranked higher in terms of importance than “regulating and maintenance” or provisioning services. For instance, in Lau et al. (2019), bequest value of reefs is ranked higher than coastal protection value from reefs; and in Grantham et al. (2020), gleaners ranked “nature enjoy” higher than income, with respect to gleaning in rough season.

3.5. Author affiliations

For the 57 studies, we found 53 identifiable first authors with an identifiable affiliation. In 34% of the 53 studies, the first author was from a PSIDS (i.e., the first author’s affiliation is located in a PSIDS), and 49% of the 57 studies associate at least one author from a PSIDS. We found no significant trend over time regarding the origin of authors, and no significant difference between reports and peer-reviewed articles (Table 3.2). Among the 53 identifiable first authors, eleven were from the European Union, nine from Australia, and five from the United States of America. The other non-PSIDS countries from which the first authors came from were Chile, Japan, Malaysia and South Africa, and they were represented by only one author.

3.6. Policy recommendations: mainly in reports involving PSIDS authors and directed at PSIDS governments

We found that 61% of the studies (35 out of 57) contained recommendations regarding the management of coastal ecosystems. These recommendations were far more frequently contained in reports than in peer-reviewed articles, as 84% of total reports and 42% of peer-reviewed articles contained recommendations (Table 3.2). Studies involving PSIDS authors were the most likely to include policy recommendations (three-quarters did), as compared to studies that did not associate involve PSIDS authors (half included policy recommendations). Policy recommendations were diverse and mainly referred to (i) actions to be implemented or banned to safeguard ES, (ii) the need to involve multiple stakeholders in coastal management, including local communities or organizations, and (iii) the need to share results and lessons learned. Recommendations were directed primarily to PSIDS governments, and to a much lesser extent, to local communities (usually advising them to become more involved in ES assessments or management processes). No recommendations were directed to entities (e.g., governments, non-governmental organizations) outside the PSIDS.

4. Discussion

4.1. Literature gaps and comparison with the global scale

The distribution of coral reefs, mangroves and seagrasses in the Pacific region, which decreases from west to east (i.e., from Melanesia to Polynesia) (Table 3.1), may partly explain why the literature is more abundant in Melanesia than in Polynesia and Micronesia. Similarly, the fact that coral reefs are more abundant in PSIDS than mangroves and seagrasses (Table 3.1) may partly explain why coral reefs were more frequently assessed. Seagrasses have been increasingly assessed over time, reflecting the fact that the field of seagrass ES research is a relatively novel research area compared to coral reefs' and mangroves' (Ruiz-Frau et al., 2017), and that their importance in PSIDS is increasingly recognized. This greater consideration could encourage seagrass conservation in PSIDS, where marine conservation has focused primarily on coral reefs, with seagrasses marginalized in legislation and policy despite their high resilience in PSIDS compared to other regions (McKenzie et al., 2021b).

Pendleton et al. (2016b) showed that human dependence on coral reefs services in the Pacific region is the highest for Papua New Guinea, Fiji and the Solomon Islands. However, more than half of coral reef services assessments in Melanesia focused on Vanuatu (47 assessments) and Fiji (20 assessments), while only 4 assessments focused on Papua New Guinea and 14 on Solomon Islands. In light of this, our results suggest a literature gap in terms of coral services assessments in Papua New Guinea, and in Solomon Islands to a lesser extent. In these countries, future assessments would be valuable to better reflect the local importance of coral reef services to people.

Coastal ES in PSIDS have rarely been assessed together, which can hinder the efficiency of coastal management because the individual benefits from ES from coral reefs, seagrasses and mangroves are smaller than when they are considered together (Guannel et al., 2016). Therefore, PSIDS, and in particular Melanesian PSIDS where there are more diverse and abundant seagrasses and mangroves (Table 3.1), would benefit from integrated coastal ES assessments that take greater account of ecosystems interconnections, to support a more sustainable management of coastal ecosystems.

When we compare our results for PSIDS to those obtained by Liqueste et al. (2013) for the global scale, we can see that food provision, particularly fisheries, was the most frequently assessed coastal ES both at the global and PSIDS' scales. In addition, contrary to our expectations, cultural ES were not assessed more frequently in proportion in the PSIDS as compared to the rest of the world, despite the heavy reliance of PSIDS on coastal tourism (SPREP, 2020) and their importance for the Pacific cultures (Movono et al., 2018). Indeed, cultural ES were assessed in 67% of the 57 studies, which is similar to the two-thirds of assessments that involved cultural ES at the global scale according to the UN Sub Global Assessment Network's global database (available at www.ecosystemassessments.net/) (Fish et al., 2016). Besides, we found no study in PSIDS that assessed the water purification service associated with coastal ecosystems, while it is the second most frequently assessed "regulating and maintenance"

service from coastal ecosystems globally (Liquete et al., 2013), and while lagoon water quality in PSIDS is considered low (SPREP, 2020).

4.2. Overuse of the benefit transfer method

Although the ecosystem service concept has succeeded in promoting the importance of nature to humans, the concept faces criticism and challenges (Schröter et al., 2014). Common criticisms include the fact that this concept is too anthropocentric and too focused on economic valuations (Schröter et al., 2014). Accurately representing ES is a huge challenge, since the connections between people and ecosystems differ from place to place and from person to person, depending on the ecological, economic or social contexts (Himes-Cornell et al., 2018b; Skewes et al., 2016). For example, one person might use a mangrove for timber while another will “use” it for recreational purposes. In addition, one person may perceive an ecosystem negatively (e.g., as dangerous) while another will perceive it positively (e.g., as a source of pleasure or income). Hence, a service can be viewed as a disservice⁴⁹ to another (Friess et al., 2020). To reduce uncertainties on ES assessments, it is therefore important to (i) consider in ES assessments the full suite of services provided (Gallagher et al., 2022), and (ii) conduct assessments that reflect how ecosystems are actually valued and used locally, by the many people interacting indirectly or directly with them (Himes-Cornell et al., 2018b).

Our review of literature shows that these two last points may not be adequately addressed for the PSIDS region. First, many studies focused on a few coastal ES only (Table 3.D.1 in the Supplementary Material Appendix 3.D provides the details of each ES assessment). This can involve an underestimation of the full range of coastal ES to people. Second, our review shows an overuse of benefit transfer valuations, as almost one third of total ES (and more than half of ES valued monetarily) were assessed using the benefit transfer method. This is particularly the case for (i) regulating services linked to “maintenance of life cycles”, “waste treatment”, “air quality regulation” and “climate regulation”, and (ii) cultural services associated with “aesthetic information”, “information for cognitive development” and “inspiration for culture, art and design” (Table 3.3). This result implies that for these assessments, there is potentially an important bias with reality, as benefit transfers fail to accurately describe the local importance of ecosystems to people (Himes-Cornell et al., 2018b). An overuse of the benefit transfer method was also found by Himes-Cornell et al. (2018b) in their review of mangrove ecosystem services at the global scale, and described as one of the two main issues affecting mangrove valuation literature.

Our analysis shows that climate regulation services (through carbon sequestration) from mangroves and seagrasses are those with the highest monetary values per hectare per year as compared to the other types of services, especially when they are valued without benefit transfer methods (Table 3.3). This is interesting because at the global scale, the value of carbon sequestration from blue carbon ecosystems

⁴⁹ Ecosystem disservices can be defined as the processes and functions that affect humans in “negative” ways, causing costs and damage (Gallagher et al., 2022; Costanza et al., 2017).

is quite low compared to the overall contribution of blue carbon ecosystems to wealth (Merk et al., 2022). Indeed, Costanza et al. (2014) estimated the global value of all coastal ES to be US\$ 31.6 trillion per year. In comparison, Bertram et al. (2021) estimated the value of global blue carbon ecosystems' carbon storage to be much lower, at around US\$ 190.7 billion per year (± 29.5 bn) (Merk et al., 2022). In our case, an aggregation of values might have been necessary to compare the contribution of blue carbon ecosystems to climate regulation with their contribution to all the other types of services they provide in PSIDS. We decided not to calculate aggregated values and not to make these comparisons because of the high level of uncertainty in obtaining meaningful values. Indeed, large-scale (global, regional, or even national) assessments, which involve aggregations (sums) of values, are not always meaningful (Lloyd-Smith, 2018): difficulties in properly accounting for the interconnectedness of ecosystems or the full range of services based on different stakeholder perspectives inevitably imply biases in the assessment of ES (Lloyd-Smith, 2018; Pendleton et al., 2016c). For example, Lloyd-Smith (2018) has shown that valuations of global ecosystem services sometimes rely on a few influential outliers that can have a very strong influence on the final value (Lloyd-Smith, 2018).

In our review, studies involving benefit transfer valuations, and more generally monetary valuations, often did not explicitly referred to the persons who actually benefited from ES, as compared to studies based on participatory methods. Assessments based on participatory methods involving a wide range of stakeholders best allowed to identify who benefited from ecosystem services (e.g., in Grantham et al. (2020) on gleaning on the reefs) (identified beneficiaries were coastal community members directly interacting with coastal ecosystems). However, ecosystems deliver distant services to people who do not directly interact with them (Seppelt et al., 2011). Considering people outside of PSIDS in ES assessments as well would help to better understand the dynamics of these complex socio-ecosystems. In particular, it would be interesting to both investigate how people distant from an ecosystem are affected by changes in the ecosystem, and how in return they influence a change in ecosystem value. Conducting such assessments would require extensive data collection but would be valuable to better understand how people and natural ecosystems in PSIDS are actually adapting and could increase their adaptive capacity to environmental change.

4.3. Policy recommendations in the literature

In line with the challenges described in the above sub-section 4.2, ES assessments still face difficulties in providing useful and usable information to policymakers (Marre et al., 2016). Despite increasing calls for the consideration of ecosystem services valuation in decision-making, less than 5% of published evaluation studies report uptake in policy decisions (IPBES, 2022). Our analysis revealed that more than half of the studies (35 out of 57) included recommendations to manage coastal ecosystems in a more sustainable or equitable manner. This indicates a willingness among the authors of the 35 studies to inform policy on priority actions to be implemented, based on their research findings or on lessons learnt

from a project. While all of these recommendations were directed at PSIDS' governments - and local communities to a lesser extent -, not one recommendation was directed at a non-PSIDS government or organization. This result is notable as PSIDS' ecosystems are also affected by stressors from other parts of the world, such as greenhouse gas emissions from northern countries that contribute to coral bleaching through ocean warming and acidification (Hughes et al., 2003). This finding raises the question of who has a responsibility for managing PSIDS' coastal ecosystems, knowing that (i) these ecosystems provide both services locally (e.g., through coastal protection) and globally (e.g., by contributing in global biodiversity balance, and climate change mitigation), and that (ii) local decisions can affect the delivery of distant ecosystem services, a phenomenon referred to as "off-site effects" (Seppelt et al., 2011). Our analysis of the studies' authors shows that the interest for coastal ES in PSIDS goes beyond the PSIDS' boundaries, involving many authors and institutions from the European Union, Australia and the United States of America in particular. One explanation for this could lie in the fact that PSIDS' coastal ecosystems provide distant services that the international community cares about. Further research on the motivation of the authors and institutions conducting ES assessments would be needed to understand the context in which these studies were carried out. A future step could be to explore the extent to which PSIDS' governments and institutions are aware of, recognize, and take into account the results of coastal ES assessments in their policies and practices.

4.4. Recommendations based on our findings

4.1.1. The importance of participatory methods and the use of non-monetary indicators in ES assessments

Our classification of ES assessment methodologies into three categories based on the associated indicator types (monetary, quantitative non-monetary, qualitative) allowed to investigate the extent to which these indicators can help inform coastal decision-making in PSIDS.

Our results suggest that coastal ES in PSIDS that are valued monetarily are unlikely to comprehensively reflect the full picture of local ES uses and values, and their importance for people, because half of monetary assessments are based on benefit transfers and aggregations of values. Hence, we advise that these monetary values should therefore be viewed with caution by decision-makers in PSIDS, bearing in mind that a significant proportion of them (in particular those inducing value aggregations and benefit transfers) may provide inaccurate information. These monetary values would need to be supplemented by other information (qualitative descriptions of uses, indications from quantitative non-monetary indicators, which are available in literature, as shown by our review) to better reflect how coastal ecosystems are important to people locally.

Qualitative assessments may be more difficult for policymakers to use as compared to monetary valuations in the absence of quantified benefits and costs, and in the absence of indicators to compare management options. However, we found that qualitative descriptions provide useful information to

understand local uses and preferences associated with coastal ecosystems in PSIDS. For instance, qualitative assessments in our review provide valuable insight into local traditional practices related to mangrove raw materials, medicinal resources, seafood and inspiration for art in particular.

Methods that use non-monetary quantitative indicators to assess coastal ES appear to allow the identification of a wide range of local ES and the assessment of their relative importance from multiple perspectives. This is interesting because policy-makers tend to prefer to use a variety of measures in ES values as well as tangible information, such as the number of households at risk or the proportion of people relying on a given ecosystem for their livelihoods (Ruckelshaus et al., 2015). Indeed, such information is often more usable for policy-makers than economic values alone (Ruckelshaus et al., 2015). Moreover, we found that the method used to assess cultural ES seems to have an important influence on their values. We found that traditional cultural ES (i.e., all cultural ES except “opportunities for recreation and tourism”) are valued much lower in monetary units as compared to “provisioning” or “regulating” ES (Table 3.3). However, when assessed via ranking methods, cultural ES such as “bequest” (i.e., non-use value placed on conserving resources for future generations) were more frequently ranked higher in terms of importance than “provisioning” or “regulating” services.

This finding underlines the need expressed by the literature (see in Armatas et al., 2018; Pike et al., 2015 and De Groot et al., 2012) to develop and use more non-monetary indicators to assess coastal ES in order to better acknowledge the multiple perspectives of local stakeholders on the importance of coastal ES, in particular cultural ES linked to traditional practices and non-use values. For instance, people may see themselves as *living with nature*, valuing its life-supporting processes in connection to “other-than-humans” (IPBES, 2022). People may also see themselves *living as nature*, perceiving it as a physical, mental or spiritual part of themselves, seeking to live in harmony with their environment (IPBES, 2022). Taking non-monetary indicators into account would therefore allow to move from a still too utilitarian view of nature on a global scale (i.e., the nature is valued for the services it provides to humans) to a recognition of nature’s right to thrive independently of human needs, as strongly recommended by the IPBES (2022). Finally, this practice is likely to reduce socio-environmental conflicts linked to value clashes, and achieve management outcomes that are respectful of non-human species and diverse human ways of life (IPBES, 2022).

4.1.2. The importance of taking into account reports and studies involving non-monetary ES assessments in ES literature reviews

Although we found a significant number of studies assessing ES in non-monetary units, we are not aware of any other literature review on coastal ES in other regions that has considered these non-monetary ES. However, we found a significant proportion of ES assessed non-monetarily in our study, which provide relevant information to understand the contributions of coastal ecosystems to people in PSIDS. We therefore recommend that qualitative assessments and quantitative non-monetary assessments of coastal ES should be considered not only in ES assessments, but also in literature reviews, in order to provide

a more comprehensive and accurate description of coastal ecosystem services. This practice is likely to make cultural services more visible to researchers conducting literature reviews, and ultimately to policy. Finally, our results outline the importance of considering reports in literature reviews of ES, as we found that they (i) provide valuable information to better understand the importance of coastal ES in PSIDS, and (ii) contain the majority of identified policy recommendations, as opposed to peer-reviewed articles. To minimize research gaps and bias on policy recommendations associated with coastal ES, it would therefore be valuable to take reports into account in future systematic literature reviews of ES, echoing the recommendations of Blythe et al. (2020). Reports are referenced in databases such as the Pacific Hub Database used here, which facilitates their inclusion in this type of review.

4.5. Limitations

The main pitfall of our study probably lies in the selection of the 57 studies examined in our literature review. We have tried to be as comprehensive as possible in our literature identification, following rigorous steps, but we acknowledge that we have certainly missed some relevant studies given the impossibility of identifying all of the relevant literature. This is particularly the case for reports, which are scattered on the internet.

A second limitation to this study lies in the choice of the classification of ES. We decided to base our classification on that of the TEEB (2010), which is based on the Millennium Ecosystem Assessment (MEA, 2005), as the majority of the 57 studies explicitly framed their analysis in this framework. Only one study used the term “nature’s contribution to people” (in Grantham et al., 2020) to refer to the alternative framework developed by the IPBES. However, although the majority of studies were framed within the MEA, many did not categorize their assessed ES into a common TEEB or MEA category or type of service. For example, some ES, such as medicinal resources or raw materials, were in fact designated as “goods with traditional value” (cultural aspect of provisioning). In this sense, these studies show the inherent overlap between the different categories and types of ES, and highlight the multiple and complex ways in which people perceive the contributions of coastal ecosystems to humans (IPBES, 2022). If we had decided to include only non-material services in the cultural services category (thus excluding raw materials and medicinal resources), this would have yielded different results. In particular, we would have found fewer cultural ES and more provisioning services.

5. Conclusion

This review summarizes the state of the literature on coral reef, mangrove and seagrass services in PSIDS to better understand the contributions of these coastal ecosystems to people in a region with high vulnerability to ocean change. Our results outline both a wide variety of coastal ES and of assessment methods. However, only three ES types (food provision, opportunities for recreation and tourism, raw materials) and three assessment methods (market price, benefit transfer and contingent valuation) account for half of the total ES assessments. Our results also highlight the importance of the choice of assessment method. For instance, cultural ES were systematically (except in one case) valued lower than provisioning and regulating services when monetary methods were used, while they were more often rated higher than provisioning and regulating services in terms of importance when ranking and participatory methods were used. In addition, we found an overuse of the benefit transfer methods, which generally tend to underestimate coastal ES in PSIDS.

Further research could involve additional coral reefs services assessments in Papua New Guinea where only four assessments were found even though the country is one of the most dependent on coral reef health globally (Pendleton et al., 2016b). Research could also focus on assessing more ES types, in particular water purification services, which is the second most frequently assessed coastal regulating service globally (Liquete et al., 2013). Additional ES monetary valuations would also be needed to provide meaningful comparisons. Finally, we recommend that future literature reviews on ecosystem services (i) take into account non-monetary ES assessments, which are likely to provide valuable information on cultural ES in particular, and (ii) consider reviewing reports, given that in our review, the majority of policy recommendations were included in reports.

This work enriches existing ES databases such as the global ESVD, by compiling data from peer-reviewed studies but also from reports, which are currently absent from this database. This study provides a pathway for future systematic literature reviews to more fully reflect the state of knowledge on coastal ES, via the consideration of non-monetary assessments and findings from the grey literature. The categorization of assessment methods into three types (monetary, quantitative non-monetary and qualitative) establishes a background that can facilitate the process of future ES analyses in other regions and for other types of ecosystems.

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Chapter 4

Stakeholder involvement in the management of mangrove ecosystems: case study in a coastal community in Fiji

Chapter 4 is an exploratory chapter. It presents a collaborative field study conducted between Australia, Fiji and France, between 2020 and 2022. This study is part of a larger project on blue carbon ecosystem values and livelihoods, and constitutes one of its activities. Unlike the other three thesis chapters, Chapter 4 is not necessarily intended to be a stand-alone publication. Instead, some of the results may be included in a journal article that deals more broadly with the results of the project, in collaboration with the project partners.

1. Introduction

1.1. Key organizational drivers supporting the sustainable management of coastal ecosystems

In Fiji, as in many PSIDS, mangroves are essential ecosystems providing critical services to human communities, such as provision of food, timber and medicine, carbon sequestration and protection of shorelines from erosion and submersion (Veitayaki et al., 2017). Mangrove coverage in Fiji is among the highest of all PSIDS (Table 0.2 of the General Introduction shows the PSIDS' respective mangrove coverages), with approximately 600 km² (652 km² according to the estimates of Cameron et al. (2021) and 525 km² according to Bhattarai et al., 2014)). However, climate change, combined with other direct anthropogenic pressures such as pollution, land clearing or overfishing, is altering the functioning of these mangroves and other coastal ecosystems in Fiji. These pressures affects the goods and services provided by mangroves with negative effects on the well-being of coastal communities that depend on them for livelihoods and income (Johnson et al., 2020a; Dutra et al., 2019; Bell et al., 2018; Hills et al., 2013; Cinner et al., 2012).

Many ocean-related environmental problems can be attributed to dysfunctional governance systems⁵⁰ involving perverse market incentives, poor monitoring systems, lack of information, inadequate or absent regulation and loss of traditional knowledge and authority (Dutra et al., 2019; Dutra et al., 2015a). Beyond the challenges of collecting, analyzing and communicating biophysical data, the effective management of coastal ecosystems is complex and involves intense negotiations between various stakeholders with different, divergent and often overlapping objectives and mandates (Dutra et al., 2015a). Issues with governance (e.g., actors, formal/informal rules, compliance and enforcement) are often associated with poor natural resource management and outcomes to ecosystems, including human communities (Stephenson et al., 2023).

There is a common understanding of the general processes needed to enhance climate adaptation and to manage ocean resources and ecosystems effectively (Dutra et al., 2019; Ostrom, 2009; Ostrom et al., 2007). These include understanding the ecological, social and economic components and dynamics of a given socio-ecological system, setting clear objectives and ensuring monitoring and compliance (Dutra et al., 2019; Ostrom, 2009; Ostrom et al., 2007). Other key governance drivers that support adaptive capacity include leadership, clear responsibilities, effective integration of knowledge and insights, learning approach and coordinated participation in decision-making (Dutra et al., 2015b). In addition, effective decision-making requires the identification and prioritization of values and management objectives, integrated socio-economic assessment, and adequate stakeholder engagement (Dutra et al., 2015a).

⁵⁰ Here, governance systems refer to the actors (individuals or organizations) and systems of rules structuring their interactions.

The scientific literature widely recognizes that the involvement of local stakeholders, including local communities and indigenous people, is key to achieving a sustainable and equitable ecosystem management that contributes to enhancing climate adaptation and resilience (IPBES, 2022; IPBES, 2019; Lau et al., 2019; Romanelli et al., 2015). Hence, management approaches focusing on community leadership, such as community-based adaptation and community-based ecosystem management, are increasingly recognized by policy and practice as relevant tools to sustainably and equitably manage coastal resources, for instance through locally managed marine areas (LMMAs) (Johnson et al., 2020b; Remling & Veitayaki, 2016). These approaches have been shown to maintain engagement in the long-term and are more likely to succeed in terms of stakeholder buy-in to improved agreed management practices than top-down monitoring (Johnson et al., 2020b). Governance system that acknowledges the needs, rights, knowledge and aspirations of local populations promotes social acceptance, collaboration, policy coherence, and opportunities for mutual learning and knowledge dissemination (IPBES, 2022; IPCC; 2022; Romanelli et al., 2015). In addition, local communities are at the forefront to identify impacts on ecosystems, implement local actions and monitor progress that could be linked to regional planning processes and international commitments made by countries. This is especially the case in countries where there is limited capacity within government departments to conduct regular monitoring, such as PSIDS (Johnson et al., 2020b). On the contrary, ignoring, excluding or marginalizing local voices, needs and values often leads to unnecessary socio-environmental conflicts, undermining the effectiveness of environmental policies and increasing development inequalities (IPBES, 2022; Sangha et al., 2019).

This chapter explores the involvement of local stakeholders in the management of coastal ecosystems (particularly mangroves) in a context of complex governance system. We seek to better understand the dynamics of coastal ecosystem management in Tawake, a coastal Fijian village located in the second largest Island in Fiji (Vanua Levu) in the Province of Cakaudrove. As in Fiji, most of the land (including intertidal and submerged areas) and fishing grounds are under customary care, any NbS initiative must engage with traditional owners and local governance to be effective and equitable. Understanding the perception of communities about their involvement in mangrove management is therefore important because it can inform how to better engage. According to the Mangrove Management Act of Fiji (2013), there is a need for new initiatives at the village level to conserve, protect, and, where necessary, restore mangrove both to support and improve ecosystem services and also as a potential source of direct cash benefits via carbon credits. In Fiji, where a system of traditional marine resource management prevails and coastal resources are dwindling, community engagement and empowerment are key for sustainable coastal management (Johnson et al., 2020b).

1.2. The ownership of coastal resources in Fiji

1.2.1. State ownership over coastal resources

Around 1979⁵¹, decision-making in Fiji was transferred from hereditary chiefs and community councils to government officials. Nowadays, all intertidal⁵² and submerged land is owned by the Fijian State (State Lands Act, Cap 132). Hence, the State technically owns most mangrove areas (Veitayaki et al., 2017; Mangrove Management Plan 2013). Similarly, coastal fishing grounds in which mangroves can live are owned by the State. These fishing grounds, originally owned by indigenous Fijians, are called *qoliqoli*⁵³. In Fiji, 411 *qoliqoli* are registered by the Native Land and Fisheries Commission, covering an area of about 30,011 km² (Sloan & Chand, 2016). Figure 4.1 shows the localization of *qoliqoli* in Fiji, as well as *tabu* areas, which are prohibited fishing zones for a period of time to allow fish resources to recover (Veitayaki et al., 2011).

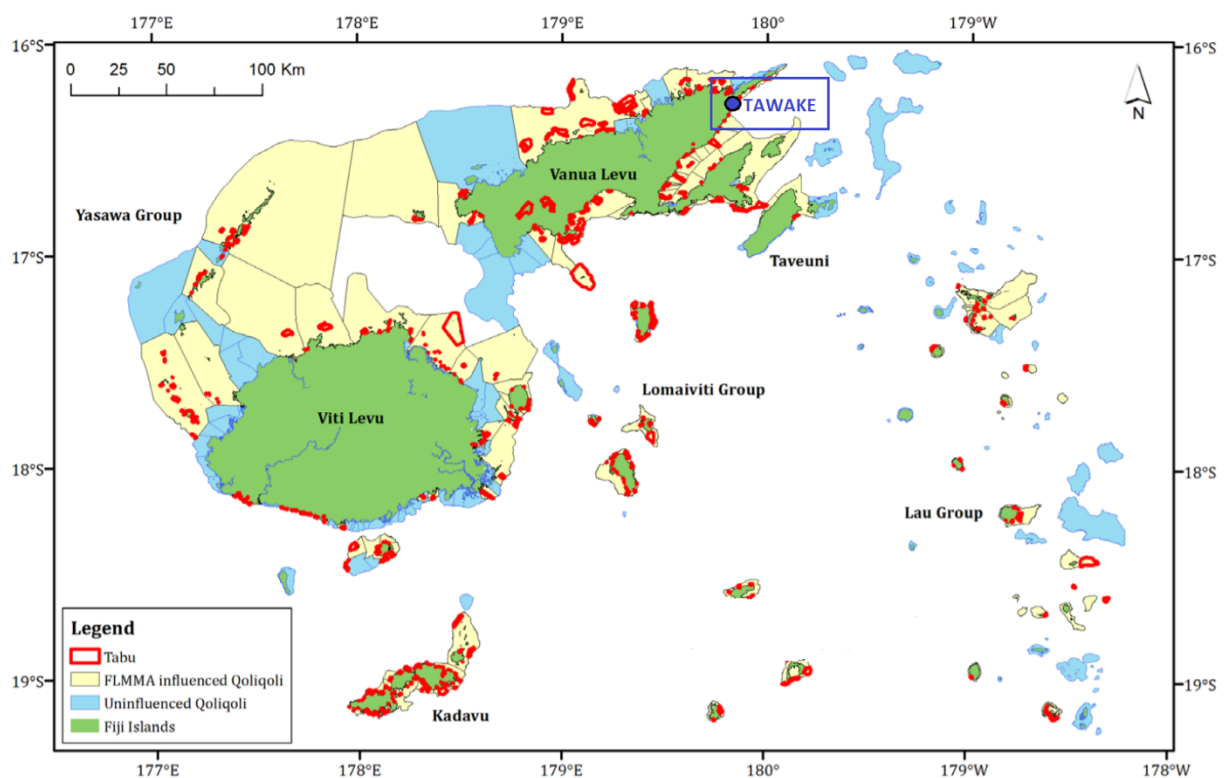


Fig. 4.1. Map of Fiji showing location of *qoliqoli*, those influenced by Fijian Locally Managed Marine Areas (FLMMAs) and the localization of the village case study Tawake. Source: Mills et al., 2011.

⁵¹ Fiji gained its independence in 1970.

⁵² The intertidal zone corresponds to the seashore area that is covered at high tide and uncovered at low tide.

⁵³ *Qoliqolis*' boundaries run from the shoreline to the edge of coral reefs. Indeed, *qoliqolis* are based on customary fishing grounds that roughly followed the general geomorphology of the reefs (Sloan & Chand, 2016).

1.2.2. Coastal resource ownership in practice

In practice, *qoliqoli* are mostly held by *iTaukei*, i.e., indigenous Fijians (Sloan & Chand, 2016). In Fiji, traditional marine practices still exist (e.g., *tabu* areas) and Fijians have customary rights to use the living resources in their intertidal and coastal zones (Veitayaki et al., 2011). This implies, for example, that the State will not consent to a coastal development project without consulting the traditional leaders and communities concerned by the project (Sloan & Chand, 2016). This traditional governance system based on marine customary rights is accepted in practice despite a lack of clear laws and policies regulating how *qoliqolis* work⁵⁴ (Sloan & Chand, 2016). Traditional leaders can also develop and endorse ecosystem-based management plans, as illustrated by the Ecosystem-Based Management Plan of the Kubulau District (WCS, 2012). Rather than “stakeholders”, Fijian *iTaukei* (i.e., indigenous Fijians) consider themselves principal rights holders as resource owners - or “custodians” (Vierros et al., 2010).

1.3. Decision-making in Fiji: an hybrid governance system

The management of coastal ecosystem and resources in Fiji is underpinned by a dual governance system where informal management by customary resource users coexists with a formal centralized approach instituted by the Fijian government (Veitayaki et al., 2016; Vierros et al., 2010).

1.3.1. A centralized formal governance for mangrove management

The regulation of mangroves, which lie on the land-ocean interface, is challenging in Fiji. At present⁵⁵, three government bodies (ministries) are involved in mangrove regulation and management. These are the Ministry of Lands and Mineral Resources, the Ministry of Forests and the Ministry of Local Government, housing and Environment (source: Ocean law bulletin, 2017). These ministries have the responsibility to implement the provisions of the Environment Management Act (2005), whose one of the main purpose is “to apply the principles of sustainable use and development of natural resources”. The Environment Management Act (2005) also requires an Environmental Impact Assessment for any development proposal impacting mangroves in Fiji. In addition, the Fisheries Act regulates a wide range of activities related to fisheries and marine life, and thus to mangroves as they provide habitat to fish species in the high tide.

The Fijian policy discourse and policies also increasingly recognize the role of coastal ecosystems for climate adaptation and mitigation (Cameron et al., 2021). These policies include the Fiji’s updated Nationally Determined Contribution (NDC) 2020, the National Adaptation Plan 2018, the Mangrove Management Plan developed under the 2013 Mangrove Ecosystems for Climate Change Adaptation and

⁵⁴ Although the Fisheries Act recognizes the existence of customary rights, it does not detail how they are applied (Sloan & Chand, 2016).

⁵⁵ Prior to 1975, Fiji’s mangroves were constituted as Forest Reserve, and were managed solely by the Forestry Department.

Livelihoods Project (Cameron et al., 2021), and the Low Emission Development Strategy 2018-2050. The latter highlights, for instance, “*the need to sustainably manage and protect marine and coastal ecosystems, strengthen their resilience, and restore them when they are degraded. This involves conserving ocean reservoirs as carbon sinks through supporting the restoration, enhancement and conservation of coastal ecosystems such as mangroves, seagrasses and coral reefs*”. To preserve its coastal resources and ecosystems and enhance climate adaptation and mitigation, Fiji has set a national goal of establishing 30% of its exclusive economic zone (EEZ) as marine protected areas, and working towards 100% management of its EEZ by 2030 through the implementation of its National Ocean Policy 2020-2030 (Fiji updated NDC, 2020). Yet, mangroves in Fiji are still cleared for coastal development and suffer from pollution and climate impacts such as cyclones (Cameron et al., 2021; Veitayaki et al., 2017). Cameron et al. (2021) have estimated the mangrove loss in Fiji to be 1,135 ha between 2001 and 2018, mainly due to tropical cyclones and coastal developments.

1.3.2. Local mangrove management in practice

In practice, and although not clearly defined, coastal Fijian communities have considerable independence over the manner in which they use mangroves, as customary and traditional owners (Veitayaki et al., 2017; Mangrove Management Act, 2013). Traditional decision-making involve village council meetings. During village council meetings, the proponents of a given initiative (for example to plant mangrove) officially asks for permission to initiate management activities at the community level (CSIRO, 2023). A decision will be taken during the meeting whether or not the proposed activity is approved. The “High Chief” of the village assesses and make final decisions, based on communication with chiefs from other villages and clans. Indeed, the heads of the land owning groups (*Mataqali*) advise the “High Chief”. Representatives or groups (such as church, women or youth groups) are also part of the village council and participate in decisions at both village and *yavusa* (groups of clans) levels (Itaukei Affairs, 2016).

Figure 4.1 illustrates the different units that form the traditional social and governance structure in Fiji, i.e., the *iTaukei* system. Several *tokatoka* (families) form a *mataqali* (clan), several of which forming a *yavusa* and a *tikina* (district) (Fig. 4.2). The *Yasana* result from the merger of districts by the British authorities during colonization in the 19th and 20th centuries. *Matanitu* correspond to three “confederacies” which are the result of territorial upheavals in Fiji during colonization. The Fijian indigenous society attaches great importance to the family unit (*tokatoka*), clans (*mataqalis*) and villages (*koro*). Although often described as pyramidal or hierarchical, the traditional Fijian structure is more complex, as several layers often overlap without coinciding (Aswani et al., 2017; Sloan & Chand, 2016).

The Fijian traditional structure is centered around the *Vanua*, which is both the largest social grouping in which community members claim to belong to (Fig. 4.2) and an essential concept of the indigenous Fijian culture (CSIRO, 2023; Sloan & Chand, 2016). According to Sloan & Chand (2016), it

“symbolizes a traditional belief in an intrinsic connection that the people have with their environment and in this, the land and sea are considered together”. The *Vanua* thus encompasses physical and abstract aspects such as land, spirituality, social structures, and harmony between individuals and their environment (Taboada et al., 2020). The *Vanua* brings obligations for people to care for the *Vanua*, and a strong sense of belonging (Yee et al., 2022). In the context of climate change, which affects ecosystems and people, the *Vanua* provides a strong impetus for local communities to protect coastal ecosystems (Yee et al., 2022).

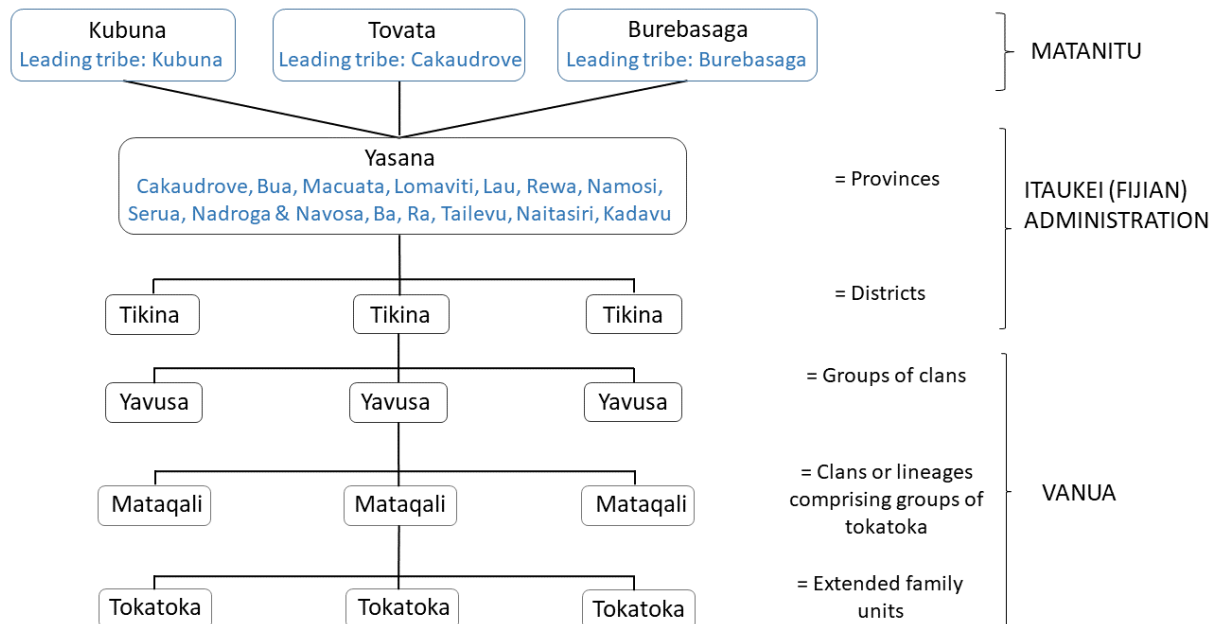


Fig. 4.2: Traditional Fijian governance structure. Design inspired from Taboada et al. (2020) and Mataiciwa (2021).

There are challenges related to the fact that coastal resources and ecosystems in Fiji are subject to both a formal and a traditional governance. Firstly, all coastal activities must comply with both traditional and governmental rules, such as timing and zone of ecosystem restoration. However, compliance with government’s policies and regulations is challenging at the community level, as communities are not always aware of existing government’s policies or regulations, or when new ones are put in place (CSIRO, 2023). Secondly, limited knowledge on mangrove ecosystem processes or local societal aspirations can impede the local management of mangroves. In addition to the recognition of community ownership and control of coastal zones and resources, the traditional and local knowledge are essential components of good management practices (Vierros et al., 2010). Overall, communities have sustainably used mangroves for over three thousand years (Mangrove Management Act, 2013). Many communities living close to mangrove ecosystems have a deep understanding of mangrove ecology and use (Mangrove Management Act, 2013). However, traditional knowledge on mangroves as well as

traditional authority are decreasing in Fiji as a result of the colonization and changes in lifestyles associated with urbanization (Veitayaki et al., 2011; Techera et al., 2009). Subsistence-based livelihoods have increasingly had to be integrated with a commercial imperative and the cash economy. In this context, mangroves have proven to be very important in supporting rural communities (Mangrove Management Plan 2013). Like in other PSIDS, governance structures, respect, practices and beliefs are changing over time in Fiji and are questioned by people (Vunisea, 2002). A better understanding of local governance practices is needed to support the sustainable management of coastal ecosystems and resources.

1.4. A study framed into a regional project on blue carbon and livelihoods

In this context, we sought to (i) assess how members of a coastal community in Fiji perceive their involvement in the mangrove management, (ii) understand their constraints to greater involvement, and (iii) highlight potential risks and opportunities associated with the community's perspectives. We used a survey approach and collaborated with members of a local non-governmental organization (NGO) to develop and administer the surveys.

This study is a component of a larger regional project between Australia and Fiji, entitled "Blue Carbon Ecosystem Services and Livelihoods (BCESL, 2019-2022)", which is itself a component of the broader programme "Pacific Blue Carbon Program" commissioned by Australia. The BCESL project notably involves a range of researchers from the Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia), the Fijian Government, The University of the South Pacific, the NGO "Transcend Oceania" and local communities. It aims to identify constraints and opportunities in existing governance structures related to coastal ecosystem in order to maximize human well-being. This project includes a governance mapping (i.e., identification of key actors, rules and interactions that are part of decision-making processes), and an identification and quantification of ecosystem goods and services provided by blue carbon habitats (i.e., mangrove and seagrass) for the community and other stakeholders. Figure 4.3 provides a description of the project components. The present study developed in this thesis Chapter complements the regional project's component on "governance mapping and ecosystem services assessment" by providing insight on how community members perceive their contribution to coastal management (orange circle in Fig. 4.3).

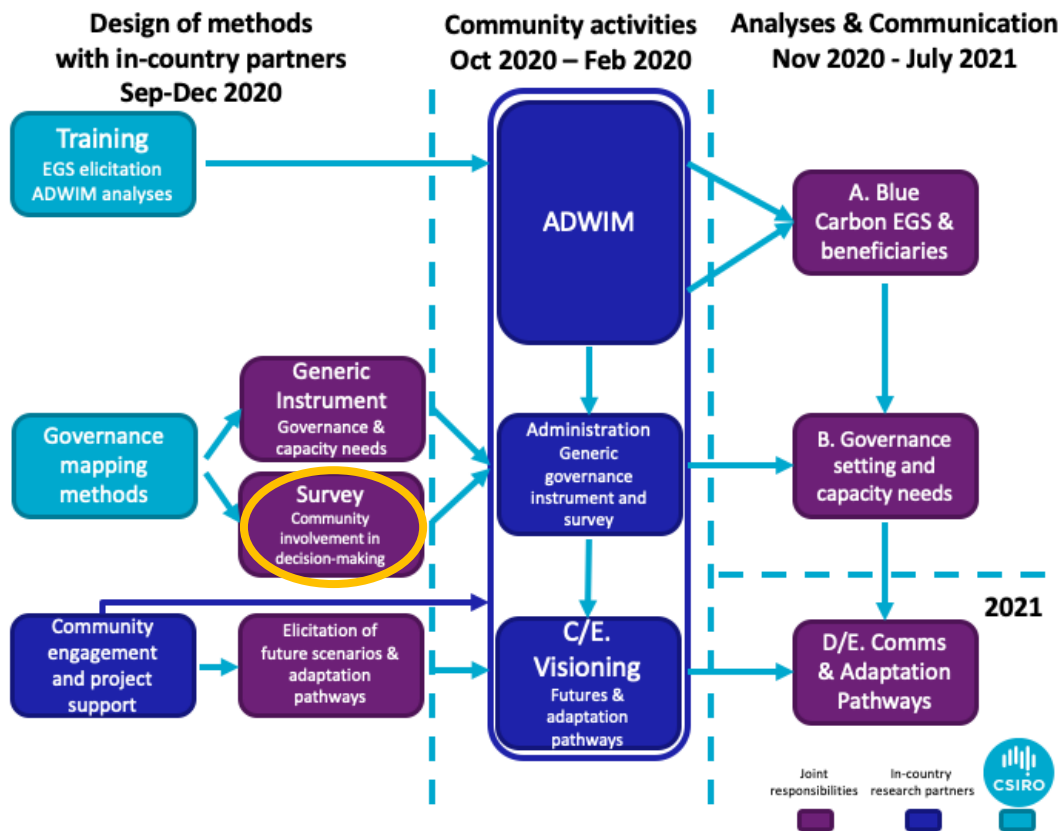


Fig. 4.3. Summary of the activities part of the Blue Carbon Ecosystem Services and Livelihoods project. The survey supporting the work described in this thesis Chapter is circled in orange. ADWIM: the Asset Drivers, Well-Being Interaction Matrix (see Skewes et al. (2016) for further details on this participatory tool for estimating future impacts on ecosystem services and livelihoods). Source of the figure: Application form to the CSIRO Human Research Ethics Committee.

2. Materials and method

2.1. Characteristics of the case study site

This study focuses on a Fijian coastal village, Tawake. Tawake is located on Vanua Levu Island, one of the two main islands of Fiji, in the Cakaudrove Province, Northern Division (Fig. 4.1). Tawake village is part of the district also known as Tawake, which includes the villages of Tawake, Wainiika, Nagasauva, Vatu, Wainigradu and Yasawa. When we use the term “Tawake” in what follows, we are referring to the village and not to the district. Tawake is located about 100 km east from Labasa, the main nearby urban center. The village of Tawake is culturally important as it is the home of the *Turaqana Vunivalu* or “High Chief”, a customary leader with authority over several other nearby villages. This broader authority facilitated the participation of representatives from a broader area, i.e., from villages in the neighboring provinces of Cakaudrove and Macuata. In Tawake, the main governing tribe is called Yavusa Koroivoco. At the time of the research, the community has a population of approximately 200 inhabitants.

There were two main considerations for selecting the site of Tawake for the BCESL project. Firstly, there is an existing network of stakeholders in Tawake who are willing to collaborate. We should note that prior to the BCESL project, Tawake have had limited interactions with research projects. Secondly, Tawake can be considered representative of the social, cultural, and biophysical contexts of Fiji. Like many other villages in Fiji, Tawake is located in a rural and remote coastal area, with limited infrastructure, including a lack of clean water supply and difficult road access (it takes three hours to drive to from Labasa to Tawake, via a steep, unpaved road that is often closed during the rainy season). The community's livelihoods are based on informal and subsistence activities, including crop farming and fishing. These subsistence activities are primarily based on coastal and marine resources, which are particularly vulnerable to environmental threats, such as climate impacts and pollution (Pratchett et al., 2011).

2.2. Timeline of the study: two surveys held during workshop weeks two years apart

We have designed and conducted two surveys targeting the community of Tawake, both of which aiming at assessing how the community perceives its involvement in mangrove management, as well as constraints and opportunities to improve it. The first survey was conducted in October 2020, and the second in July 2022. Both surveys were conducted at times where other activities (workshops) were held in Tawake as part of the BCESL project. This arrangement facilitated the administration of the surveys since members of the BCESL project (researchers, partner NGO) were present in Tawake.

Other workshops within the BCESL project - whose activities were not directly related to our surveys - took place in Tawake between October 2020 and July 2022. The BCESL workshops aimed to generate and share knowledge on the importance of blue carbon ecosystems and their values to the community. The objectives of the BCESL project were to better understand decision-making processes and capacity needs, develop no-regrets strategies to future proof the community, and also to collect samples from mangroves and seagrasses to determine blue carbon storage and fluxes. Ultimately, the BCESL project aims to identify governance issues and pathways based on climate projections and community priorities and aspirations for development and ecosystem services. These workshops and all the work carried out between 2020 and 2022 with the community of Tawake may have influenced its involvement in coastal ecosystem management. Conducting a second survey allowed for a comparison of the evolution over time of community's perception of involvement in mangrove management.

2.3. A collaborative survey design

In their format, the two surveys were designed and conducted in a similar way, but they have slight differences in their content. I prepared the survey questions, which were then reviewed by Leo Dutra (CSIRO), Ingrid van Putten (CSIRO) (for the first survey only) and Adi Vasulevu M. Levu (Managing Director of the Fijian NGO partner "Transcend Oceania"). Remote meetings were held between us to review the survey questions before conducting them. Both surveys targeted the Tawake community

members, and are structured in four parts: (i) respondent characteristics such as age, gender, social role and activity, (ii) the perception of their involvement, (iii) their perception of government involvement, and (iv) their perception of the involvement of their traditional leaders. We followed the research ethics protocols approved by the CSIRO Human Research Ethics Committee (Human Research Ethics Approval 126-20). This included the provision of information to participants, seeking their consent to participate and to withdraw from participation at any time, in case respondents decide to withdraw from the research after the survey was completed.

The second survey was designed on the basis of the feedback from the first survey. Changes from the first survey questionnaire included specific questions about the three stages of decision-making process (design, implementation, monitoring), as many respondents to the first survey indicated that these distinctions were too detailed and irrelevant. The second survey is shorter (16 questions instead of 26). Each survey questionnaire is available in Supplementary Material, Appendix 4.A. Types of questions included:

- (i) Closed questions. These include for instance questions where respondents are asked to choose only one possibility among integers between 0 and 5. Example: “Q4. Do you see yourself involved in the management of mangroves, in the next 5 to 10 years? 0 (not at all involved); 1 ; 2 ; 3 ; 4 ; 5 (fully involved)”;
- (ii) Open-ended questions where answers are based on free writing. Example: “Q12. How do you think traditional leaders can better consider your inputs into traditional village by-laws rules?”;
- (iii) Ranking questions where the respondents were asked to rank different options in terms of importance. Example: “Q5. In your opinion, what are the constraints hindering your involvement in mangrove management? Please use numbers 1 to 10 where 1 is the most important constraint. *Your gender* ; *b. Your age* ; *c. Your role or position in the community* ; *d. Your knowledge* ; *e. Financial constraints* ; *f. Institutional or administrative constraints* ; *g. Time* ; *h. Communication within the community* ; *i. Communication with government and traditional leaders* ; *j. Other* *Specify:.....”.*

2.4. Survey administration and analysis

Both surveys were administered via face-to-face interviews due to very limited internet access in Tawake, which could prevent participation of respondents in an online survey. At the time of the first survey (October 2020), travel restrictions due to the COVID-19 pandemic made it impossible to travel between Fiji and France. The surveys were administered in the field by a research facilitator, who is both a staff of Transcend Oceania and a member of Tawake. The interviews were conducted in groups of two or three people. This method facilitated discussion and understanding of the questions, as the research facilitator was able to explain certain terms if necessary and translate questions and explanations to Fijian when needed. It took approximately 30 minutes on average to conduct one

interview in the second survey, compared to approximately 45 minutes for one interview in the first survey. The facilitator added the data (i.e., survey responses) in an Excel spreadsheet and send it to me, and I analyzed them. The survey responses were de-identified and organized to highlight results from descriptive statistics (e.g., gender, age) and significant elements or trends.

For one-choice questions where respondents were asked to give a note between 0 and 5 (integer numbers), we calculated the average score among participants. For open-ended questions, we gathered similar answers when they referred to a similar idea. For the question Q5 on ranking the constraints hindering involvement in mangrove management, we took into account the two highest constraints for each respondents. We made this choice because in most cases, respondents cited only two constraints, instead of 10 as we proposed. In addition, constraints were not put in order (e.g., they were presented as “a & d” for instance (where “a” is gender and “d” is knowledge) instead of “first constraint: a; second constraint: d” or “first constraint: d; second constraint: a”). We sought to know if characteristics such as gender or age had an influence on the respondents’ involvement. We used statistical tests (student *t*.test) to assess the extent to which results are significant across several groups of respondents. We selected the bilateral distribution (“2” in the equation), and the unequal variance distribution (heteroscedastic, “3” in the equation). Equations are in the format: $t.test(\text{sample A}; \text{sample B}; 2; 3)$. The samples correspond to a set of responses. For example, if we want to know if the difference in involvement between women and men (Q2) is significant, sample A will correspond to all scores (integers between 0 and 5) for men, while sample B will correspond to all scores (integers between 0 and 5) for women. The null hypothesis was that the means of the two samples are not significantly different. We rejected the null hypothesis if the student test was less or equal to 5%. The number of stars represents the significance level of the test: one star (*) if significant at 5%; two stars (**) if significant at 1%; and three stars (***) if significant at 1%.

3. Results

3.1. Characteristics of the respondents

Fifty participants responded to the first survey, and forty-five to the second, which in both cases corresponds to about a quarter of the size of the community. In both survey rounds, each group (e.g., women, men, youth, community leaders) was fairly well represented in terms of the number of participants, with the exception of respondents aged under 18 year old as there were no respondents in the first survey, but three in the second survey.

Most of the respondents are engaged in subsistence or informal activities such as fishing and farming (86% of respondents of the first survey and 75% of the second). Also, most of them are members of a community group (e.g., youth group, women group, church group) (70% of respondents of the first survey and 80% of the second), the most common being the women group and the youth group. The

youth group is mainly composed of participants aged under 31, but 2 respondents aged between 31-45 considered themselves to be part of the group. Two thirds of the respondents were also participating to some BCEESL workshops organized the same weeks of the surveys (70% of respondents for the first survey and 73% for the second survey).

3.2. A great interest in mangrove protection and restoration among participants

In the following, we will describe the results of the second survey only, except when the results of the first survey are significantly different from those of the second survey. Figure 4.4 shows how respondents perceive (i) their current involvement in mangrove management and decision-making (Q2), (ii) their desire to be more involved (Q3), and (iii) their long-term involvement (Q4), according to their age and gender. On average, two thirds of respondents to the second survey were, at the time of research, currently involved in mangrove management and decision-making (Q2, Fig 4.4), which is a higher proportion compared to the first survey (40%). On average, respondents wished to be more involved in mangrove management (Q3), with an averaged score of 4.2 among participants, where 0 means not involved at all and 5 means that they wish to be fully involved. Moreover, respondents see themselves involved in mangrove management in the long-term, i.e., 5 to 10 years (Q4), with an average score of 4.2. These scores are very close to those from the first survey (4.4 and 4.8 respectively for Q3 and Q4).

Not surprising, given the hierarchical roles and responsibilities according to family positions, gender and age, the youngest participants (aged <18 years and 18-30) felt the least involved in mangrove management, while those aged 31-45 years felt the most involved (Fig. 4.4). This result slightly differs from that of the first survey, where perception of involvement continued to increase proportionally with age. Furthermore, there is very little difference in the perception of current involvement in management (Q2) between men and women (both felt involved); however, their future aspirations about involvement in decision-making processes about mangroves differ (Fig. 4.4). Men wish to be more involved than women (Q3) (*t*.test of 0.0452*), and men also see themselves as more involved in the long term than women (Q4) (*t*.test of 0.0173*) (Fig. 4.4).

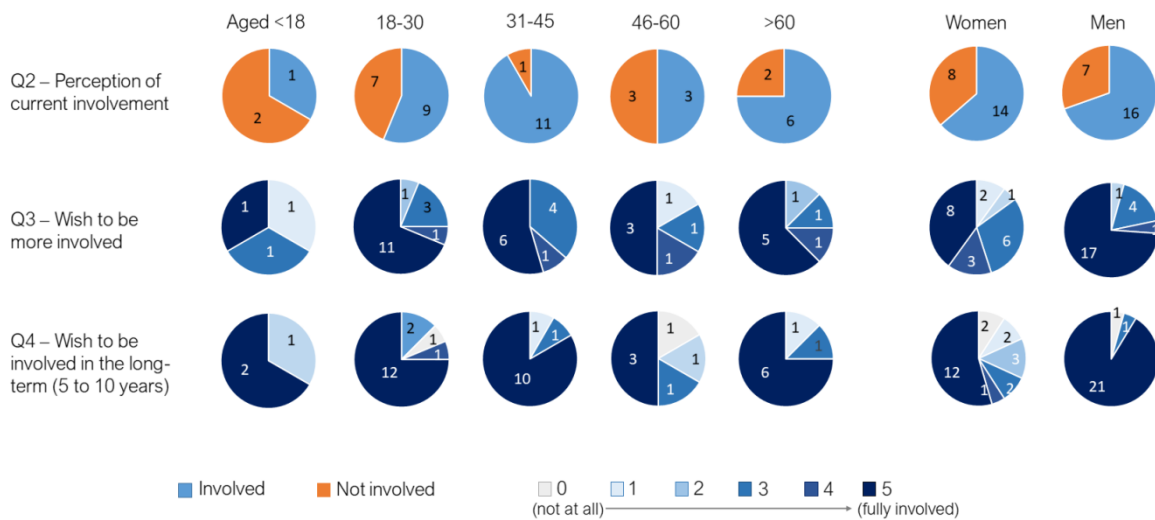


Fig. 4.4: Results of survey 2: Perception of community members' involvement in mangrove management, for current involvement (Q2), aspirations (Q3) and long-term involvement (Q4), according to their age and gender.

3.3. Managing mangroves focusing on restoration (replanting)

The main action envisioned by respondents about mangrove management is restoration, through mangrove replanting; eleven respondents out of 45 explicitly mentioned mangrove replanting (Table 4.1). To a lesser extent (7 responses), respondents identified the importance of “not damaging mangroves” in the first place, for example by banning mangrove cutting, and reducing plastic pollution (Table 4.1). For other coastal ecosystems, such as coral reefs and seagrasses, other strategies are favored. In particular, the protection of coral reefs, rather than their restoration, is considered a priority (Table 4.1). Specific associated actions highlighted by respondents include, for example, prohibiting fishing in particular areas and ensuring that corals are not touched when swimming and diving. With regard to seagrasses and seaweeds, which were less frequently mentioned, participants identified the need to protect and replant as a priority (Table 4.1). Compared to the first survey, the level of detail on how to manage coastal ecosystems is greater in the second survey, which highlights much better the differences between potential management approaches (mangrove replanting versus coral reef protection). Despite these differences, half of the respondents emphasized that coastal ecosystems should be managed differently, since “*they adapt differently*”, and as a whole, since “*they are connected in the sea and in the same place*”. This holistic view of marine life seems to refer to the concept of *Vanua* (“*when you manage one [ecosystem], you manage all marine life*”).

Table 4.1: Management options that should be undertaken for the different coastal ecosystems, according to the respondents of survey 2. The numbers correspond to the number of times the option was mentioned among all 45 respondents.

	Protection (e.g., not damaging, taking care of, not using)	Planting or replanting	Other
Mangrove	7	11	
Coral reef	8	3	
Seagrass	2	4	1 (“it replicates on its own”)
Seaweed	2	4	1 (“it replicates on its own”)
Coastal ecosystems in general	1	1	

3.4. Existing policies and traditional rules

The perception of the existence of policies or rules for mangrove management is heterogeneous among the participants, as shown in Fig. 4.5. Comparing the results of the two surveys, we found that there is a lower proportion of respondents to the second survey (7% of respondents) who think that there are no governmental policies dealing with mangroves compared to the first survey (36% of respondents) (Fig. 4.5). Similarly, there is a lower proportion of participants to the second survey who believe that there are no traditional mangrove rules (22%) as compared to participants to the first survey (36%) (Fig. 4.5). These changes may be related to the information provided during the workshops and the opportunity some of the respondents who attended the workshops had to discuss with both government representatives and community leaders. According to half of the respondents to the second survey, mangrove policies developed by the central government are focused at the district level (53%). Similarly, for 53% of respondents, there are traditional mangrove rules developed at the *yavusa* level (groups of clans) (53%). On average, respondents who believe that policies are developed at the district level are also those who believe that there are traditional rules applied at the *yavusa* level. Only 18% of respondents of the second survey think that there are government policies on mangroves at the national level (Fig. 4.5). In addition, only seven out of 45 respondents (16%) think that there are government rules at several levels (i.e., national, provincial, district), and three (7%) think that there are traditional rules at several levels (Fig. 4.5).

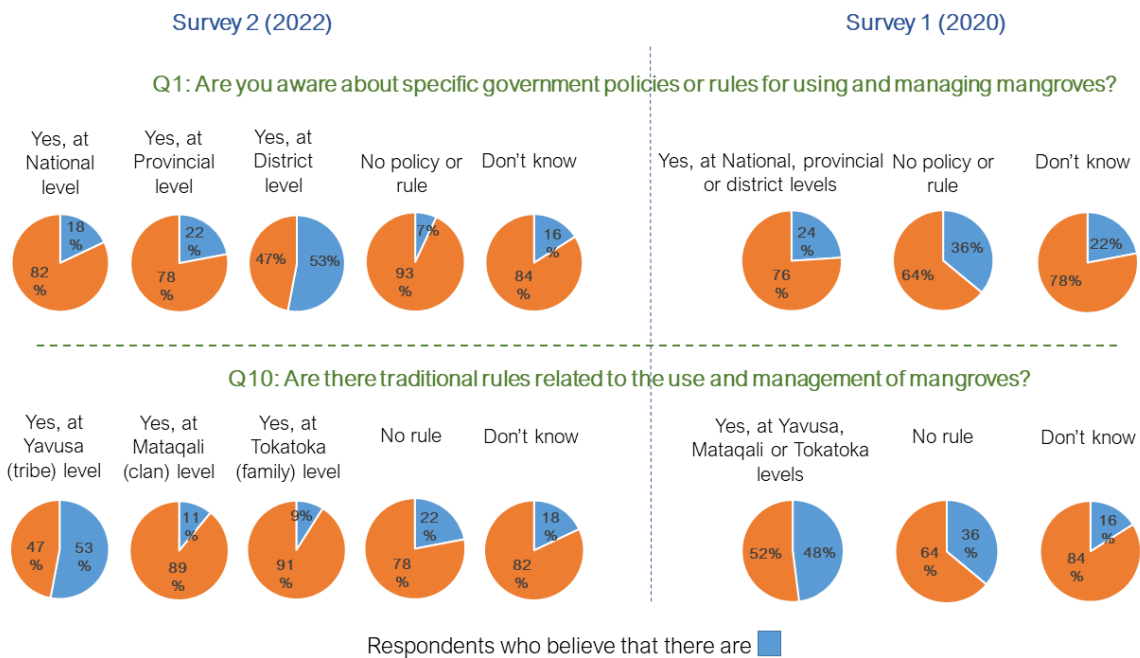


Fig. 4.5: Perception of the existence of mangrove policies and rules according to the respondents, for the two surveys.

3.5. Constraints to mangrove management: lack of knowledge and communication, and age

We asked participants what they thought were the constraints to their involvement in mangrove management, from the following choices: a. gender; b. age; c. role or position in the community; d. knowledge; e. financial constraints; f. institutional or administrative constraints; g. time; h. communication within the community; i. communication with government and traditional leaders; j. other. The most frequent constraints to their (greater) involvement in mangrove management cited by respondent were knowledge (14 participants), followed by age (12 participants), communication with government or traditional leaders (11 participants) and gender (10 participants) (Fig. 4.6).

Knowledge was mentioned regardless of age. Participants identified advanced age (aged > 60) and young age (aged < 30) as constraints. Financial and time constraints were the most important constraints only for respondents aged 31-45.

Gender-related constraints were expressed by women, except in two cases. The main constraint cited by women for greater involvement in mangrove management was gender, followed by communication with leaders, and age. For men, the most important constraints were, in order, knowledge, age and communication with leaders.

On average, participants felt that their views and insights are moderately taken into account, whether by the government (average score of 2.3) or their traditional leaders (average score of 3, on a scale of 0 (not taken into account) to 5 (fully taken into account)). These results are slightly more positive than those of the first survey (average scores of 1.5 and 2.6 with regard to the government and traditional leaders

respectively). The fact that respondents felt that their traditional leaders heard their concerns better than the government was more significant in the first survey (t -test of 0.0019**) than in the second one (t -test of 0.078). Participants also felt that government officials and traditional leaders were working together in a moderately satisfactory manner, with an average score of 2.9 (0 meaning “not well” and 5 meaning “very well”).

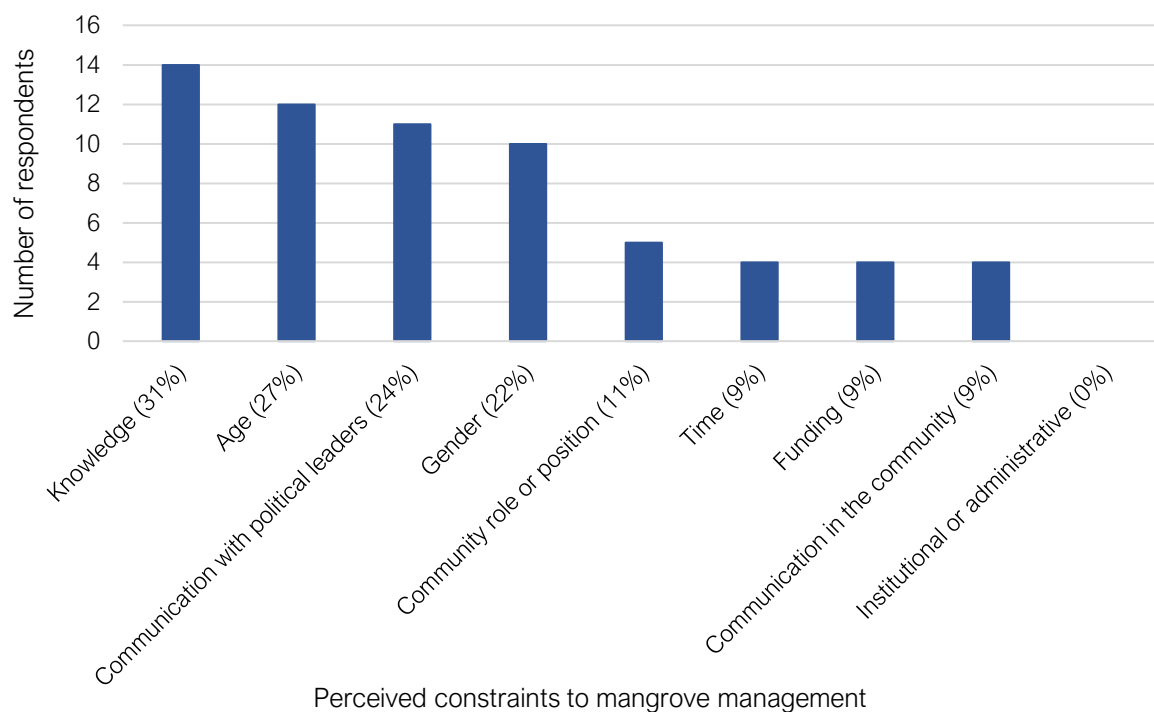


Fig. 4.6: Main constraints identified by respondents for their involvement in mangrove management (survey 2).

3.6. Ways of improvement

3.6.1. Knowledge and awareness

According to the respondents, information is the primary attribute to improve mangrove decision-making processes. With information, they will better understand the importance of mangroves for marine life and the community and therefore better decide on courses of action needed. The need for better information about the role and importance of mangroves was also strongly expressed in the open answers about general comments (Q16). In the last open-ended questions on general comments (Q16), 24 respondents out of 45 spontaneously mentioned that the workshop had allowed them to acquire knowledge about the importance of mangroves. Five respondents spontaneously mentioned that more awareness on blue carbon ecosystem services is still needed. For the respondents, knowledge about mangroves and the services they provide can mainly be improved through workshops organized either by external actors such as the government or researchers, or in-house by traditional leaders during village

meetings. Furthermore, the role of local NGOs such as Transcend Oceania was mentioned as critical to facilitate knowledge sharing and communication between the different stakeholders.

3.6.2. Role of the government: a top-down approach

Improving communication and encourage community and political leaders (government and traditional ones) to work together was also mentioned by the respondents as a key aspect for improving mangrove management. According to the respondents, the government is expected to provide the means to act, in particular through awareness and knowledge. This reflects a fairly top-down view of mangrove management. When analyzing the responses to the open question Q9 “How do you think the government can better take into account your contributions regarding mangrove management?”, 25 out of 40 respondents mentioned that the government should support community awareness on the importance of mangroves (e.g., “they are supposed to do the awareness raising”), through workshops or training programmes (Table 4.2). The second most common point raised in the responses (7 responses) was the need for government officers to visit the community more often and to increase the quality of communication of decisions or policies, especially through appropriate dialogue and active listening of community needs. To a lesser extent, the community feels that the government should: a) provide financial support (3 responses), b) provide mangrove seedlings (1 response), c) plant mangroves to lead by example (2 responses), and d) look after the initiatives carried out by the community (1 response) (Table 4.2).

3.6.3. Role of traditional leaders: a more bottom-up approach

According to the survey respondents, the priority for their traditional leaders should be to better listen to the community members, their concerns, and to learn from them (15 responses, Table 4.2), which relates to a more bottom-up management approaches. Compared to the expectations towards the government on providing knowledge (25 responses), the community seems to expect less from the traditional leaders to provide them with knowledge (7 responses) (Table 4.2). According to the respondents, traditional leaders should embrace a more inclusive approach, by “listening to all voices” and “inviting everyone to village meetings”. To a lesser extent (and similar to responses about the government), traditional leaders are expected to encourage the community to implement actions and provide support in mangrove management (3 responses). Monitoring progress and ensuring that the law is respected (2 responses) were also highlighted by respondents as responsibilities of traditional leaders (Table 4.2).

Table 4.2: Community perception of their leaders' involvement in mangrove management and decision-making.

	Q9: How do you think the government can better consider your inputs regarding mangrove management?	Q12: How do you think traditional leaders can better consider your inputs into traditional village by-laws rules?
By providing awareness and knowledge	25 responses	7 responses
By better listening the community members and learn from them		15 responses
By visiting the community more often	7 responses	
By encouraging the community and providing support		3 responses
By providing financial support	3 responses	
By monitoring progress and ensuring that the law is respected		2 responses
By planting mangroves to lead by example	2 responses	
By looking after the initiatives carried out by the community	1 response	
By providing mangrove seedlings	1 response	

According to the respondents, it is also important that their traditional leaders and the government communicate better together in order to improve the management of their mangroves. The results highlight that the most important priority (19 responses) would be for the government to visit traditional leaders more frequently, consult them more and better include their views in decision-making processes, in order to build stronger relationships. According to one participant, “*the community will be more enthusiastic when they see their leaders working together to preserve the environment and livelihoods*”. In addition, the government is expected to provide financial and technical assistance and listen to the community (4 responses). In return, traditional leaders should better consider government inputs and be more transparent with the government about what is being done locally (2 responses).

4. Discussion

4.1. Potential risks and challenges associated with mangrove management in Tawake

4.1.1. Insufficient communication and lack of knowledge

The risks associated with mangrove management in Tawake appear to be mainly related to the perception of community members of (i) not knowing enough about the importance of mangroves, and (ii) not feeling properly heard by their political leaders. These results are not surprising since knowledge generation, communication and leadership have been identified as key decision-making attributes in the co-management of coastal resources, i.e., the sharing of power and responsibilities between local

resource users and the government (Dutra et al., 2014; Berkes, 2009). This reflects the hybrid governance in Fiji (Section 1.3), which incorporates both traditional and central government rules and practices (Weeks & Jupiter, 2013).

The traditional governance system in Tawake is based on village council meetings where everyone is invited to participate and share their opinion. However, community members feel the need to improve the communication process within the village to involve and disseminate decisions by traditional leaders and information from village meetings to the broader community. This situation is not unique, as Veitayaki et al. (2011) explain: “in many cases [in Fiji], not everyone in the village is aware of what is going on, with resource management decisions made by a small group including the chief.” The fact that decisions are made by a small group of individuals representing community and landowner groups (*mataqali*) may hinder community involvement, as the involvement of a wider group depends on how well the message and decision are disseminated within the community (Veitayaki et al., 2011). A high-quality knowledge co-production process to support sustainable management initiatives allows for continuous learning among actors, active engagement and frequent interactions, which self-reinforce the knowledge co-production process (Norström et al., 2020). Strengthening systematic and inclusive dialogue within the community, particularly with traditional leaders, would help build trust among its members. This would support traditional leadership and decision-making, as the implementation of decisions often depends on how leaders communicate issues and decisions, and how much the community trusts their leaders (Dutra et al, 2015a).

The fact that women identified their gender as the primary constraint to their involvement in mangrove management might suggest that their exclusion is involuntary and not a will, but more evidence would be needed to conclude on this point. According to Veitayaki et al (2011), meetings [in Fiji] are held primarily for men, who normally inform their wives; but even if women were to or wanted to attend, meetings are often held at times when women are busy preparing a meal and looking after the children. The perception of women respondents about being heard by traditional leaders improved significantly between the pilot and final surveys which were conducted two years part (2020 and 2022). We can only speculate about the reasons, but the unprecedented challenges associated with COVID-19 restrictions and impacts on the community may have encouraged traditional leaders to discuss and listen more to community members in order to decide on village issues.

The perception of respondents that they do not know enough does not seem to refer to anything in particular, i.e., it is not specified what kind of knowledge the respondents would like to acquire. The fact that respondents frequently considered that knowledge comes from outside their community is also interesting. Community members experience the environment (e.g., farming, fishing) and observe changes learning from their experiences. Hence, they certainly have valuable information and knowledge to share within the community and with their leaders and other stakeholders. Respondents seem to undervalue this knowledge, as they did not identify sharing their knowledge with each other as

a potent way of gaining knowledge. However, this perceived lack of knowledge is coupled with a desire to learn more, which is positive for further action. Indeed, when people have the desire to know more, they tend to seek out more information on a subject, which helps them to see a problem in a new light (Dijksterhuis, 2004) and find better solutions. This attitude therefore promotes informed decisions and supports long-term motivation and commitment (Ryan & Deci, 2000; Wood, 1989).

The perception of respondents about the existence of government policies or traditional rules on mangrove management do not agree. Seven percent of respondents believe that there are no government policies on mangrove use and management, whereas in fact there are, the main ones being the Environment Management Act (2005), the Mangrove Management Plan of Fiji (2013) and the National Ocean Policy (2020). Similarly, 22% of respondents believe that there are no traditional rules for mangroves in Fiji. However, traditional leaders have the power to set local rules for mangrove use, and to restrict (spatially or temporally) access to coastal and marine areas (*tabu*; Vierros et al., 2010). More and more mangrove areas are incorporated into LMMAs, which represent a major opportunity to conserve and protect mangroves in Fiji (Mangrove Management Plan, 2013). However, at the moment, the government provides no legal recognition for LMMAs and has no applicable protected area for mangroves. The Fiji Mangrove Management Plan (2013) argues that rectifying this would be a powerful mechanism for harnessing the huge potential, energy and interest of local communities in mangrove management. With regard to traditional mangrove management, the Vanua decided in the recent years to prohibit mangrove harvesting in the Tawake district, which encompasses the village of Tawake and five other villages. Today, mangrove planting is encouraged in Tawake and this traditional law is enforced at the village level (CSIRO, 2023). We found that this knowledge of existing policies and rules increased significantly between the first and second surveys. It would be interesting to know why. Another question that might be interesting to ask to community members would be: “Do you think there is a need to update or create new policies, regulations and rules on mangroves to facilitate community-based ecosystem management?” This would allow capturing what the community expects from such policies and traditional rules.

4.1.2. Potential risks associated with mangrove restoration

According to the respondents, the priority actions to manage their mangrove refer to mangrove restoration through (re)planting. This result first indicates that mangroves have been damaged or destroyed around Tawake; mangroves in Tawake have been impacted by cyclones that have hit Fiji in recent years (including Winston in 2016, and Yasa and Harold in 2021). It also suggests that community members are aware of the importance of mangroves. This awareness can be related to the work carried out in the 5-10 past years by the NGOs “Transcend Oceania” and “Adventist Development & Relief Agency-Fiji”, which has helped to raise awareness of mangroves in Tawake (CSIRO, 2023). However, respondents feel that they still lack awareness and knowledge about mangrove ecosystem services.

Overall, mangrove restoration is considered by the scientific literature as a cost-effective option that has the potential to contribute both to biodiversity conservation, climate change mitigation and adaptation, as well as sustainable development and livelihoods (IPBES, 2022; Su et al., 2021; Ellison et al., 2020). However, it is important to consider the following aspects when planning some mangrove restoration initiatives. Firstly, restoration should not detract from the need to preserve existing mangrove ecosystems, as natural mangrove ecosystems perform greater ecosystem functions than restored ones (Su et al., 2021). Secondly, mangrove restoration, as commonly practiced around the world (notably through monogeneric stands of *Rhizophora*) is not the solution to mangrove loss (Lovelock & Brown, 2019; Kamali and Hashim, 2011). In fact, large-scale mangrove planting projects have often failed, and small-scale projects may not provide the desired benefits, even if they are led by local communities (Lovelock et al., 2022). These failures are mainly due to short-term initiatives that have been developed in inappropriate or unsuitable locations, with insufficient community support (Lovelock & Brown, 2019). Many mangrove restoration initiatives have taken place on land not owned by anyone and unsuitable for mangrove growth (Lovelock & Brown, 2019). However, restoration can be successful if the causes of degradation or loss are understood and adequately addressed. Mangrove ecosystems can even recover naturally if environmental conditions (e.g., hydrology, elevation and slope, soil and water pH, soil texture, wave energy, nutrient concentration) are appropriate (Kamali & Hashim, 2011).

There are many ways to restore mangroves given the diversity and complexity of factors influencing the success of mangrove restoration (Lovelock et al., 2022). The challenge is to determine where, what and how to restore given the socio-economic and environmental local characteristics (e.g., historically present species, hydrology, land type). The scientific literature provides guidelines to support community-led mangrove restoration projects (e.g., in Lovelock et al., 2022). For instance, Lovelock et al. (2022) advise that small restoration projects at the community level should be aggregated through the establishment of collaborative networks. This aggregation could facilitate knowledge sharing between local communities as well as attractiveness to donors, while also reducing the costs of maintaining key infrastructure (e.g., mangrove nurseries and verification costs for carbon-based projects) through economies of scale (Lovelock et al., 2022). In addition, initiatives in Tawake can draw on those conducted elsewhere in the South Pacific, where, as in Fiji, mangroves are mostly indigenous (Gilman & Ellison, 2007). For example, lessons learned from mangrove restoration projects in American Samoa (in Gilman & Ellison, 2007) could support the development of similar projects in Fiji. The responses to the surveys carried out in this study do not detail where and how restoration should primarily take place around Tawake according to the respondents. Determining which practices are most appropriate for Tawake will involve knowledge co-production with the community and their leaders on both (i) the bio-physical and ecological conditions to determine which species could be planted and where, and (ii) the local socio-economic characteristics and aspirations to enable effective, adaptive, fair and viable mangrove management.

4.2. Current strengths and future opportunities to engage in mangrove management in Tawake

4.2.1. A strong will to participate in mangrove management today and in the future

From our results, we can identify some strengths and opportunities associated with sustainable mangrove management in Tawake. First, a major strength of Tawake is the strong will of its community members to participate in mangrove management today and in the future, i.e., in 5-10 years - which is the average timeframe for gaining local community support for restoration projects (Lovelock & Brown, 2019). This echoes recommendations in the scientific literature on engaging local communities in ecosystem management to improve the chances of delivering positive outcomes for both biodiversity and human populations (IPBES, 2022). Future mangrove initiatives in Tawake should involve collaboration with other stakeholders (e.g., funding partners, government, NGOs), and an understanding of community capacity (human and financial) to implement projects that fulfill community needs and aspirations. The co-development of a set of options to enhance and sustain livelihood opportunities in the future based on the community's aspirations is one of the work step part of the BCE SL Project. This work will be useful to achieve ecologically effective and socially fair mangrove-based actions. In addition, it will be necessary to define meaningful criteria and indicators to determine whether the mangroves have been successfully restored or protected according to local values and aspirations, as recommended by Ellison (2000). For example, for many indigenous communities, marine natural resource management is underpinned by values of communalism linked to the *Vanua* rather than market and capitalism (Yee et al., 2022; Plagányi et al., 2013). Consequently, criteria and indicators of performance need to reflect these values (Yee et al, 2022).

4.2.2. Opportunities in improving communication with leaders

Similarly, the respondents' desire to support and empower traditional leaders while strengthening dialogue with government is consistent with lessons learned from the literature. Vierros et al. (2010) have argued that improving coastal management partly involves strengthening pre-existing traditional resource management systems, while allowing for the incorporation of cooperative management strategies to adapt to circumstances. The success of coastal management partly depends on community members' respect for their leaders (Veitayaki et al., 2011; Vunisea 2002). Successful communication between the community and the government will require regular visits and follow-up activities so that the government is consulted and kept informed of what is being done, what remains to be done, and potential problems (Veitayaki et al., 2011). In fact, the government bears primary responsibility for mangrove management, but is not equipped to undertake any of the « on-the-ground » management requirements, since it does not have a field presence (Mangrove Management Plan, 2013). Improved communication with the government can also empower community management as the government can enforce existing laws to help local communities protect their resources. For instance, if marine and

coastal protected areas are to be successful, the government must recognize their importance and support them through appropriate policies, legislation, plans and strategies (Veitayaki et al., 2011).

4.2.3. Role of bridging organizations

The Fijian government could provide technical expertise but does not have mangrove monitoring capability with its current resources, and thus relies on other agencies to undertake this role (Mangrove Management Plan of Fiji, 2013). Bridging organizations provide a forum for knowledge raising and coordination of tasks that enable cooperation, such as accessing resources, bringing together different actors, building trust, resolving conflict, and networking (Berkes, 2009). The fact that the community considers the role of the local NGO Transcend Oceania as important and valuable suggests that their relationship is constructive and positive and that Transcend Oceania might be well placed to take up the role of a bridging organization. This positive perception holds out the promise of a solid basis for cooperation, which is an asset for future steps of decision-making, implementation and monitoring of actions.

4.3. Limitations and research perspectives

We identify a lack of data as a limitation to our work, regarding (i) the actual involvement of community members in mangrove management and the existing actions that are (and have been) carried out to protect, restore or use mangroves, and (ii) the perception of the responsibilities of the respective stakeholders in mangrove management. This prevents us from making a clear interpretation of the responses obtained, as we cannot (i) fully appreciate the difference between the current situation and the desired one, and (ii) distinguish between voluntary aspirations and expected responsibilities. The inclusion of additional questions in survey questionnaires to understand what is currently being done, and how community members perceive their roles and those of their leaders and other organizations (e.g., NGOs, research institutions) could have helped to reduce these gaps. In particular, it would be useful to ask how community members see their role and contribution to the village meetings. Another interesting line of enquiry would be to understand the reasons why those who are not involved in mangrove management do not participate. This would be useful to understand whether this lack of engagement is a voluntary choice or not, for example to understand why a larger proportion of women than men do not wish to be more involved and do not see themselves involved in the long term. In addition, I did not have the opportunity to experience the culture and issues on the ground due to travel restrictions in 2020. This can involve bias in interpreting some results.

5. Conclusion

This study, based on field surveys, provides an insight into the perception of a coastal community's involvement in mangrove management and their aspirations for the future. In particular, it reveals a strong desire among respondents to preserve and improve mangrove ecosystems and their ecosystem services, in collaboration with political leaders and local organizations. Our results also highlight potential risks and challenges as well as opportunities for sustainable mangrove management in Tawake. On the one hand, the main constraints to community members' involvement in mangrove management are related to a perceived lack of knowledge and poor communication with their political leaders. Age and gender are the other two main constraints to participation in mangrove management, which could be overcome by including more youth people and women in decision-making processes. In addition, mangrove restoration, which is considered the priority action by the respondents, needs to be implemented carefully to minimize the risks associated with local bio-physical, ecological and socio-economic conditions. On the other hand, our results highlight some strengths and opportunities for a sound and effective mangrove management. These are mainly related to the strong willingness of community members to participate in mangrove management, their awareness of the importance of mangroves for their livelihoods, and their interest in collaborating with other stakeholders (political leaders and bridging organisations) in order to improve knowledge dissemination and ownership, and to access human and financial resources. The issues encountered in Tawake appear to be common problems throughout Fiji, and Tawake is very representative of the other villages of Fiji, both in terms of socio-ecological and geographical characteristics (Johnson et al., 2020b; Dutra et al., 2015a; Veitayaki et al., 2011). These results may therefore suggest that the local constraints and opportunities for mangrove management that we have identified could also apply to other villages in Fiji.

Although this study provides interesting elements on how the community perceives its involvement in mangrove management and how it perceives barriers and opportunities, more data would be needed to complete our results. In light of the constraints revealed in this study, it would be useful to acquire data in order to better understand how these constraints could be mitigated and to what extent the opportunities highlighted by respondents are concretely achievable. Gathering more information through additional interviews on the opinions of decision-makers on protection or restoration options and funding opportunities will be necessary to determine with local stakeholders where and how to conduct meaningful mangrove management. Putting these results into perspective with those of other activities carried out under the BCESL project, such as governance mapping and ecosystem service preferences, will help to fill this knowledge gap. A survey targeting the government on its own perception of the roles of the different stakeholders (community, government, traditional leaders, NGOs), management options and current constraints would allow for a comparison of community and government views. In addition to collecting this information, the next step would be to present our survey outcomes to the community and political leaders. This step is planned for the end of April 2023.

It would also be useful to ask for their feedback on the surveys (e.g., on the relevance of the questions, the way the interviews were conducted, what they retained). These perspectives will help to co-construct with the community and other stakeholders desirable ways forward for Tawake.

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General Discussion and conclusion

This thesis focuses on the design of coastal nature-based solutions (NbS) and broader ocean-based climate actions (OBCAs) in the policies of Pacific Small Island Developing States (PSIDS). Coastal NbS and other OBCAs in general are increasingly viewed by science and practice as relevant integrated actions to mitigate climate change and adapt to its effects. Interdisciplinary and collaborative approaches were used to address the following research questions:

- (1) How do PSIDS incorporate coastal NbS into their policies to address climate-biodiversity-ocean issues, according to assessment and management tools that seek to improve the effectiveness of actions (e.g., standards, ecosystem services (ES) assessments, best practices related to policy integration and stakeholder engagement)?
- (2) How relevant are these tools for PSIDS?

In what follows, I will discuss the findings from the PhD research in the context of the research questions.

1. How do PSIDS incorporate coastal NbS into their policies to address climate-biodiversity-ocean issues

1.1. The importance of coastal ecosystems for climate in PSIDS is reflected in their policy documents and in coastal ES assessments

This research indicates that PSIDS increasingly incorporate coastal NbS into policies because of their relative importance to PSIDS. Chapters 1 and 2 show that PSIDS' national policies (i.e., the Nationally Determined Contributions (NDCs) and the policies referenced in NDCs) include coastal ecosystems for climate adaptation and/or mitigation because of the ecosystem services (ES) they provide. This finding strongly suggests that by including coastal NbS into policies, PSIDS are increasingly committed to protect, restore and sustainably manage coastal ecosystems for climate adaptation and mitigation, with additional co-benefits for nature and people. In the broad spectrum of OBCAs, which include both actions based on coastal ecosystems (i.e., coastal NbS) and actions not based on coastal ecosystems (e.g., marine renewable energy, relocation of people, construction of seawalls), coastal NbS feature prominently in the national policies of PSIDS. Chapter 1 (section 3.1.1) shows that the three most considered categories of OBCAs in the current NDCs of PSIDS are (i) ecosystem-based coastal protection for climate adaptation, (ii) ecosystem-based fisheries management for climate adaptation and (iii) the protection/restoration for blue carbon ecosystems for climate mitigation, with co-benefits for adaptation often being recognized. My collaborator and I have demonstrated (Chapter 1, 3.2.5) that the consideration of the co-benefits for adaptation and mitigation, and for nature and people, is more

frequent in revised NDCs than in original NDCs, suggesting that PSIDS are better informed about the wide range of ES from mangroves, coral reefs and seagrasses (Brodie et al., 2020; Selig et al., 2019).

OBCAs (which include both coastal NbS and OBCAs not based on nature) in the NDCs of PSIDS mainly target adaptation, as opposed to mitigation. This result is consistent with Williamson and Gattuso's findings that the protection and restoration of blue carbon ecosystems is highly beneficial for climate adaptation, including coastal protection, food supply and biodiversity conservation (Williamson & Gattuso, 2022). This finding is also interesting because the adaptation component in NDCs is not mandatory; other national policies developed under the UNFCCC, such as National Adaptation Plans, are specifically dedicated to adaptation (Hammil et al., 2017).

The inclusion of coastal ecosystems in NDCs for climate change mitigation purposes has been questioned by the recent literature. Overall, the scientific literature (IPCC, 2022) supports the design of actions to protect blue carbon ecosystems such as mangroves and seagrasses to mitigate climate change, as these ecosystems contribute to store between 200 and 900 million metric tons of CO₂ per year globally (IPCC, 2019). This is equivalent to between 0.5 and 2% of annual human-induced CO₂ emissions (IPCC, 2019). With regard to the restoration of blue carbon ecosystems, uncertainties remain about its effectiveness for climate mitigation, in particular due to uncertainties in the calculation of carbon fluxes (Williamson & Gattuso, 2022). In addition, restoration actions require strict guidelines in order not to damage already highly vulnerable ecosystems (IPCC, 2022).

The results of this thesis also show an evolution over time in the way coastal protection actions are designed. Results reveal an increased preference for coastal NbS over the construction or reinforcement of coastal defense structures such as seawalls. This result echoes the growing scientific recommendations on considering coastal NbS instead of seawalls for protecting coasts in PSIDS, where seawalls have generally failed to address coastal erosion, particularly in small islands and rural areas (Nunn et al., 2021).

Even though the adaptation component with regard to ocean-based actions is prominent in the NDCs of PSIDS, my collaborator and I have found that that mitigation efforts are also gradually increasing (Chapter 1, 3.1.1). In particular, the two OBCA categories whose consideration has increased the most over time in the NDCs of PSIDS are: (i) the decarbonization of the maritime transportation sector, which is directly considered in 50% of revised NDCs as compared to 7% of original ones; and (ii) the relocation of people to safer locations such as higher grounds or other islands (50% as compared to 13%).

Chapter 3 presents the results about the importance of coastal ecosystems to people in PSIDS. Results highlights a wide range of coastal ES in the literature focusing on PSIDS. Food provision, through coastal fisheries, is the most frequently assessed service (representing 27% of the total 292 ES), followed by the opportunities offered by coastal ecosystems in terms of recreation and tourism (Chapter 3, 3.3.3). This feature is not a regional specificity, as the provision of food from coastal ecosystems is also the

most frequently assessed coastal ES at the global scale (Liquete et al., 2013). Moreover, contrary to my expectations, cultural ES were not assessed more frequently in proportion in the PSIDS compared to the rest of the world (in Liquete et al., 2013), despite the heavy reliance of PSIDS on coastal tourism for employment (SPREP, 2020) and the spiritual importance of ocean ecosystems in PSIDS (Movono et al., 2018). Strong disparities have been observed across regions and ecosystems, Melanesia being the most studied region (Chapter 3, 3.2.1) and coral reefs being the most assessed ecosystems (Chapter 3, 3.2.2). These disparities may be related to the fact that coastal ecosystems are more abundant in Melanesia than in Micronesia and Polynesia, and that coral reefs are more abundant than mangroves and seagrasses in PSIDS according to available coverage estimates (Chapter 3, 2.2). Seagrasses have been increasingly assessed over time, which may encourage seagrass conservation in PSIDS where marine conservation has traditionally focused on coral reefs (McKenzie et al., 2021).

The results of Chapter 3 have shown that when the service types “coastal protection” and “moderation of extreme events” are considered together to reflect the importance of coastal ecosystems in protecting coastal areas from climate impacts, this combination accounts for 12% of total number of coastal ES assessments. This finding was expected because there is wide recognition in PSIDS of the role of coastal ecosystems for protecting coasts against erosion and flooding (Laurans et al., 2013). In comparison, climate mitigation from blue carbon ecosystems accounted for 7% of total number of coastal ES assessments. However, when looking at the monetary values, I found that on average, climate regulation was the highest valued type of ES, at 3,629 US\$/ha/year, whereas the average monetary value of coastal protection was much lower, at 370 US\$/ha/year, like food provision (370 US\$/ha/year) (Chapter 3, 3.3.1).

1.2. Positive signals from policy design for wider and more effective implementation of coastal NbS

Through indicator-based analyses, the results of Chapters 1 and 2 showed that in addition to being increasingly included in PSIDS’ policies, coastal NbS have been increasingly described into more detail with information useful for understanding their scope and measuring their effectiveness (e.g., through measurable targets). This greater level of detail improves clarity and transparency in climate action planning, as required by the Paris Agreement, and as recommended in the scientific literature to deliver robust actions (e.g., in Coscieme et al., 2021; Northrop et al., 2020; Hoegh-Guldberg et al., 2019a). Chapter 1 showed that coastal NbS have also been increasingly integrated (i) across different categories of OBCAs (i.e., a given NbS is described to respond to several purposes such as climate mitigation and coastal protection) as well as (ii) across multiple policies focusing on different sectors (environment, climate, and development). More specifically, the analyses of Chapter 1 (in sub-sections 3.2.5 and 3.2.6) have demonstrated that the co-benefits of coastal NbS have been progressively emphasized in policy documents, whether between nature and climate, between nature-based actions and non-nature-based

actions, and between adaptation and mitigation components. Integration in policy design across different policy sectors is reflected by the fact that a given NbS can be found in NDCs and other policy documents that focus on other sectors such as environment in general, or development (we have even found some coastal NbS in policies focusing on specific sub-sectors such as gender). Consistent with the results of Chapter 1 (3.2) on increased NbS precision and integration, the descriptions of coastal NbS in the NDCs of PSIDS have been increasingly aligned with the criteria of the IUCN Global Standard for NbS over time (Chapter 2, 3.2). The results of Chapter 2 further support the findings from Chapter 1 by providing additional detail on the precision and integration dimensions, which are embedded in the criteria of the IUCN Standard that deal with the societal challenges addressed by the NbS, biodiversity net-gain, economic feasibility and policy mainstreaming. Since all these dimensions are considered key to deliver effective environmental management (IPBES, 2022, Coscieme et al., 2021; Northrop et al., 2020), the findings of Chapter 2 suggest that coastal NbS are increasingly designed to effectively assist PSIDS in addressing the challenges of nature loss and degradation, climate change, and sustainable development altogether more generally.

1.3. Despite increased levels of precision and integration of coastal NbS in PSIDS' policies, the successful implementation of coastal NbS is not guaranteed

1.3.1. Challenges in accessing adequate information for the design and adaptive management of coastal NbS

In Chapter 3, I investigated the relevance of using the outcomes of coastal ES assessments to better inform coastal management in PSIDS. The results highlight knowledge gaps and biases that may hamper decision-making in PSIDS by not adequately reflecting the importance of coastal ES to people locally.

A first potential knowledge gap revealed by the analyses relates to the overuse of the benefit transfer method to assess ES. One third of total assessments - particularly those referring to “regulating” services (such as coastal protection, climate regulation, maintenance of life cycle, waste treatment) and “cultural” services - had been assessed by studies’ authors via the benefit transfer method. This echoes the results obtained for the global scale on mangrove ES by Himes-Cornell et al. (2018), who found a trend of less and less original data collection and increasing old value estimates. This important proportion of ES assessed using benefit transfers can be a problem since benefit transfers fail to accurately describe the local importance of services to people (Himes-Cornell et al., 2018). The benefits people derive from a same ecosystem type (e.g., mangrove) change from place to place, depending on local socio-ecological contexts (e.g., uses, health of the ecosystem), and thus cannot be simply extrapolated (Himes-Cornell et al., 2018; Skewes et al., 2016). Chapter 3 further supports the argument that ES are contextually dependent as I found that in general this bias tend to underestimate the importance of all coastal ES, except regarding food provision (Chapter 3, 3.2.2). This is particularly the case for “regulating” services and “cultural” service. For example, climate regulation services provided by blue carbon ecosystems

average of 1,919 US\$/ ha/year in the studies where the authors used benefit transfers, compared to 6,865 US\$/ ha/year for the studies that did not involve benefit transfers.

A second potential bias could be linked to an under-estimation in the literature of (i) the importance of coral reefs in some PSIDS, and (ii) of the water purification services from coastal ecosystems. Firstly, I found few assessments of coral reef services for Papua New Guinea and to a lesser extent in the Solomon Islands (4 and 14 respectively), despite these being countries with the highest human dependence on coral reef services in the Pacific region (Pendleton et al., 2016). Secondly, I found no studies in PSIDS that have assessed the water purification service associated with coastal ecosystems. Yet, it is the second most frequently assessed type of regulating service of coastal ecosystems globally (Liquete et al., 2013), and the water quality of lagoons in PSIDS is considered low (SPREP, 2020). These biases further hamper the ability of policy-makers to access reliable data on alternative management options - such as their relative benefits and costs – in order to prioritize actions. Yet, prioritizing action has been identified in the literature as one of the greatest challenges for environmental management in PSIDS (Nurse-Bray et al., 2013; Campbell & Barnett, 2010).

In Chapter 4, the most important barrier identified by community members to their involvement in mangrove management was their perceived lack of knowledge, followed by age, unsatisfactory communication with political leaders, and gender (one third of women identified their gender as the greatest constraint to their involvement in mangrove management). The survey responses also revealed that community members generally consider that knowledge comes from outside their community, particularly from their government, which they consider responsible for providing information about mangroves. This is interesting because community members have tacit, practical and traditional knowledge about ecosystems, based on their direct experience with their environment (e.g., through fishing) and observation of changes over time (Vince et al., 2017). As a result, community members certainly have valuable information and knowledge to share within the community and with their leaders and other stakeholders. This perceived lack of local knowledge and unsatisfactory communication with their leaders can be problematic as it can affect the community's trust in their leaders and reduce knowledge generation and information sharing. Ultimately, this can undermine the willingness of community members to actively participate in mangrove management in a collaborative and effective manner.

1.3.2. Challenges in financing, delivering equitable social benefits, and monitoring NbS based on their description in NDCs

Despite the increased incorporation over time of greater information on quantitative objectives in particular, coastal NbS in the NDCs of PSIDS and associated policies still contain very few information on timeframes and costs of implementation (Chapter 1, 3.2.3). Dates by which targets should be met and implementation timeframes were often found in NDCs but not at the action scale. They generally apply

at the level of aggregated actions comprising OBCAs and other non-OBCA actions, without specifying dates or timeframes for an individual OBCA. It is therefore difficult to know if there is a long-term vision on OBCA implementation planning by analyzing NDCs. This relates to the findings of Scobie et al. (2016) who, in their review of climate policies in the Caribbean SIDS, demonstrated that policies do not adequately address timelines nor sources of finance. Based on a semi-quantitative approach, the analysis in Chapter 2 supports this finding, showing poor alignment of NbS regarding indicators on economic feasibility. Indeed, most PSIDS' NDCs explicitly mention the need to foster climate finance but they rarely identify potential finance channels that could be used for the implementation of OBCAs. In addition, the feasibility and sufficiency of the budget are not described. To sum up, PSIDS' national policies do not clearly state when nor with which resources coastal NbS included in NDCs will be implemented and how their effectiveness would be monitored (Chapter 1 and Chapter 2). This can be a problem since PSIDS made their need for external financial, capacity-building or technical support explicit as a prerequisite to achieve their NDC targets (Crumpler & Bernoux, 2020). In addition, being able to attract donors for NbS funding requires a thorough understanding about the costs involved, setting clear and measurable targets and establishing effective monitoring system that can track the effectiveness of their implementation (Swann et al., 2021; IUCN, 2020).

Chapter 2 also explores additional characteristics of NbS that were not examined in Chapter 1. These include their design at scale (to recognize the complexity and uncertainty that occur in living seascapes), inclusive governance, trade-off balance (to acknowledge and equitably manage the conflicting stakeholder values and interests) and adaptive management (IUCN, 2020). These dimensions are considered essential to improve environmental decision-making and management (IPBES, 2022; IPCC, 2022). In particular, the participation of local stakeholders in environmental management can improve the effectiveness of NbS by recognizing the often divergent interests, needs and aspirations of different stakeholders, and thus reduce the risk of conflict and maladaptation (IPBES, 2022). Enhanced participation of local stakeholders in NbS management can also improve the monitoring of NbS as local communities are well placed to experience the environmental changes induced by the NbS. However, coastal NbS in PSIDS' NDCs are generally inadequately aligned with the IUCN Global Standard for NbS regarding these dimensions (Chapter 2, 3.1). Monitoring systems for tracking the effectiveness of coastal NbS are generally lacking in PSIDS' NDCs. As my collaborators and I have argued (Chapter 2, 4.2), this lack of information is likely to impede the global stocktake mandated by the Paris Agreement to assess the progress of global climate action in 2023. Chapter 2 therefore complements the findings of Chapter 1 by showing that, despite a growing use of quantitative NbS objectives in PSIDS' NDCs (Chapter 1), the information provided is unlikely to be sufficient to effectively monitor progress on climate action, both locally (the NbS scale) and at the national and global levels.

2. Pathways to reduce challenges associated with coastal NbS design, funding and monitoring

2.1. Ways to increase the ambition of NDCs to make climate needs and actions more visible

Through an analysis of NDCs and associated policies in Chapter 1, my collaborator and I have found areas where NDCs could contain more ambitious OBCAs, based on what is included in the policies they refer to. We have demonstrated that NDCs do not always reflect the national climate ambition of the countries in terms of coastal NbS (Chapter 1, 4.3). In other words, policies referenced in NDCs sometimes contain either additional coastal NbS, or NbS that are updated (i.e., with highest associated targets). For instance, the revised NDC of Samoa (published in July 2021) does not explicitly include OBCAs for climate mitigation. However, it mentions Samoa's National Ocean Policy (published in 2020), which includes actions with quantitative targets directly related to (a) mangrove forest protection and restoration for climate change adaptation and mitigation benefits for coastal communities; and to (b) the reduction of marine pollution and carbon emissions levels from ships and ports. Overall, we have found the highest gap between NDCs and other policies for the two following OBCA categories: (i) the protection/restoration of blue carbon ecosystems for climate mitigation, and (ii) infrastructure-based actions to protect coastlines from climate impacts. Including OBCAs in NDCs in a more explicit manner could help PSIDS make climate action more visible and increase policy integration, in a context where the majority of PSIDS' NDCs promote policy mainstreaming and coherence (Crumpler & Bernoux, 2020). Thus, Chapter 1 highlights specific areas (i.e., blue carbon protection and infrastructure-based coastal protection) where actions could be more integrated between NDCs and the policies they mention.

2.2. Increased opportunities of cross-cutting climate-biodiversity funding for NbS

In PSIDS, the limited financial resources to implement climate actions is a pressing challenge (IPCC, 2022; Campbell & Barnett, 2010). In Chapter 2, my collaborators and I have stressed that standardizing the description of NbS in NDCs based on the IUCN Global Standard for NbS could support PSIDS in accessing funding for implementing coastal NbS included in NDCs (Chapter 2, 4.1). We have argued that funding accessibility could be increased by providing information on economic feasibility and on how societal challenges like climate change and biodiversity net gains will be concretely addressed by the NbS. This echoes our analysis of the Global Environmental Facility (GEF) funding trends between 2018 and 2022 (Chapter 2, Supplementary Material Appendix 2.D) that showed that GEF funding for cross-cutting biodiversity-climate projects in PSIDS have gradually increased while funding for projects to support climate or biodiversity issues alone have decreased. In addition, the recently launched IUCN funds "Blue Natural Capital Financing Facility" and "IUCN Global Facility for NbS" are based on the evaluation of project against the IUCN Global Standard for NbS.

2.3. ES assessment practices that could contribute to improving access to more accurate and up-to-date information for coastal management

The analyses of Chapter 3 have allowed identifying ways of gaining a more comprehensive and accurate understanding of coastal ES to people locally. These are:

- 1) Taking into account a larger number of indicators, including non-monetary ones, both when conducting ES assessments and literature reviews on ES assessments.
- 2) Taking into account grey literature (reports) when conducting literature reviews in addition to peer-reviewed studies, as they provide useful complementary information, especially with regard to policy recommendations.

Chapter 3 (3.3) showed that participatory and ranking methods involving quantitative non-monetary indicators seem to be more likely to highlight the importance of cultural services in PSIDS than monetary and non-participatory methods. More specifically, cultural ES were systematically (except in one case) valued lower than “provisioning” and “maintenance and regulating” services when monetary methods were used, while they were more often rated higher than “provisioning” and “regulating” services in terms of importance when ranking and participatory methods were used. Therefore, methods that used non-monetary quantitative indicators to assess coastal ES appeared to allow the identification of a wider range of local ES, as well as the assessment of their relative importance from multiple perspectives. Ruckelshaus et al. (2015) identified that policy-makers tend to prefer to use a variety of measures of the value of ES as well as tangible information (such as the number of households at risk or the proportion of people dependent on a given ecosystem for their livelihoods). Indeed, such information is often easier to use for policy-makers than economic values alone (Ruckelshaus et al., 2015). These results therefore supports the need identified in the literature (see in Armatas et al., 2018; Pike et al., 2015 and De Groot et al., 2010) to develop and use more non-monetary indicators to assess coastal ES in order to understand with better accuracy how local stakeholders value coastal ES, in particular cultural ones, and adequately inform policy-making. Furthermore, even though the literature review of Chapter 3 allowed the identification of a large number of studies assessing ES in non-monetary units, I am not aware of any literature review on coastal ES that have actually considered these non-monetary ES. This could suggest a bias in the literature regarding the assessment of coastal ES.

To fill in this gap, I recommend that future literature reviews on coastal ES in PSIDS consider both qualitative ES assessments and quantitative non-monetary assessments to provide more comprehensive and accurate descriptions of coastal ES. This practice will most likely make cultural ES more visible to researchers conducting literature reviews, and, ultimately, to policy-makers. It will help to address the need highlighted by the IPBES (2022) to recognize the diversity of human-nature connections, which are not only based on economic rationality (i.e., the ecosystems are valued for the services they provide to human society), but also on a desire to live in harmony with “non-human” life and/or to recognize an

intrinsic value of ecosystems and species with a right to thrive. This idea that nature has the right to exist, thrive and evolve independently of human needs is known as the concept of “nature’s rights”, which advocates for legal recognition of the intrinsic value of ecosystems and species. Although relatively new in the western policy arena, this idea that nature has rights and should be respected is reflected in long-held beliefs in some indigenous communities around the world, including in the South Pacific (Movono et al., 2018). Recognition of nature’s rights can help promote sustainable and equitable conservation practices (Harden-Davies et al., 2020; Borràs, 2016; Berry, 2011; Cullinan, 2003).

The results of Chapter 3 also revealed that reports and peer-reviewed studies are complementary, containing different types of potentially very useful information on coastal ES in PSIDS. While reports are more focused on monetary valuations (77% of coastal ES in the reports are expressed in monetary units compared to 47% in the peer-reviewed studies), on average they also contain more policy recommendations (84% of the reports include policy recommendations, compared to 42% of the peer-reviewed studies).

In addition, the review of coastal ES has highlighted a growing interest in assessing the services from seagrasses (3.2.2). Disseminating the results of seagrass ES assessments in policy could encourage seagrass conservation in PSIDS, where marine conservation has mainly focused on coral reefs (McKenzie et al., 2021b). This better consideration of seagrasses into policies, which is observed through the analyses of NDCs as part of this thesis work (Chapter 1), is important to enhance the positive outcomes of protection or restoration actions. Indeed, Guannel et al (2016) have shown that the joint management of coral reefs, mangroves and seagrasses (i.e., by taking into account their interactions), helps to support the health, safety and well-being of coastal human populations. This holistic ecosystem approach allows enhancing the resilience of coastal ecosystems, which protect each other, and thus maintain or even increase the services they provide to human populations (Guannel et al., 2016).

2.4. Opportunities for improving the monitoring of coastal NbS

The IUCN Global Standard for NbS stresses the critical importance of regular monitoring throughout the lifetime of the intervention to ensure that the NbS delivers the intended benefits and to prevent unintended adverse consequences. As such, a monitoring and evaluation plan is one of the key components of adaptive management that could be used to adequately respond to external factors influencing NbS (IUCN, 2020). At the global scale, my collaborators and I have identified that using the IUCN Global Standard for NbS as a basis for describing NbS in NDCs could inform the global stocktake expected to be carried out in 2023 through a facilitated aggregation and comparison of the countries’ NDC contents (Chapter 2, 4.2). Indeed, the Standard contains indicators that capture many of the elements that should be reported in the NDCs to achieve the global stocktake⁵⁶ (Chapter 2, 4.2).

⁵⁶ In 2018, the sources of inputs required for the global stocktake were defined (UNFCCC, 2018, CMA.1). These include: (a) the state of greenhouse gas emissions and removals, (b) the overall effect of countries’ NDCs and

Informing the global stocktake is important to assess where the international community stands with regard to climate actions and to determine in which regions and in which sectors action should be strengthened, considering national circumstances (e.g., the country's GHG emissions, level of development and domestic resources).

For example, in Fiji, it is challenging for the government to monitor the effectiveness of on-the-ground environmental actions, as the government does not have a field presence (Mangrove Management Plan of Fiji, 2013). The collaboration between governments and local actors (e.g., communities) who experience their natural environment is therefore a valuable asset for monitoring, evaluating and analyzing the changes that take place in their environment following the implementation of actions (Vince et al., 2017). A successful local-national collaboration in implementing NbS is however based on good practice principles, including robust communication to gain mutual confidence and knowledge sharing, and the provision of adequate resources (e.g., human, technical (monitoring technics) and financial) (Seddon et al., 2021). Practices that promote good communication between local communities and government include regular visits to the community and follow-up activities. This ensures that the government is consulted and kept informed of what is being done, what remains to be done and potential problems, and can provide the means to resolve them (Veitayaki et al., 2011). The results of Chapter 4 (3.5) corroborate these findings as Tawake community members expressed the need for more regular visits from government representatives to monitor actions, as well as increased training and awareness on the importance of mangroves.

3. Limitations

While this thesis work provides insights into both how coastal NbS are incorporated into the national policy documents of PSIDS, and how certain assessment and management tools can support effective management of these actions, limitations to this work should be acknowledged.

3.1. Limitations to policy document analysis (in Chapter 1 & Chapter 2)

This thesis focuses on the design stage of coastal NbS. This a basic assumption of the research (stated in Chapter 1) as the success of NbS depends on their proper planning, whether by incorporating them in policy documents by following good practices, obtaining accurate and up-to-date information, or involving local stakeholders in their design. However, the policies reviewed (e.g., the NDCs and associated strategies, policies, plans or laws) in Chapters 1 and 2 (i) may not encompass all coastal NbS designed by PSIDS, and (ii) may not give an accurate picture of how the NbS they contain are actually designed. I have identified the following three limitations of the study of policy documents. These are:

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.

First, this dissertation only applies to the subset of NbS that appear in PSIDS' NDCs (Chapter 2) plus policies referenced in NDCs (Chapter 1). However, the NDCs do not necessarily refer to all relevant policies that might contain coastal NbS for climate adaptation and/or mitigation. Indeed, Chapter 1 revealed that the contents of PSIDS' NDCs do not accurately reflect the ambitions of PSIDS regarding coastal NbS. In other words, certain coastal NbS are included in policies referenced in a given NDC but are not directly included in the NDC. Yet, NDCs are required to reflect the country's "*highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances*" under the Paris Agreement (Article 4, paragraph 3). Countries could have omitted (or not updated) relevant actions in NDCs that are included in other policies, or even that are not included in any of the policies we have reviewed. This is for example the case of Palau, which in 2015 created the Palau National Marine Sanctuary, a marine protected area approximately the size of its EEZ, 80% of which being closed to fishing to protect marine biodiversity and living resources. The NDC of Palau, published one year later in 2016, neither explicitly (directly in the NDC) or implicitly (in policies referenced in NDCs) includes this flagship action for biodiversity with co-benefits for climate adaptation and mitigation. If NDCs are not up-to-date and accurate regarding climate actions, other policies may not be as well. As we have not explored the full range of policies in PSIDS (this was a methodological choice because of time constraints, as this range is extremely wide), we cannot accurately appreciate the extent to which our study gives a clear picture of the coastal NbS designed by PSIDS.

Second, policy documents only reflect what countries intend to do, not what they are actually doing or will do. A resulting limitation of our study is that by only analyzing information included in NDCs, it is impossible to conclude on whether or not the implementation of the coastal NbS these policies contain are or will be successful. As long as there is no specific requirements or strong incentives to describe in detail how and when the actions contained in policy documents will be implemented (as it is the case for NDCs), countries remain free to decide on the content of their policy documents and whether or not to implement them. The lack of information about implementation in policy documents may reflect different potential situations, as follows:

- (i) Detailed information on the design of the intervention (targets, timeframes, costs, etc.) is unavailable, i.e., the policy document reflects gaps that exist in reality;
- (ii) the information is available but the policy-makers who have elaborated the policy documents were not aware of it;
- (iii) they are aware of this information but may find it irrelevant or useless to provide it in the policy document.

Finally, climate action is evolving rapidly, both at the regional level as illustrated by the results of Chapters 1 and 2, which showed an evolution of the NDC contents between original and revised NDCs, and globally as illustrated by the IPCC (2022). Therefore, the thesis results are time-dependent as they

only reflect the period under consideration, i.e., approximately 2016-2021, plus policies that are referenced in NDCs and were developed prior the original NDCs. The learnings from this thesis results are nevertheless generalized and expected to have broader application both in space and time.

3.2. Limitations related to the use of indicators (in Chapter 1 & Chapter 2)

Indicators used to inform on coastal NbS characteristics (i.e., in Chapter 1 and Chapter 2) involve a subjective appreciation of the extent to which indicators are met. The attempts to minimize associated potential biases included a variety of approaches: two independent evaluations with final cross-reference and argumentation, definition of a clear assessment scale and process, and final review to ensure that each indicator was evaluated consistently both across all countries and coastal NbS. It is often difficult to appreciate the extent to which some information in a policy document clearly applies to a coastal NbS for example, or to a broader policy goal. Information can be available but is often scattered in policy documents and these often lack clarity on the concrete actions that will be implemented and expected results. While several aspects such as quantitative targets and policy sectors were relatively easy to identify and assess, others were less so. For example, the level of detail on dates or costs was sometimes too low to understand whether the dates or costs refer to the action level. Often, programs or policies are dated or costed but without details about specific actions, making it difficult to assess indicators and accurately qualify coastal NbS.

3.3. Limitations to the interpretation of the results

I also identified limitations related to the interpretation of the thesis results. First, Chapter 3 was intended to provide a complete picture of existing coastal ES assessments in PSIDS. However, the identification of coastal ES assessments may be limited. In particular, I may have missed key references in the grey literature (e.g., reports), as they are more difficult to identify because they are often not referenced in scientific literature databases. In addition, a greater number of studies involving ranking methods would be needed in order to increase the robustness of the result referring to the fact that cultural ES are considered more important when ranking and quantitative non-monetary methods are used than when monetary methods are used.

Second, with regard to Chapter 4 on community engagement in coastal management, one of the main limitation for the interpretation of the results is probably that I did not have the opportunity to experience the culture and issues on the ground in Tawake.

At its beginning (October 2019), this thesis work was designed to be more field-oriented. With my supervisors, I had planned to conduct survey interviews targeting PSIDS' government representatives to collect their views (needs, aspirations, concerns, constraints) around NbS design, implementation and monitoring. It was also intended that I would develop and test a methodology to assess coastal ES in specific locations in PSIDS. These field studies have not been conducted due to travel constraints in the

context of the Covid-19 pandemic. With my supervision team, we made adjustments in spring 2020 in the planning of the thesis to accommodate the conditions imposed by travel restrictions. We decided that the thesis would focus more on desktop research based on existing ES literature (Chapter 3) and policy documents (Chapters 1 and 2) rather than on fieldwork. Chapter 4 is slightly different in its approach as I had the opportunity to collect new field data at the local level by collaborating with a local NGO and CSIRO.

4. Research perspectives

This thesis identifies areas where further research would be valuable to complement the PhD findings and address the limitations described above. Further research would notably imply field works in PSIDS in order to better understand the perspectives of PSIDS government representatives on various aspects.

4.1. Investigating funding opportunities for coastal NbS

In future research, it could be particularly useful to further investigate the funding dimensions of coastal NbS for climate adaptation and mitigation. The Paris Agreement, through Article 2.1, gives an impetus to considering co-benefits, aiming to “*make finance flows consistent with a pathway towards low GHG emissions and climate-resilient development*”. Despite this, the integration of mitigation and adaptation aspects in projects is not always economically profitable for private investors (Zamarioli et al., 2021). Understanding the extent to which describing in NDCs the intended the co-benefits of coastal NbS is likely to attract private investors would therefore be useful in advising the future design of NbS in NDCs.

4.2. Investigating the development of locally-adapted tools to enhance the effectiveness of coastal NbS

Regarding the use of global standards to guide the design of robust NbS, Chapter 2 identified the necessity to understand the conditions for the applicability of such standards in PSIDS. Further research could examine the potential trade-offs between more standardization and less flexibility in PSIDS to customize coastal management approaches, at the country level. This would help inform how standards could be adapted to better fit local contexts. This data collection could be done through surveys and interviews to collect the views from government representatives in PSIDS on the benefits and barriers they identify regarding the use of standards for both (i) NbS reporting in NDCs (i.e., how NbS should be described into NDCs) and (ii) the NbS design more generally. This research could support the development of locally-adapted tools to enhance the effectiveness of NbS, through an identification of the specific and operational barriers faced by PSIDS to develop effective NbS.

4.3. Enhancing knowledge and consensus on the respective roles and responsibilities of stakeholders in coastal management

At a more local scale, gathering the views of PSIDS' government representatives would be useful to complement the results of Chapter 4 on stakeholder engagement in mangrove management. Chapter 4 focused on how the community members of a Fijian coastal village perceive their involvement in mangrove management. Complementary interviews with government representatives could allow gathering their views on: (i) their own involvement in mangrove management; (ii) their perception of their own roles and responsibilities and those of other stakeholders (e.g., communities, NGOs, researchers, traditional leaders); and (iii) perceived constraints and opportunities for effective mangrove management. This would allow for a comparison of the expectations of one group versus the other regarding which management actions should be prioritized, by whom and how (resources, modes of collaboration, management planning).

In addition to collecting this information, a next step will be to present the survey results to the community and political leaders concerned. Planned for spring 2023, this step will ensure transparency but also allow discussions around the results of the survey, which could lead to further knowledge sharing and production. In addition, it would be interesting to ask the community and its political leaders to take different roles so they could appreciate the challenges in each role (Dray et al., 2006). This could be done via a role-playing game exercise in which community leaders play the role of government representatives and vice versa; or through semi-structured interviews with government representatives. Moreover, it could be interesting to collect additional information to refine the interpretation of the survey results. For example, an outstanding question is whether non-participation in mangrove management is a voluntary choice or a non-choice imposed by constraints. This question refers particularly to the situation of women and young respondents (30 years and under), who felt on average less involved and less committed to long-term management than men and older respondents. Refining the survey questionnaires to better address these insights and applying the refined survey to other locations in PSIDS could also be a valuable step forward.

The question of who is responsible for managing coastal ecosystems in PSIDS has also been identified as critical from the results of Chapter 3 (4.5) on ES assessments. Coastal ecosystems can provide contributions to people both locally (e.g., through coastal protection) and globally (e.g., by contributing to the maintenance of global biodiversity and the mitigation of climate change). The analysis of the authorship of the 57 studies in Chapter 3 (3.5) showed that the interest for assessing coastal ES in PSIDS goes beyond the PSIDS' boundaries. Approximately half of authors were from outside PSIDS (mainly from the European Union, Australia and the United States of America). This interest may be explained by the fact that the South Pacific could become the main reservoir of coral species on the planet, because the erosion of reef biodiversity is less severe in the Pacific Islands than in the Indian Ocean or the Caribbean (Hilmi et al., 2014). The decisions taken in PSIDS can affect the delivery of distant ES, and

reversely (Seppelt et al., 2011), a phenomenon called “off-site effects”. For Hilmi et al. (2014), this gives Pacific people an increased responsibility on a global scale for future generations. However, coastal ecosystems in PSIDS are also affected by global pressures (e.g., climate change impacts related to ocean acidification, deoxygenation, warming, and extreme events), for which PSIDS are not responsible (IPCC, 2022).

Furthermore, NbS will only provide long-term benefits if ecosystems are healthy and can adapt to changes (Macreadie et al., 2019). This may not be the case as illustrated by the IPCC (2019) projection of 20 - 90% of current coastal wetlands to be lost by 2100 (and potential 99% loss of warm water corals by 2100). Therefore, as Anderson et al. (2019), Hoegh-Guldberg et al. (2019) and Seddon et al. (2020) have argued, the growing implementation of NbS should not distract the international community’s attention from the urgent reduction of global GHG emissions. This question of how the international community should support PSIDS is crucial (to provide adequate resources that best match local values and aspirations), yet it received little emphasis in the reviewed studies in Chapter 3. The studies that incorporated policy recommendations to improve coastal ecosystem management were mainly addressed to PSIDS’ governments and, to a lesser extent, to local communities (Chapter 3, 3.6). None of the recommendations were directed at stakeholders beyond PSIDS, despite the fact that other countries outside PSIDS have a responsibility for the degradation of PSIDS’ coastal ecosystems (IPCC, 2022). A future step could be to investigate the extent to which PSIDS’ governments and institutions are aware of, agree with, and take into account the recommendations contained in the literature I have reviewed, and if not, for which reasons.

4.4. Addressing the gaps in research highlighted by the results

Chapter 3 has identified research gaps regarding coral reefs services in Papua New Guinea and certain types of coastal ES that have rarely been assessed in PSIDS, such as water purification services. Additional assessments to fill these gaps would help to better understand the links between coastal ecosystems and people under a rapid changing world, and identify priority places where ecosystems need to be protected or restored given their importance for people. As recommended by O’Leary et al. (2022), this additional research would benefit from interdisciplinary and transdisciplinary approaches to provide additional evidence to identify where coastal ecosystems are most likely to thrive or recover, based on their specific exposure, vulnerability and adaptive capacity.

Another research perspective could be to assess the ES associated with the coastal NbS included in NDCs. For Gupta et al. (2021), evaluating the ES in NbS would give confidence to climate strategists, investors and buyers for market and non-market approaches. This could leverage NbS integration into the Paris Agreement’s market and non-market mechanisms, such as REDD+. Assessing the ES associated with coastal NbS would require the development of indicators considering the local conditions, the type of ecosystem and its assets (Gupta et al., 2021). The development of adequate

indicators is a major concern in the literature to assess the effectiveness of NbS in meaningful terms, and is reflected in the findings of Chapter 2. Chapter 2 (3.2) showed that monitoring and adaptive management aspects of coastal NbS for climate adaptation and/or mitigation have only been marginally taken into account in the national policies of PSIDS so far. Furthermore, the results of Chapter 3 revealed a wide variety of coastal ES in PSIDS, suggesting that a wide range of indicators targeting many aspects (for instance related to fisheries, carbon sequestration, but also spiritual aspects) would be needed to comprehensively reflect the variety of ES associated with coastal NbS. This information could help to reduce knowledge gaps on NbS risks and uncertainty (Riisager-Simonsen et al., 2022).

4.5. Moving beyond NbS design

Finally, it could be valuable to go beyond NbS design and understand how the coastal NbS included in PSIDS' NDCs are and will be concretely implemented, and assess if they provide the intended results. Again, visits to PSIDS and interviews with policy-makers, NGOs, international donors and regional organizations and other relevant stakeholders could be applied to better understand the implementation of coastal NbS in PSIDS. Semi-structured interviews with PSIDS' government representatives could help to understand how PSIDS' governments concretely envision the development of coastal NbS, in terms of funding and collaborations with external institutions and with local communities. Furthermore, our study focused only on one aspect of policy integration (the integration in policy design, but not in implementation). It could therefore be valuable to analyze the extent to which there is an institutional structure in each PSIDS that can effectively support the integration of coastal NbS across different governmental scales (national – provincial – local) and enable effective implementation of coastal NbS more generally. To quote the UNEP Adaptation gap report (2022), *“the ultimate test of the adequacy and effectiveness of adaptation planning will be whether these plans are implemented and, in turn, whether this implementation reduces risk and vulnerability and bolsters resilience and adaptive capacity”*. This additional research would allow to better assess the “implementation gap” of coastal NbS (i.e., the gap between words/discourse and concrete action). This would help to set ambitious but realistic targets for coastal NbS, and to explore how new socially just and environmentally desirable incentives can create opportunities for nature conservation and for improving the safety, health and well-being of human populations.

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Appendices - Supplementary Material

Appendix 1.A: Categorization of policies

Table 1.A: Categorization of the policies (only those containing ocean-based climate actions) referenced in the Nationally Determined Contributions of the Pacific Small Island Developing States according to the sector or sub-sector they most relate. In italics, policies that only include mentions of ocean-climate impacts but not ocean-based climate actions.

	Policy name	Referenced in	Climate change (CC)		CC - Environment		Environment			CC - Development	(Sustainable) Development	
			CC general	Energy/Transport	N/A	Environment general	Biodiversity	Agriculture	Forestry	Ocean	N/A	Development general
Cook Islands	<i>Te Kaveinga Nui' (Pathway for Sustainable Development in the Cook Islands): Living the Cook Islands Vision: A 2020 Challenge: National Sustainable Development Plan (2007)</i>	Original NDC										
	Joint National Action Plan for Disaster Risk Management and Climate Change Adaptation 2011-2015 (2012)		X									
	Te Kaveinga Nui: National Sustainable Development Plan 2016-2020 (2016)										X	
Fiji	National Climate Change Policy (2012)	Original NDC	X									
	National Energy Policy (2013)			X								
	Draft Energy Strategic Action Plan (2013)			X								
	Green Growth Framework (2014)										X	
	National Development Plan (2017)									X		
	Fiji Low Emission Development Strategy 2018-2050 (2018)	Revised NDC									X	
	National Climate Change Policy 2018-2030 (2018)		X									
	National Ocean Policy (2020)								X			
	National Adaptation Plan (2018)		X									
Kiribati	National Adaptation Programme of Action (NAPA) (2007)	Original NDC	X									
	Kiribati National Energy Policy (2009)			X								
	Kiribati Development Plan 2012-2015 (2012)										X	
	National Framework for Climate Change Adaptation (2013)		X									
	Kiribati Integrated Environment Policy (2013)					X						
	Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management 2014-2023 (2014)		X									

	Policy name	Referenced in	Climate change (CC)		CC - Environment	Environment				CC - Development	(Sustainable) Development	
			CC general	Energy/Transport		N/A	Environment general	Biodiversity	Agriculture		Forestry	Ocean
Marshall Islands	National Climate Change Policy (2011)	Original NDC	X									
	Joint National Action Plan for Climate Change Adaptation (2014-2018) (2014)		X									
	2016 Energy plans (2016)			X								
	Title Til Eo 2050 Climate Strategy: Lighting the way (2018)	Revised NDC 2018	X									
	Adaptation Communication to the UNFCCC (2020)		X									
	Title Til Eo 2050 Climate Strategy: Lighting the way (2018)	Revised NDC 2020	X									
	RMI Electricity Roadmap (2018)			X								
Micronesia	National Energy Policy (1999)	Original NDC		X								
	Yap Joint state action plan for disaster risk management and climate change (2016)		X									
Nauru	<i>National Sustainable Development Strategy 2005-2025 (2005, revised in 2009)</i>	Original NDC										
	Republic of Nauru Framework for Climate Change Adaptation and Risk Reduction: "Climate Change: Building our Resilience" (RONAdapt) (2015)		X									
	Republic of Nauru Environmental Management and Climate Change Act (2020)			X								
	<i>Coastal Fisheries and Aquaculture Act (2020)</i>	Revised NDC										
	Republic of Nauru Environmental Management and Climate Change Act (2020)			X								
	<i>Coastal Fisheries and Aquaculture Act (2020)</i>											
Niue	National Energy Policy (2005)	Original NDC		X								
	Niue's Joint National Action Plan for Disaster Risk Management and Climate Change (2012)		X									

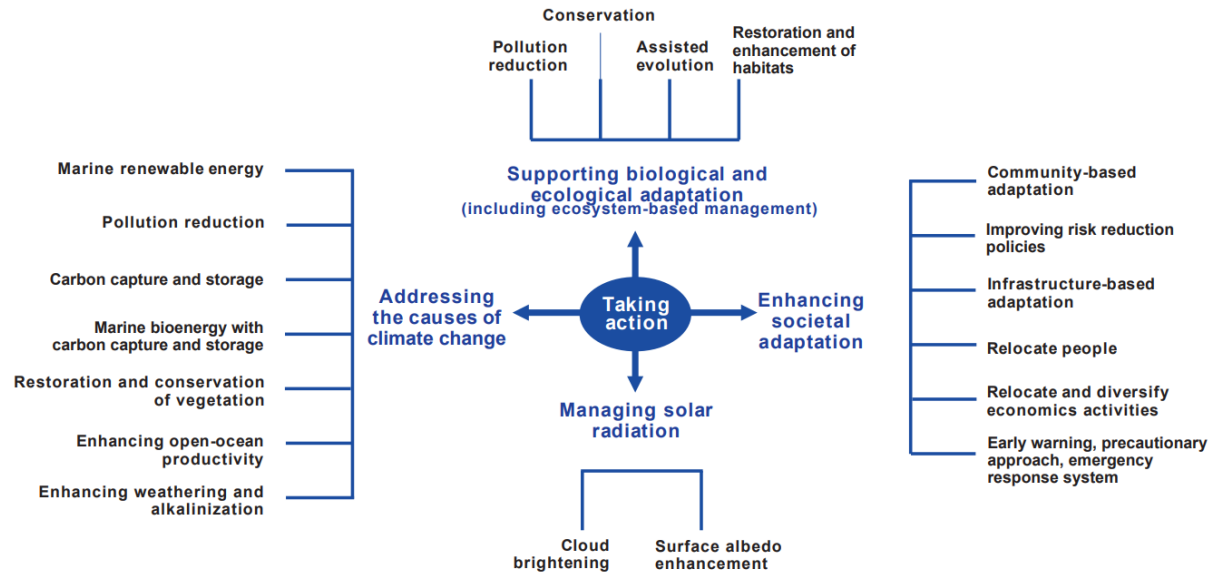
	Policy name	Referenced in	Climate change (CC)		CC - Environment	Environment				CC - Development	(Sustainable) Development	
			CC general	Energy/Transport		N/A	Environment general	Biodiversity	Agriculture		Forestry	Ocean
Palau	Palau Climate Change Policy (2015)	Original NDC	X									
Papua New Guinea	Papua New Guinea Vision 2050 (2009)	Original NDC									X	
	Second National Communication to the UNFCCC (2014)		X									
	National Climate Compatible Development Management Policy (2014)										X	
	Climate Management Act (2015)		X									
	First National Communication to the UNFCCC (2000)	Revised NDC	X									
	National Strategy for the Responsible Sustainable Development for PNG (2014)										X	
	Second National Communication to the UNFCCC (2014)		X									
	Medium Term Development Plan III 2018-2022 (2018)										X	
	Climate Change and Development Authority Corporate Plan 2018-2022 (2018)									X		
	National Transport Strategy (2020)			X								
	Papua New Guinea's Sustainable Development Goal 13 Roadmap: An Empowering Response to Challenges and Opportunities Posed by Climate Change: 30 Actions by 2030 (2020)									X		
Samoa	National Adaptation Programme of Action (NAPA) (2005)	Original NDC	X									
	National Policy on Combating Climate change (2007)		X									
	Samoa Energy Sector Plan 2012-2016 (2012)			X								
	Strategy for the development of Samoa (SDS) 2016/17-2019/20: 'Accelerating Sustainable Development and Broadening Opportunities for All' (2016)										X	

	Policy name	Referenced in	Climate change (CC)		CC - Environment	Environment				CC - Development	(Sustainable) Development			
			CC general	Energy/Transport	N/A	Environment general	Biodiversity	Agriculture	Forestry	Ocean	N/A	Development general	Gender/Community	
Samoa	National Adaptation Programme of Action (NAPA) (2005)	Revised NDC	X											
	Second National Communication to the UNFCCC (2009)		X											
	Transport Sector NAMA 2013-2018 (2013)			X										
	<i>Samoa Tourism Sector Plan 2014-2019 (2014)</i>													
	Agriculture Sector Plan 2016-2020 (2016)							X						
	Strategy for the development of Samoa (SDS) 2016/17-2019/20: 'Accelerating Sustainable Development and Broadening Opportunities for All' (2016)											X		
	Energy Sector Plan 2017-2022 (2017)			X										
	Community Integrated Management Plans, Aleipata Itupa I Labo-Upolu (2018)												X	
	Samoa Ocean Strategy 2020-2030 (2020)									X				
	National Policy on Gender Equality and rights of Women and Girls 2021-2031 (2021)													X
Solomon Islands	National Adaptation Programme of Action (NAPA) (2008)	Original NDC	X											
	<i>National Development Strategy 2011 to 2020 (2011)</i>													
	National Climate Change Policy 2012-2017 (2012)		X											
	National Adaptation Programme of Action (NAPA) (2008)	Revised NDC	X											
	<i>National Development Strategy 2011 to 2020 (2011)</i>													
	National Climate Change Policy 2012-2017 (2012)		X											
	National Development Strategy 2016-2035 (2016)											X		
	The National Biodiversity Strategic Action Plan 2016-2020: Building a unified, vibrant and informed Solomon Islands (2016)						X							
REDD+, readiness proposal (2019)							X							

	Policy name	Referenced in	Climate change (CC)		CC - Environment	Environment				CC - Development	(Sustainable) Development	
			CC general	Energy/Transport		N/A	Environment general	Biodiversity	Agriculture		Forestry	Ocean
Timor-Leste	National Adaptation Programme of Action (2010)	Original NDC	X									
	<i>Strategic development plan 2011-2030 (2011)</i>											
	Biodiversity Decree (2012)					X						
Tonga	National Biodiversity Strategy and Action Plan (NBSAP) (2006)	Original NDC				X						
	National Forest Policy (2009)						X					
	Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management 2010-2015 (2010)		X									
	Tonga Strategic Development Framework 2015-2025 (2015)										X	
	Tonga Agriculture sector plan 2016-2020 (2016)											
	Climate Change Policy: A resilient Tonga by 2035 (2016)		X									
	Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management (2018-2028) (2018)		X									
	National Forest Policy (2009)							X				
	<i>Tonga Strategic Development Framework 2015-2025 (2015)</i>											
	Tonga Agriculture sector plan, 2016-2020 (2016)							X				
Management Plan for the Forests & Tree resources of Tonga (2017)							X					
Joint National Action Plan for Climate Change Adaptation and Disaster Risk Management (2018-2028) (2018)	X											
Long-Term Low Emission Development Strategy 2021-2050 (2021)									X			
Tuvalu	National Adaptation Programme of Action (2007)	Original NDC	X									
	National Climate Change Policy 2012-2021 (2012)		X									
	National strategic Action Plan for Climate change and disaster risk management 2012-2016 (2012)		X									
	Te Kakeega III National strategy for sustainable development (2016)										X	

	Policy name	Referenced in	Climate change (CC)		CC - Environment	Environment			CC - Development	(Sustainable) Development		
			CC general	Energy/Transport		N/A	Environment general	Biodiversity		Agriculture	Forestry	Ocean
Vanuatu	Priorities and Action Agenda (2006)	Original NDC									X	
	National Adaptation Programme of Action (2007)		X									
	National Energy roadmap (2013)											
	Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)		X									
	Second National Communication to the UNFCCC (2014)		X									
	First National Communication to the UNFCCC (1999)	Revised NDC										
	Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)		X									
	Updated Vanuatu National Energy Road Map 2016 - 2030 (2016)			X								
	National Sustainable Development Plan 2016 to 2030: Vanuatu 2030 The People's Plan (2016)											X
	National Energy Road Map (2016-2030) Implementation Plan (2019)			X								
	Third National Communication to the UNFCCC (2020)		X									

Appendix 1.B: Classification of the main ocean-based climate actions according to Gattuso et al. (2022)*, modified from Gattuso et al. (2018) and Abram et al. (2019)*****



*Gattuso J.-P., Jiao N., Chen F., Jouzel J., Le Quéré C., Lu Y., Tréguer P., von Schuckmann K., Wang Z. L. & Zang J., (2022). Ocean-based climate action. 12 p. Chinese Academy of Sciences and European Academy of Sciences. DOI: 10.5281/zenodo.6410659



**Gattuso, J. P., Magnan, A. K., Bopp, L., Cheung, W. W., Duarte, C. M., Hinkel, J., ... & Rau, G. H. (2018). Ocean solutions to address climate change and its effects on marine ecosystems. *Frontiers in Marine Science*, 337.

***Abram, N., Gattuso, J. P., Prakash, A., Cheng, L., Chidichimo, M. P., Crate, S., ... & Von Schuckmann, K. (2019). Framing and context of the report. *IPCC special report on the ocean and cryosphere in a changing climate*, 73-129.

Appendix 1.C. Working tables



Below are the 24 working tables created in Chapter 1. They detail the ocean-based climate actions included in the 24 NDCs + policies referenced in these 24 NDCs, for each Pacific Small Island Developing States.

WORKING TABLE #1: COOK ISLANDS. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems	MP: "The Cook Islands is confident that its strategies and policies pre 2020 and post 2020 will reduce and offset its carbon emissions and strengthen resilience. These actions include inter alia marine conservation."		
Marine renewable energy			
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management		Strategic outcome: "Fisheries and marine ecosystems are well managed for adaptation to climate change"; Action related: "Strengthen and build resilience in the fisheries sector, with climate change considerations." (Joint National Adaptation Plan for Disaster Risk Management and Climate Change Adaptation (2011-2015)).	
Ecosystem-based coastal protection		"Improve the conservation and management of biodiversity in a changing climate" (Joint National Adaptation Plan for Disaster Risk Management and Climate Change Adaptation (2011-2015)).	
Coastal NbS for other or general purpose	"Designating its entire EEZ of almost two million sq km as a marine park is evidence of national commitment to the global effort to building the resilience of marine ecosystems." MP: "The Cook Islands is confident that its strategies and policies pre 2020 and post 2020 will reduce and offset its carbon emissions and strengthen resilience. These actions include inter alia marine conservation."	Commitment to ensure that oceans, lagoons and marine resources are protected for generations to come." Support healthy coral reefs, as reefs play an important role in protecting islands and communities from the impacts of climate change (indicator is "statistically significant improvement, or consecutive years of non-significant improvements"); (Second National Sustainable Development Plan (2016-2020)). "Improve the conservation and management of biodiversity in a changing climate" (Joint National Adaptation Plan for Disaster Risk Management and Climate Change Adaptation (2011-2015)).	
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection		"Strengthen and climate-proof key infrastructure in the coastal zone to withstand hazard damage". Promote integrated management of the coastal zone to build resilience to hazards including climate change and sea level rise" (Joint National Adaptation Plan for Disaster Risk Management and Climate Change (2011-2015)).	
Relocation and diversifying of activities		Strategic outcome: "Reduction of the negative environmental impact of hotels and resorts." Related action: "strengthen and build the resilience in the tourism sector, including to the impacts of climate change" (Joint National Adaptation Plan for Disaster Risk Management and Climate Change Adaptation (2011-2015)).	

Relocation of people			
Multiple			"Inclusivity, communities management, transparency are all principles that guide the implementation of the Cook Islands" (JNAP 2011-2015).



WORKING TABLE #2. FIJI. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy	SA: Continued research and development in the area of new renewable energy technologies, including further exploration of ocean energy, wave energy, in order to reduce dependence on imported fossil fuel as a source of energy for electricity generation.	"The research and development of new and renewable energy technologies will continue. This includes further exploration of ocean energy, geothermal energy, wave energy and the generation of energy from waste." (National Development Plan 2017).	"Assess and utilise appropriate renewable energy sources, such as waves, tidal [...], hydro" (p33/82) (National Climate Change Policy 2012); "Continue the research and development of new and renewable energy technologies, including further exploration of ocean energy, and wave energy." (National Development Plan 2017); "Continued research and development in the area of new renewable energy technologies, including further exploration of ocean energy, geothermal energy, wave energy" (Green Growth framework 2014);
Maritime transportation		Provision of regular, affordable and sustainable shipping industry: Short Term (up to 2 years): <ul style="list-style-type: none"> Improve the operating efficiency of vessels, for example efficient slipways [...], better hull and propeller designs which could result in fuel savings. Reinvigorate traditional knowledge of using small "canoe" and "camakau" boats for accessing jetties to reduce the use of fossil fuel operated outboard motors. Purchase of a renewable energy vessel through a partnership between Government Shipping Services and the private sector investors in close consultation with interested communities. (Green Growth Framework 2014) <p>"Support the development and implementation of the Department of Transport's land and marine transport</p>	Short-term: Support initiatives that assist in the transition to a low carbon sea transport future.; Build relationships with global and regional industry leaders and researchers working in the field of sustainable sea transport. Medium Term (3 to 5 years): Incorporate incentives for trialing and adoption of low carbon technologies for domestic shipping in relevant strategies, policies and plans.

		<p>policies that encourage a shift towards more energy efficient forms of land and sea transport." "2) Investigate the potential and cost-effectiveness of energy efficiency and renewable energy solutions for sea vessels, including biofuels, solar and sail-assisted sea transport and efficient motors, vessel design, and improved maintenance models to improve the overall efficiency and reduce fuel consumption in sea transport within Fiji." (National Energy Policy 2013)</p> <p>"Review the potential to improve the fuel efficiency of marine transport, including considering imposing mandatory inter-island vessel standards and considering the options for the better integration of regional sea freight movement." (Draft Energy Strategic Action Plan 2013);</p> <p>MP: "Prepare guidelines for environmental impact mitigation and climate change adaptation for maritime infrastructure" (National Development Plan 2017).</p>	(Green growth framework 2014)
ADAPTATION			
Ecosystem-based fisheries management	<p>Fisheries policies have been developed. They focus on the sustainable management of Fiji's natural marine resources.</p>	<p>"Adaptation measures within the marine and fisheries sector include preservation of mangroves areas, coral reefs and other coastal zones" (National Climate Change Policy 2012).</p>	<p>"Include vulnerability assessments and climate change impact projections into resource management planning, such as integrated coastal and watershed management plans" (p33) (National Climate Change Policy 2012);</p> <p>"Strengthen research and development and cooperation with regional and international research efforts in agricultural and fisheries and climate change implications" (National Development Plan 2017).</p>
Ecosystem-based coastal protection		<p>"Support the ecosystem-based approach throughout Fiji, recognising that ecosystem services, such as food security, natural hazard mitigation and physical coastal buffer zones, increase resilience." (National Climate Change Policy 2012).</p>	<p>"Review the town plan regulations to facilitate the enforcement of zoning and buffer zones for coastal areas, rivers banks, high risk areas and mangrove areas. Review to be completed by 2016."; Develop hazard maps and models for all potential hazards (including sea level rise, storm surge, flood and tsunami) by 2020. (Green Growth Framework 2014);</p> <p>"Develop and make accessible hazard maps of coastal areas [...] in Fiji" (p33) (National Climate Change Policy, 2012).</p>

Coastal NbS for other or general purpose	The planting of mangroves is part of ongoing initiatives to build resilience.	"Adaptation measures [...] include more rigid development conditions to restrict development on dunes and foreshore areas" (National Climate Change Policy, 2012).	
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection	Construction of seawalls is part of ongoing initiatives to build resilience.		Develop hazard maps and models for all potential hazards (including sea level rise, storm surge, flood and tsunami) by 2020. (Green Growth Framework 2014); "Develop and make accessible hazard maps of coastal areas [...] in Fiji" (p33) (National Climate Change Policy, 2012); "Prepare guidelines for environmental impact mitigation and climate change adaptation for maritime infrastructure" (National Development Plan, 2017).
Relocation and diversifying of activities		"Adaptation measures within the marine and fisheries sector include alternatives to commercial fishing practices to diversity and increase stock sustainability" (National Climate Change Policy 2012).	
Relocation of people	Relocation of communities to higher grounds is part of ongoing initiatives to build resilience.		
Multiple	Review the town plan regulations to facilitate the enforcement of zoning and buffer zones for coastal areas, rivers banks, high risk areas and mangrove areas. Develop hazard maps and models for all potential hazards (including sea level rise, storm surge, flood and tsunami) by 2020. (proposed way forward, actions and time bound indicators) (Up to 2 years).		

WORKING TABLE #3. FIJI. From Fiji NDC 2020:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems	<p>MP: Establish 30% of our EEZ as MPA and work toward 100% management of our EEZ by 2030 through the implementation of the National Ocean Policy.</p> <p>PCB: Conserve ocean reservoirs as carbon sinks through supporting the enhancement and conservation of coastal ecosystems such as mangroves, sea grasses and coral reefs. (Conserve natural environment and biodiversity wealth enabling sustainable long-term provision of ecosystem services, including sequestration potential.)</p>	<p>"In protecting and promoting coastal wetlands, it will be critical for Fiji to adopt a mangrove management plan, to develop and implement policies and plans to replant mangroves, and to conduct extensive mapping and establish field studies of mangroves as well as seabed grasses. The inclusion of mangroves and other coastal wetlands in future updates to Fiji's LEDS could add significantly to the potential to achieve deep decarbonisation in Fiji's economy." (Fiji Low Emission Development Strategy 2018-2050);</p> <p>MP: Protect, restore, and improve ocean ecosystems, climate services and biodiversity so that these benefits contribute towards fair and equitable participation for current and future generations through the sustainable management of 100 percent of Fiji's ocean within national jurisdiction. (National Ocean Policy 2020);</p> <p>Enhance blue carbon sinks and reservoirs (strategy) ; "Mangrove protection and nature-based coastal protection applications are quantified further within Fiji's NDC targets" (strategy); "BC initiatives and other carbon sequestration service-enhancing activities contribute to net zero carbon emissions targets" (strategy) ; "Mangroves are protected and enhanced through afforestation and regeneration programmes, and protection incentives which cumulatively service to ensure there is no net loss in mangroves by 2030 (using 2016-2019 baseline)" (strategy) ; "Mangrove planting initiatives are quantified further within Fiji's NDC targets (strategy) ; "Reef and fisheries conservation is quantified further within Fiji's NDC targets (strategy). Outcome: preserve and enhance Fiji's natural carbon sinks and carbon reservoirs. (National Climate Change Policy 2018-2030).</p>	<p>"In protecting and promoting coastal wetlands, it will be critical for Fiji to adopt a mangrove management plan, to develop and implement policies and plans to replant mangroves, and to conduct extensive mapping and establish field studies of mangroves as well as seabed grasses. The inclusion of mangroves and other coastal wetlands in future updates to Fiji's LEDS could add significantly to the potential to achieve deep decarbonisation in Fiji's economy." (Fiji Low Emission Development Strategy 2018-2050))</p> <p>MP: Support the sustainability of coastal ecosystems through strengthened environmental protection measures, 2) monitoring the health of the marine environment, 3) increase financing for marine initiatives, 4) enforcement of MPAs and promote the sustainable management of inshore fisheries, 5) regulation and enforcement of national fisheries and activities within Fiji's EEZ. (National Ocean Policy 2020)</p>
Marine renewable energy			
Maritime transportation	<p>Reduce domestic maritime shipping emissions by 40%, as a contribution to the target aiming at reducing 30% of BAU CO2 emissions from the energy sector.</p>	<p>1)"A national action plan for decarbonisation of maritime transport; 2) • Transition from 2- to 4-stroke engines; and 3) • Revitalisation of traditional sailing culture and development of low carbon vessels." (Fiji Low Emission Development Strategy 2018-2050);</p> <p>"Fiji's NDC is enhanced to reflect ambitious decarbonisation targets for inter-island marine transportation"; "Low-carbon maritime transport options and shipping efficiency improvements are used to improve the coast-effectiveness of shipping routes, increasing inter-island connectivity"; "support low-carbon shipping transitions through increased</p>	



		engagement with the IMO (Strategies) (National Climate Change Policy).	
ADAPTATION			
Ecosystem-based fisheries management	<p>Adopt sustainable practices in fisheries taking climate change into account. MP: Adaptation action with mitigation co-benefits: "Fiji will prioritize the conservation and protection of its marine biodiversity and critical ocean ecosystems. This would include measures for promoting sustainable fishing practices, coastal protection, preservation, and enhancement of its mangroves, and engaging with coastal communities to promote sustainable practices and livelihoods." (SA)</p>	<p>"Integrated coastal and fisheries management methods are used to help protect local food security and livelihoods" (strategy) (National Climate Change Policy 2018-2030);</p>	<p>Measure 12.F.4: (ongoing) Upgrade existing database to capture data on the status of inshore/coastal and offshore marine resources (including regeneration and harvesting levels) for planning and informed decision making and improve accessibility to all fisheries stakeholders" (National Adaptation Plan, 2018);</p> <p>MP: Mention of the Fiji's National Oceans Policy, which will: 1) support the sustainability of coastal ecosystems through strengthened environmental protection measures, 2) monitoring the health of the marine env., 3) increase financing for marine initiatives, 4) enforcement of MPAs and promote the sustainable management of inshore fisheries, 5) regulation and enforcement of national fisheries and activities within Fiji's EEZ. "Large-scale marine managed areas and locally managed coastal fisheries are supported by governance frameworks designed to help ensure that managed and protected marine zones build measurable environmental and human resilience" (strategy) (National Climate Change Policy, 2018-2030)</p>
Ecosystem-based coastal protection	<p>Prioritise nature-based solutions to mitigate the impact of flooding and cyclones. Protection of critical ocean ecosystems (mangroves, coral reefs) to mitigate the impact of flooding and cyclones. MP: Adaptation action with mitigation co-benefits: "Fiji will prioritize the conservation and protection of its marine biodiversity and critical ocean ecosystems. This would include measures for promoting sustainable fishing practices, coastal protection, preservation, and enhancement of its mangroves, and engaging with coastal communities to promote sustainable practices and livelihoods." (SA)</p>	<p>"The percentage of mangroves protected by env. law is increased with a priority given to protecting areas which provide natural protection to people and ecosystems" (strategy) (National Climate Change Policy 2018-2030);</p> <p>Measure 14.1.: "Scale up efforts to strengthen coastal boundaries of urban centres and rural communities through hybrid or nature-based solutions to risk reduction purposes and to slow the need to relocate communities and infrastructure "; Measure 15.D.1. : Integrate ecosystem-based adaptation measures into considerations regarding the construction of seawalls and river banks, including mangrove planting. ; Measure 16.4. (ongoing) "Assess and monitor the state of coastal ecosystems and protect and enhance the natural coastal defences." (National Adaptation Plan 2018).</p>	<p>Measure 15.D.1. : Integrate ecosystem-based adaptation measures into considerations regarding the construction of seawalls and river banks, including mangrove planting. ; Measure 16.4. (ongoing) "Assess and monitor the state of coastal ecosystems and protect and enhance the natural coastal defences." MP: Assessment: Measure 7.6: (ongoing) "Develop and make accessible user-friendly hazard assessments, maps and models focusing on site-specific risks across coastal, riverine, urban and inland areas in Fiji, for all potential hazards (including sea level rise, storm surge, flooding, drought, salt intrusion, landslide, tsunamis etc) to guide development planning at both national and sub-national level." (National Adaptation Plan 2018).</p>

<p>Coastal NbS for other or general purpose</p>	<p>MP: Adaptation action with mitigation co-benefits: "Fiji will prioritize the conservation and protection of its marine biodiversity and critical ocean ecosystems. This would include measures for promoting sustainable fishing practices, coastal protection, preservation, and enhancement of its mangroves, and engaging with coastal communities to promote sustainable practices and livelihoods." (SA) MP: Establish 30% of our EEZ as MPA and work toward 100% management of our EEZ by 2030 through the implementation of the National Ocean Policy.</p>	<p>Measure 16.8: (ongoing) "Implement ecosystem-based approaches to adaptation to [protect, maintain, and] restore degraded habitats with active community, NGO and private sector engagement in particular the restoration of critical watersheds, riparian and coastal zones."; Measure 16.3: (ongoing) "Implement mangrove rehabilitation projects and strengthen the regulations regarding mangrove removal and conversion." (National Adaptation Plan 2018); MP: Protect, restore, and improve ocean ecosystems, climate services and biodiversity so that these benefits contribute towards fair and equitable participation for current and future generations through the sustainable management of 100 percent of Fiji's ocean within national jurisdiction. (National Ocean Policy 2020).</p>	<p>Measure 16.8: (ongoing) "Implement ecosystem-based approaches to adaptation to [protect, maintain, and] restore degraded habitats with active community, NGO and private sector engagement in particular the restoration of critical watersheds, riparian and coastal zones."; (Withing 5 years)"Expand 'Tree-Planting Campaign' to encourage voluntary tree and/or mangrove planting activities which are to be conducted as a part of school curriculums, community stewardship and the Corporate Social Responsibility."; PCB: Endorsement: Measure 16.3: (ongoing) "Gain endorsement of mangrove management plan, implement mangrove rehabilitation projects and strengthen the regulations regarding mangrove removal and conversion." (National Adaptation Plan 2018); MP: Mention of the Fiji's National Oceans Policy, which will: 1) support the sustainability of coastal ecosystems through strengthened environmental protection measures, 2) monitoring the health of the marine env., 3) increase financing for marine initiatives, 4) enforcement of MPAs and promote the sustainable management of inshore fisheries, 5) regulation and enforcement of national fisheries and activities within Fiji's EEZ. (National Climate Change Policy) MP: National Ocean Policy 2020: support the sustainability of coastal ecosystems through strengthened environmental protection measures, 2) monitoring the health of the marine env., 3) increase financing for marine initiatives, 4) enforcement of MPAs and promote the sustainable management of inshore fisheries, 5) regulation and enforcement of national fisheries and activities within Fiji's EEZ.</p>
<p>Reduction of marine and coastal pollution</p>		<p>Measure 16.10: (Within 5 years) Reduce the negative impacts of unsustainable activities linked to logging, river and seabed mining."; Measure 16.13: (Within 5 years) "Reduce the impact of pollution on terrestrial and marine ecosystems and the reliance upon landfill as a waste management option." (National Adaptation Plan 2018);</p>	<p>Measure 16.10: (Within 5 years) "Implement a national program for the monitoring and management of rivers and watersheds (ridge to reef) to reduce the negative impacts of unsustainable activities linked to logging, river and seabed mining."; Measure 16.13: (Within 5</p>

		Reduce marine pollutant and plastic (National Climate Change Policy 2018-2030).	years)"Endorse and implement a comprehensive waste management plan for rural and urban areas to reduce the impact of pollution on terrestrial and marine ecosystems and the reliance upon landfill as a waste management option." (National Adaptation Plan 2018); Ocean strategies of the National Climate Change Policy are listed p.59, and include "national ... platforms are used to create and promote initiatives to reduce marine pollutant and plastic"; "Fiji's marine pollution reduction objectives are clarified and progressed through policy instruments and regulations (strategy) (National Climate Change Policy 2018-2030)
Infrastructure-based coastal protection		Measure 15.D.3: (ongoing) "Implement coastal protection measures in highly vulnerable communities (e.g. foreshore protection, artificial wave breaks, etc.)." (National Adaptation Plan 2018)	Assessment: Measure 7.6: (ongoing) "Develop and make accessible user-friendly hazard assessments, maps and models focusing on site-specific risks across coastal, riverine, urban and inland areas in Fiji, for all potential hazards (including sea level rise, storm surge, flooding, drought, salt intrusion, landslide, tsunamis etc) to guide development planning at both national and sub-national level." (National Adaptation Plan 2018)
Relocation and diversifying of activities		Measure 12.A.9: (ongoing)"Strengthening the resilience of farmers and farming families by encouraging the diversification of agricultural produce for subsistence consumption and market sales (especially in the sugarcane belt, coastal and interior areas and marginal land)."; Measure 12.F.1: (ongoing) "Upgrade existing aquaculture facilities and develop pond aquaculture to boost brood and seed stock production."; (National Adaptation Plan 2018);	
Relocation of people	Relocate highly vulnerable communities, and implement the concept of 'build back better'.	Measure 9.8 (ongoing): Help protect individuals and communities and diverse social groups that are vulnerable to climate change and disaster displacement and migration, through targeted action, including relocation." (National Adaptation Plan 2018);	Measure 9.8 (ongoing): "Strengthen the capacity of sub-national development planning processes to integrate human mobility issues to help protect individuals and communities and diverse social groups that are vulnerable to climate change and disaster displacement and migration, through targeted action, including relocation." (National Adaptation Plan 2018)
Multiple		Measure 12.F.8: (ongoing) "Extend early warning systems for fishing households, including remote communities and train communities on disaster response and disaster risk reduction" (National Adaptation Plan 2018)	Measure 16.7: (ongoing) "Integrate green and blue accounting/ ecosystem valuation into the GDP formulation and budget process by 2020." (National Adaptation Plan 2018); "MSP is supported by national ocean data services and

			information systems"; "Formal government support for community-based management of marine assets is increased" (strategy) (National Climate Change Policy 2018-2030)
Other	« Plant 30 million trees by 2035. » (does not include explicitly coastal trees such as mangroves). « Fiji increases its scope to include the ocean sector recognising it as a significant carbon sink »		

WORKING TABLE #4. KIRIBATI. From original NDC 2016:



Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems	PCB: Kiribati will proactively protect and sustainably manage its mangrove resources, as well as protect coastal vegetation and seagrass beds. These actions represent effective stewardship of more than 6 million tonnes of CO2 stored, more than 100 times the current annual national emissions inventory. Kiribati will proactively enhance coastal vegetation (includes mangroves) and seagrass beds.		
Marine renewable energy			
Maritime transportation		Increase the use of renewable energy for off-grid electrification. Expected results: "Marine transportation system fuel reduction" and "All outer islands Fish centers achieve significant fuel reduction." (p2014/112) (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023)); "Encourage the use of alternative fuels such as biofuels (coconut oil)" for sea transport." (p27/32) (Kiribati National Energy Policy 2009).	
ADAPTATION			
Ecosystem-based fisheries management		Strategy 4: Increasing water and food security with integrated and sector-specific approaches and promoting healthy and resilient ecosystems. Result: Communities manage coastal fisheries taking into consideration sustainability of marine resources as well as climate change and disaster risks. (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023)); Implement Community Based Fisheries Management (CBFM) in three pilot communities to increase resilience to climate change and make use of potential benefits. Sub-actions include "Implement identified actions and monitor progress (such as artificial reefs, preservation of seafood, deployment of nearshore fish aggregating devices (FADs), management plans, establishment of marine protected area, farming of clams, etc.)." Results expected: increase in household access to oceanic and aquaculture seafood; At least 3 vulnerability assessments on fisheries reports published; Traditional knowledge and scientific and adaptation messages published as awareness materials; Adoption of best practices (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023)); Deploy networks of nearshore FADs to increase	Monitoring reports on FADs effects on increasing fish catches and maintenance costs published every 2cd year. (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023)); "Integrate competencies and learning on climate change into existing programs of Fisheries Training Center and Marine Training Center". (p.96) (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023)). "Research and on-trial use of seasonal forecast to predict movement of highly migratory species (e.g., Tuna)"; "Establish a GIS system for the Fisheries Division to facilitate access to data." (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management

		<p>access to pelagic fish and reduce pressure on coastal fisheries. With sub actions (p. 82). Results expected: Increased access of households to oceanic and aquaculture seafood FAD deployed in at least 5 locations each year; MP: Identify and promote (e.g., through the private sector) fish species that are more resilient to the impacts of climate change (p.71) (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023));</p> <p>Identify potential options such as coral transplanting and those addressing ciguatera fish poisoning, Design marine protected areas and artificial reef sites, hatcheries and equipment for stock enhancement.</p> <p>The establishment of marine protected areas in collaboration with island communities to conserve stocks of heavily-targeted species is part of MFMRD’s programme contributing to national CC adaptation (p.41 National Framework for CC Adaptation 2013);</p> <p>Replenishment by aquaculture of depleted stocks where over-fishing or climatic events have undermined natural replenishment, both form part of MFMRD’s programme contributing to national CC adaptation (p.41 National Framework for CC Adaptation 2013);</p> <p>Improve and enhance the sustainable use of resources that are in line with customary marine tenure systems. For that, identify the destructive fishing methods and gears and impose legislations to regulate these destructive fishing methods and gears (Kiribati Integrated Environment Policy 2013);</p> <p>Community-based marine resource management to enhance and improve biological resources to maintain biological diversity in the short and long term (Kiribati Integrated Environment Policy 2013);</p> <p>Develop and implement ecosystem based adaptation initiatives to enhance the resilience of the environment against global climate change impacts (fisheries included explicitly) (Kiribati Integrated Environment Policy 2013);</p>	<p>(2014-2023). Monitoring of coral reef, train Fisheries staff (p.46) (NAPA, 2007). Pilot investments to support affected ecosystems (Fisheries) (p70) (NAPA 2007)</p>
Ecosystem-based coastal protection		<p>Implement effective plans for rehabilitating and improving the resilience of the foreshore and coastal areas to combat the degradation and erosion of all islands' foreshores and coastal areas; Expand where appropriate and possible the replanting mangroves and coastal vegetation to vulnerable foreshore and coastal sites (p.64/77) (Kiribati Integrated Environment Policy 2013).</p>	<p>Establish 'geodetic benchmarks' on selected islands of Kiribati for monitoring coastal movement land erosion/accretion in relation to climate change and sea-level rise" (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023)).</p>
Coastal NbS for other or general purpose		<p>"Scaling up the conservation and management of terrestrial and marine ecosystems and island biodiversity." Associated expected outputs: reduced threats from the impacts of climate change;</p> <p>Volunteer participation and involvement of local communities in mangrove planting;</p> <p>Current actions through the National Integrated Environment Policy include mangrove conservation and management to reduce the impacts of climate change. (Kiribati Development Plan 2012-2015);</p> <p>Mangrove planting (with the communities p.51) to enhance adaptation (p.44) (NAPA 2007).</p>	

Reduction of marine and coastal pollution		"Replacement of South Tarawa's main water trunk sewer, saltwater intakes and ocean outfalls" (Kiribati Development Plan 2012-2015).	
Infrastructure-based coastal protection	Design of coastal protection leading to the construction of some coastal protection structure (already done). Enhancement in coastal resilience with primary emphasis on continuation of shoreline protection works in South Tarawa, and advisory support and asset management of coastal infrastructure.	"Retrofit coastal infrastructure (roads, causeways, jetties) to sustain it against threats of climate change and disaster risks." with sub-actions. Expected results: increase in the % of coastal infrastructure that as been retrofitted after being assessed as vulnerable to cc and disasters" (p.88) ; Enhance sea transport infrastructure to better withstand climate change and disaster risks. With sub-actions (p.88) (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023)); Current actions through the National Integrated Environment Policy include the building of seawall to reduce the impacts of climate change. (Kiribati Development Plan 2012-2015); Enhance traditional coastal protection systems (p.44) and 'Upgrading existing seawalls and causeways' (p.46, p.59) in order to (i) encroaching coastal erosion from affecting public infrastructure such as roads, airfields and community public assets, (ii) improve accessibility within the atolls and (iii) minimize potential risks to assets from climate-related disasters" (NAPA 2007). Implementation of coastal defenses ; Design, fund and execute the following actions (flood control at the National Hospital, Erosion control at the eastern end of Bonkiri airport runway, and road and causeway repair and improvement of protective works ..." (National Framework for CC adaptation, 2013).	Establish 'geodetic benchmarks' on selected islands of Kiribati for monitoring coastal movement land erosion/accretion in relation to climate change and sea-level rise"; "Establish a revolving fund to sustain infrastructure projects (public buildings and coastal and water infrastructure) and their resilience to climate change and hazards." (p.87) (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023); Monitoring, documenting and reporting of individual work on seawalls or causeways (p.46). (NAPA 2007); Develop design standards to apply to all coastal structures in Kiribati. (National Framework for CC Adaptation, 2013).
Relocation and diversifying of activities		MP: Identify and promote (e.g., through the private sector) fish species that are more resilient to the impacts of climate change (p.71); Strengthen and achieve ecotourism initiatives; "Develop and strengthen local businesses and artisanal fisheries to capitalise on the likely increase in skipjack tuna stocks and to better use bycatch for food security", with sub actions; Desalination plant for vulnerable communities (p.104) (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023)); Replenishment by aquaculture of depleted stocks where over-fishing or climatic events have undermined natural replenishment, both form part of MFMRD's programme contributing to national CC adaptation (p.41) (National Framework for CC Adaptation, 2013).	Identify and develop incentives that would generate income to local communities, while carrying out marine community based biodiversity protection and management (e.g., eco-tourism) (p.44) (Kiribati Integrated Environment Policy 2013).
Relocation of people			
Multiple			Modernize data logging for wind, tidal, sea level , sea surface temperature."Establish and formalise an interdepartmental national monitoring team on coastal changes." ; "Establish a national monitoring team to map coral, seagrass, benthic habitats, water quality, ciguatera etc" (p.69-70); Develop models of key hazards (tsunami, storm surges...) (p.100);



		<p>"Translate science and key adaptation actions into awareness materials in te-Kiribati for the wider I-Kiribati community to increase understanding of the impacts of climate change on marine resources." (p.70); Communities' involvement: "Develop and implement a program for community based integrated vulnerability assessment, climate change adaptation and disaster risk management", with sub-actions (p.76).; "Integrate competencies and learning on climate change into existing programs of Fisheries Training Center and Marine Training Center". (p.96) (Kiribati Joint Implementation Plan on Climate Change and Disaster Risk Management (2014-2023); Coastal zone management and resilience enhancement for adaptation, including awareness raising actions (Awareness raising aims to make and empower the communities to recognize and minimize risks that can arise from climate related hazards and the dynamic nature of the coastal area), information and data, institutional strengthening with detailed actions (p.44) (NAPA 2007). "The communities will be mobilized and empowered to be able to manage their own respective areas of the coastal zone" (p51); Environmental, climate change information and monitoring (p.44) (NAPA 2007); Public and private assets (finance, awareness...): such as establishing a fund to assists communities to undertake climate proffing investments and activities (p.40) (National Framework for CC Adaptation, 2013).</p>
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WORKING TABLE #5. MARSHALL ISLANDS. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems	MP: Mangrove rehabilitation programs to enhance carbon sinks as well as assist with protection of water resources and the health of the RMI people. (recognized as an adaptation action with mitigation co-benefits)		
Marine renewable energy	Extract ocean energy for power generation. SA: The RMI Government is currently supported by donors and development partners to mitigate impacts of high oil prices at policy level, focused on increasing energy efficiency, minimizing the costs of imported fuels, and investing in renewable energy sources such as solar, biofuel and ocean energy (such as OTEC (Ocean Thermal Energy Conversion). "Additional GHG reductions may become possible through the use of new technologies allowing the extraction of ocean energy for power generation."	"20% improvement in the efficiency of fuel use in the transportation sector (Data on fuel end use for land and sea transport should be collated) by 2020" (action) (p. 64) (2016 Energy plans, 2016).	"Conduct an independent study of the viability of alternatives to diesel fuel for power generation where economically sound (e.g. coconut oil, LNG, grid-connected solar, ocean energy, wind energy, etc.). Implementation of recommended viable alternatives"; "Feasibility studies and internationally supported financing plans for innovative 'game-changing' renewable energy and sustainable development opportunities including Majuro atoll waste-to-energy and Kwajalein/Ebeye atoll OTEC (Ocean Tidal Energy Conversion) plants undertaken by 2015"; "Investigate the practicality of retrofits to reduce fuel use in sea transport (e.g. more efficient propellers, sail-assist technologies, and other alternate energy sources)" (action/budget) (p. 10, 29-30, 54); "Investigate the practicality of retrofits to reduce fuel use in sea transport, e.g. more efficient propellers, sail-assist technologies, and other alternate energy sources » (action) (p. 35); "To develop a concept on how to monitor the high sea fuel bunkering" (action/budget) (p. 46) (2016 Energy Plans, 2016).
Maritime transportation	Sectoral goal to reduce domestic transport emissions (including domestic shipping) by 16% in 2025 and 27% in 2030; Actions include the introduction of solar-charged electric lagoon transport.		
ADAPTATION			
Ecosystem-based fisheries management		"Consider climate-adaptive approaches for a sustainable fisheries sector"; "Effective management of coastal resources including land and marine biodiversity" (Joint National Action Plan for Climate Change Adaptation (2014-2018) (2014))	
Ecosystem-based coastal protection			

Coastal NbS for other or general purpose			
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection			
Relocation and diversifying of activities			
Relocation of people			
Multiple	Adaptation multiple: MP: Mangrove rehabilitation programs to enhance carbon sinks as well as assist with protection of water resources and the health of the RMI people. (<i>Recognized as an adaptation action with mitigation co-benefits</i>).	"Climate adaptation such as long term planning to address sea level rise and mitigation considerations underpins all development planning and actions to ensure integrated response to building climate change resilience" (National CC Policy, 2011).	"More research is needed to identify the impacts of ocean acidification on RMI's marine environment and to identify possible management responses" (p. 15) (Joint National Action Plan for Climate Change Adaptation (2014-2018) (2014)).



WORKING TABLE #6. MARSHALL ISLANDS. From revised NDC 2018:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy		<p>"Replace all A/C with wet cooling towers/Seawater ASHP" ("Assess Majuro's and Ebeye's air conditioning infrastructure, identifying the equipment's condition and type, to verify if shifting to seawater-source heat pumps, and/or water-cooling towers, is viable, and what efficiency gains are reasonable") (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018));</p> <p>Ocean Thermal Energy Conversion (OTEC) has been previously proposed as a moonshot technology that could significantly contribute to RMI's decarbonization efforts and also make it an energy exporter. Mitigation solution with adaptation co benefits as OTEC can also be "a freshwater resource and provide drought resilience for RMI". (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018)).</p>	
Maritime transportation		Sea transportation efficiency improvements to find the best path forward. (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018))	<p>Potential measures and next steps include :</p> <p>"Examine both in-country fleet efficiency and equipment, and pass-through fleet efficiency and equipment. Examine potential standards and technical pathways for improvements (i.e., sails, engine efficiency improvement, etc.). Evaluate the economics</p>

			and implications of various options (improved efficiency standards, lower carbon fuels, etc.) to find the best path forward.”) (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018)).
ADAPTATION			
Ecosystem-based fisheries management			
Ecosystem-based coastal protection		MP: Maintaining or restoring (where human impacts are occurring) the effectiveness of the complete natural coastal defense system (and livelihood ecosystem) ; Continuation / recourse to traditional settlement patterns within each wato on islets, particularly locating development 30 – 50 m back from the lagoon edge and maintaining a vegetated buffer between the shoreline and any man-made feature. (Adaptation Communication, 2020).	
Coastal NbS for other or general purpose			
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection		<p>New construction of all types of structures should be elevated (“new policies and plans for constructing elevated settlements for future consolidation of the population will be an urgency in the future, but it not yet an action decided. (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018));</p> <p>Implementing effective (and low cost) measures, for example constructed “backstop” protection reducing over-topping impacts on properties and development. (Adaptation Communication, 2020);</p> <p>Moving from slab concrete foundations to pile foundations enabling property to be raised up or more easily relocated with the wato or on less exposed locations on the islet. (Adaptation Communication, 2020);</p> <p>MP: Maintaining or restoring (where human impacts are occurring) the effectiveness of the complete natural coastal defense system (and livelihood ecosystem) ; Continuation / recourse to traditional settlement patterns within each wato on islets, particularly locating development 30 – 50 m back from the lagoon edge and maintaining a vegetated buffer between the shoreline and any man-made feature. (Adaptation Communication, 2020).</p>	<p>”Establish financing pathway for adaptation focusing on coastal resilience including coastal vulnerability assessments. Particular immediate areas of focus for adaption are likely to be, but not necessarily limited to, coastal resilience including coastal vulnerability assessment.”; ”There is an urgent need to expand coastal protection measures and investments”). (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018)).</p>
Relocation and diversifying of activities			
Relocation of people	”While relocation should be considered the last-resort option, it is likely that some Marshallese will choose to migrate, as many have done so already. Moreover, it is possible that RMI may not be able to viably		



	accommodate the entire 60,000-plus residents that are projected to be living in the country by 2030. Therefore, the Government will need to simultaneously assure the right of citizens to remain in the islands as best it can, and ensure continued opportunity for migration for those who so choose to relocate."		
Multiple	SA: Do coastal vulnerability assessments	Other/risk management: "Resilience Project – Phase II (PREP II). The objective of the project is to strengthen early warning systems, increase climate resilient investments in shoreline protection, and provide immediate and effective responses to crises or emergencies. (Adaptation Communication, 2020).	

WORKING TABLE #7. MARSHALL ISLANDS. From revised NDC 2020:



Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy		<p>“Replace all A/C with wet cooling towers/Seawater ASHP” (“Assess Majuro’s and Ebeye’s air conditioning infrastructure, identifying the equipment’s condition and type, to verify if shifting to seawater-source heat pumps, and/or water-cooling towers, is viable, and what efficiency gains are reasonable”) (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018));</p> <p>Ocean Thermal Energy Conversion (OTEC) has been previously proposed as a moonshot technology that could significantly contribute to RMI’s decarbonization efforts and also make it an energy exporter. Mitigation solution with adaptation co benefits as OTEC can also be “a freshwater resource and provide drought resilience for RMI”. (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018)).</p>	

Maritime transportation	Introduction of a market-based measure to put a price on carbon in order to foster the decarbonization of domestic sea transportation; Reduce GHG emissions from domestic shipping 40% below 2020 levels by 2030 and full decarbonization of the sector by 2050. + "There are a number of interventions that RMI can pursue in the short medium-term to achieve a low-carbon pathway for domestic sea transportation, including changes to ship design, operation, fuel and docking facilities".	Modernization of energy-supply in fishing sector (p. 49) (RMI Electricity Roadmap, 2018).	Sea transportation efficiency improvements (potential measures and next steps include: "Examine both in-country fleet efficiency and equipment, and pass-through fleet efficiency and equipment.) Examine potential standards and technical pathways for improvements (i.e., sails, engine efficiency improvement, etc.). Evaluate the economics and implications of various options (improved efficiency standards, lower carbon fuels, etc.) to find the best path forward.") (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018)).
ADAPTATION			
Ecosystem-based fisheries management			
Ecosystem-based coastal protection			
Coastal NbS for other or general purpose			
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection		All new construction of "all types of structures should be elevated, based on the new National Building Code to be finalized in 2019 and other policies to be adopted. As conditions are likely to worsen, particularly sea level rise, new policies and plans for constructing elevated settlements for future consolidation of the population will be critical" (Tile Til EO 2050, p. 45).	"Establish financing pathway for adaptation focusing on coastal resilience including coastal vulnerability assessments. Particular immediate areas of focus for adaption are likely to be, but not necessarily limited to, coastal resilience including coastal vulnerability assessment."; "There is an urgent need to expand coastal protection measures and investments".) (Tile Til Eo 2050 Climate Strategy: Lighting the way (2018)).
Relocation and diversifying of activities			
Relocation of people			
Multiple			
Other	"Including accurate domestic shipping information in NDCs is an urgent task given that the 2020 Fourth IMO GHG Study found domestic shipping emissions to have been highly underestimated as compared to previous reports."		

WORKING TABLE #8. FEDERATED STATES OF MICRONESIA. From original NDC 2016:



Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy		"Increase the use of renewable energy" (includes wave) (Yap Joint state action plan for disaster risk management and climate change, 2016).	Activity: Carry out a site-specific monitoring program of FSM's [...] wave, OTEC" energies (National Energy Policy 1999); "Assess alternate energy sources (wave, etc.) – ongoing study" (Yap Joint state action plan for disaster risk management and climate change, 2016).
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management			
Ecosystem-based coastal protection		"Develop appropriate coastal defence systems (including coastal protection as appropriate, replanting of mangroves)"; Tree planting on coastal areas conducted at the community level" (Yap Joint state action plan for disaster risk management and climate change, 2016).	
Coastal NbS for other or general purpose		Manage and protect the nation's natural environment; protect, conserve and sustainably manage a full and functional representation of the FSM's marine environment (Joint State Action Plan for disaster risk management and climate change, 2016, quoting the Five year Environment Sector Plan 2008).	"Develop Community Management Plans for management of marine areas"; "include traditional knowledge and methods, and undertake modelling for coastal protection"; "Finalise, adopt, and implement readiness of Marine Contingency Plan"; "Assess options for developing a Manta Ray Sanctuary in Yap" (Yap Joint state action plan for disaster risk management and climate change, 2016).
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection			
Relocation and diversifying of activities			
Relocation of people		"Consider options for migration from outlying Islands", but climate related reasons for migration are not made explicit. (Yap Joint state action plan for disaster risk management and climate change, 2016).	
Multiple			

WORKING TABLE #9. NAURU. From original NDC 2016:



Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy			
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management		Support a community based ecosystem approach to fisheries management, through the development of integrated fisheries management plan which integrate climate change risks (RONAdapt 2015);	Strengthen the human capacity of government and community stakeholders in the fisheries and marine resources sector (p.24) (RONAdapt 2015); Development of effective monitoring, control and surveillance of fisheries and marine resources, and collection of data to fill knowledge gaps (RONAdapt 2015). Monitoring and surveillance of climate and disaster related risks in link with ocean temperature rise and pathogens in aquaculture and fisheries (RONAdapt 2015).
Ecosystem-based coastal protection		“Develop an integrated coastal zone management plan to reinforce coastal protection.” (RONAdapt, 2015)	
Coastal NbS for other or general purpose		The RONAdapt 2015 mentions the National Biodiversity Strategic Action Plan, which includes the goal of "A goal of the 2010 plan was "an annual increase of 2% to enhance, develop and manage current conservation and rehabilitation of biological diversity and ecosystems to increase the percentage of Nauru’s protected and conserved areas from the existing 2% of total land, including coastal areas, to 30% by 2025”. (RONAdapt 2015). Protect and conserve the reef and foreshore through the Climate Change and Environment Protection Fund (Environmental Management and Climate Change Act 2020).	
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection	Infrastructure and coastal protection: "High priorities are given to actions that can contribute towards multiple development and resilience objectives simultaneously, often cross cutting across sectors. The priority actions are arranged under sectors targeting the following areas: water; health; agriculture;	Develop and implement heavy rainfall and local flooding contingency plans. Design and construction of drainage infrastructure to reduce flood risks in critical locations (RONAdapt 2015).	

	energy; land management and rehabilitation; infrastructure and coastal protection ; biodiversity and environment".		
Relocation and diversifying of activities		Finalise an action plan for aquaculture development to promote aquaculture as an important contributor to food security that can reduce pressure on coastal fisheries (p.24) (RONAdapt 2015).	
Relocation of people			
Multiple			Develop and maintain high level of community awareness and preparedness for responding to extreme events (RONAdapt 2015); Conduct coastal vulnerability assessment and mapping (RONAdapt 2015).

WORKING TABLE #10. NAURU. From revised NDC 2021:



Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy			
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management	SA: Collect and analyze data on climate change impacts on fisheries and marine resources to improve resilience by collecting data to better understanding cc impacts on agriculture, fisheries and marine resources.		
Ecosystem-based coastal protection	SA: Conduct technical assessment of coastal erosion and develop plan for implementing nature-based solutions (benefits for adaptation identified include increased resilience of coastal zone ecosystems and biodiversity)		
Coastal NbS for other or general purpose			
Reduction of marine and coastal pollution	Implement the sewerage components of the Water and Sanitation Master Plan (Treating sewage appropriately before discharge into groundwater, lagoons and the ocean will enhance the SDG 14 Life below water). (Associated mitigation co benefits associated include "Potential use of groundwater supplies would reduce energy use for water desalination, reduced emissions from need to pump and truck sewage, and increased use of groundwater will reduce demande for water from electricity intensive RO plants").		
Infrastructure-based coastal protection	SA: Conduct technical assessment of coastal erosion and develop plan for implementing hard solutions. Complete construction of new climate change resilient port facility (adaptation outcomes identified include i) Increased reliability of imports, including essential food and medical supplies, and ii); Increased capacity to receive heavy equipment necessary for large infrastructure improvements (with mitigation co benefits).		
Relocation and diversifying of activities	Develop milkfish farming in support of the development and expansion of aquaculture to improve resilience by increasing domestic food production (mitigation co benefits identified, via reduced emissions related to food import).		
Relocation of people	Develop master land use plan for relocation of homes and critical infrastructures to topside (mitigation co benefits); Construction of residential units on Topside to increase resilience to SLR, extreme climate events (mitigation co benefits).		
Multiple		"Regional agencies and all stakeholders shall formulate and implement strategies and programs to: (c) address the environmental impacts of climate change on water resources, coastal areas, lands and land usage, food security, biological diversity, fisheries, economic welfare, public infrastructure and its vulnerability to natural disasters;" (Rep. of Nauru Environmental Management and Climate Change Act (2020)).	

WORKING TABLE #11. NIUE. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy			
Maritime transportation		"Minimise the detrimental impact of petroleum product consumption in the transport sector on the land, air and marine environment" (National Energy Policy, 2005).	
ADAPTATION			
Ecosystem-based fisheries management	Ecosystems Approach to Fisheries Management. In particular, climate change impacts are likely to further exasperate both freshwater lens and coastal water quality issues for Niue. For these reasons, protecting and enhancing natural resources, are among the government's main priorities.	Sub-action "Strengthen community-managed marine conservation areas and buffer zones" to ensure food security (JNAP, 2012). (Objective "Strengthen resilience of key development sectors including [...] fisheries" ; "key national policies guiding the JNAP include Ecosystem Approach to Fisheries Management 2010" (JNAP, 2012).	"Document and share traditional practices regarding [...] fisheries management" (JNAP, 2012).
Ecosystem-based coastal protection			
Coastal NbS for other or general purpose			
Reduction of marine and coastal pollution	In particular, climate change impacts are likely to further exasperate both freshwater lens and coastal water quality issues for Niue. For these reasons, adequate sanitation and wastewater treatment are among the government's main priorities.		
Infrastructure-based coastal protection			Reinforce regulation for guiding development of coastal infrastructures. (JNAP, 2012).
Relocation and diversifying of activities			
Relocation of people			
Multiple			Strategy (p.14): "Identify vulnerable areas and sectors and develop and implement adaptation options that are appropriate and cost effective to reduce vulnerabilities. These sectors include water, energy, infrastructure, tourism, natural ecosystems, agriculture, fisheries, forestry and health." (National Climate Change Policy, 2009); "Build community capacity to participate in water, reef, coastal and forest



			<p>monitoring activities" (JNAP, 2012);</p> <p>"Strengthen capacities to respond effectively to disasters" (includes tsunami) (JNAP, 2012);</p> <p>"Identify and promote use of appropriate tools to support risk assessments [Coastal Hazard Mapping] (JNAP, 2012)</p>
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WORKING TABLE #12. PALAU. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems		<p>"Improve management frameworks to strengthen the resilience of marine ecosystems and sustainably manage carbon sinks" (5,700,000\$) (such as MPAs...), 5 year action plan, with the objective of "By 2020, Palau has established the enabling framework to sustainably manage carbon sinks (terrestrial and marine) and reduce national greenhouse gas emissions by at least 20% from 2005 levels." <i>But no precise target.</i> (Palau Climate Change Policy 2015);</p> <p>MP: "Eliminate overfishing especially in herbivorous fisheries (size limits/quotas MPAs etc.) and complete ban advocacy & data collection regulations], Obj: by 2020, the enabling framework is established to build ecosystem resilience and sustainably manage carbon sinks using holistic and synergistic management approaches, 5 year action plan (p.36), (Palau Climate Change Policy 2015);</p> <p>MP: MPAs in Palau Protected area network (PAN) are ecologically connected (baseline assessments, nationwide management frameworks), 5 year action plan, cost: \$1,000,000, Obj: "by 2020, the enabling framework is established to build ecosystem resilience and sustainably manage carbon sinks using holistic and synergistic management approaches" (Palau CC Policy 2015).</p>	
Marine renewable energy			"Assess in detail the national potential of renewable energies (hydro, ocean, biomass)", 5 year action plan (Palau CC Policy 2015).
Maritime transportation		"Conversion from two-stroke marine engines to more efficient engines is ongoing" (Palau Climate Change Policy 2015).	
ADAPTATION			
Ecosystem-based fisheries management		<p>"Implement the National Policy, Institutional Framework and Strategy for Resilient Agriculture & Aquaculture to improve farm production" (obj: farm production improved), 5 year action plan, \$10,000,000 cost, (p.34) (Palau Climate Change Policy 2015);</p> <p>MP: "Eliminate overfishing especially in herbivorous fisheries" (size limits/quotas MPAs etc.) and complete ban advocacy & data collection regulations], Obj: by 2020, the enabling framework is established to build ecosystem resilience and sustainably manage carbon sinks using holistic and synergistic management approaches, 5 year action plan (p.36), (Palau Climate Change Policy 2015);</p>	

		MP: Build resilience to temperature change and ocean acidification in marine ecosystems/fisheries by protecting coral sites" (5 year action plan, cost \$2,000,000, indicators: increased number of coral sites protected, total area of coral increased; Objective: by 2020, the Palau fisheries enabling framework is established to sustainably manage and support local food production and consumption; p.16 and p.34) (Palau Climate Change Policy 2015).	
Ecosystem-based coastal protection		MP: Build resilience to temperature change and ocean acidification in marine ecosystems/fisheries by protecting coral sites" (5 year action plan, cost \$2,000,000, indicators: increased number of coral sites protected, total area of coral increased; Objective: by 2020, the Palau fisheries enabling framework is established to sustainably manage and support local food production and consumption; p.16 and p.34) (Palau Climate Change Policy 2015).	
Coastal NbS for other or general purpose		MP: MPAs in Palau Protected area network (PAN) are ecologically connected (baseline assessments, nationwide management frameworks), 5 year action plan, cost: \$1,000,000, Obj: "By 2020, the enabling framework is established to build ecosystem resilience and sustainably manage carbon sinks using holistic and synergistic management approaches" (Palau CC Policy 2015); "Based on the results of research on impacts of CC on marine ecosystems/fisheries, launch coral replanting in viable areas that have been affected by coral bleaching" (5 year action plan) (p.34) (Palau Climate Change Policy 2015).	"Undertake research on the carbon sink ability and resilience of marine ecosystems to climate change and disasters" (Palau Climate Change Policy 2015).
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection			"Integrate climate change and disaster risk management into National and Marine Spatial Plans in accordance with SLM principles; Undertake risk assessment "with the objective of establishing by 2020 a framework to strengthen resilience of critical infrastructure while reducing carbon footprint from infrastructure". (5 year action plan) (Palau CC Policy 2015).
Relocation and diversifying of activities		"Establish a program to diversify tourism products", 5 year action plan. (Palau CC Policy 2015).	
Relocation of people		"Establish a relocation/displacement or emergency support program for vulnerable members of society", 5-year action plan. (Palau Climate Change Policy 2020).	
Multiple			



WORKING TABLE #13. PAPUA NEW GUINEA. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems		<p>"Develop sustainable management strategies for fisheries and marine resources" (p.67)/ "ocean resources managed" (p.58) (Papua New Guinea Vision 2050 (2009));</p> <p>MP: "An ecosystem-based approach has been considered for adaptation to climate change for the fisheries sector." (p.119). For that, the tool would be a network of marine reserves. (<i>No clear target associated</i>). The marine protected areas proposed for fishery should include coral reefs in PNG as well as the rest of the ocean. (p.120). COSTED: USD1 m will be required as initial investment. Annually USD 40k for monitoring of reef health will also be required. (Second National Communication 2014);</p> <p>"A person or entity, before undertaking any or more of the following developments: fisheries, both at sea and shore based, shall comply with the minimum climate adaptation and compatibility standards and performance levels" (Climate Management Act 2015);</p> <p>"Establish a Sustainable Development Policy in the Oceans sector" to promote sustainable agriculture, (p.42), to promote "climate resilience through the protection of marine and fishing zones" (p.42), to promote a sustainable society through the protection and preservation of the natural environment (p.44) by 2015. (National Climate Compatible Development Management Policy 2014).</p>	<p>"The key strategic areas include research, information dissemination, and easy access to credit services, surveillance and monitoring, improved market access, building institutional capacity to improve coastal fisheries management; and develop aquaculture as a priority program." (Papua New Guinea Vision 2050 (2009));</p> <p>"The National Fisheries Policy will have to work with the Climate Change Policy to competently monitor sea surface temperature, as a slight increase in sea level temperature will severely affect biodiversity in the oceans". (National Climate Compatible Development Management Policy 2014).</p>
Marine renewable energy		<p>MP: Coastal flooding: potential measures include infrastructure (dikes, levees, sea walls, breakwaters, beach nourishment, elevating structures, reef revival, mangrove restoration, and expansion etc.), technology (e.g. adaptation in homes, storm / flood detection; system), systemic (e.g. improve disaster response, Integrated Coastal Zone Management) and financial ones (e.g. insurance schemes); various locations have been selected. Restoration and conservation of coral reefs is COSTED: USD1 m will be required as initial investment. Annually USD 40k for monitoring of reef health will also be required. (p120). (Second National Communication 2014).</p>	<p>Quantifying & Prioritizing Hazards: Identify communities and sectors most at risk to climate change impacts (e.g., coastal and inland flooding). The national coast zone management program should be reevaluated based on new hazards associated with climate change. (National Climate Compatible Development Management Policy 2014).</p>
Maritime transportation		<p>To increase resilience to the impacts of climate change and environmental changes, key indicators include: "oceans and marine areas protected" (p.58) (Papua New Guinea Vision 2050 (2009));</p> <p>MP: Mangrove protected areas proposed as adaptation options (p.120);</p> <p>"For PNG, to protect biodiversity adaptive measures has to be taken for [...] Fisheries, Coral reefs and marine ecosystem ; Mangroves and fresh water Swamp ecosystem ; Sand dunes/sandy beaches (supporting sea turtle reproduction and other species in the ecotone)" (Second National Communication 2014).</p>	

ADAPTATION			
Ecosystem-based fisheries management		MP: Coastal flooding: potential measures include infrastructure (dikes, levees, sea walls, breakwaters, beach nourishment, elevating structures, reef revival, mangrove restoration, and expansion etc.), technology (e.g. adaptation in homes, storm / flood detection; system), systemic (e.g. improve disaster response, Integrated Coastal Zone Management) and financial ones (e.g. insurance schemes); various locations have been selected. Restoration and conservation of coral reefs is COSTED: USD1 m will be required as initial investment. Annually USD 40k for monitoring of reef health will also be required. (p120). (Second National Communication 2014).	Quantifying & Prioritizing Hazards: Identify communities and sectors most at risk to climate change impacts (e.g., coastal and inland flooding). The national coast zone management program should be reevaluated based on new hazards associated with climate change. (National Climate Compatible Development Management Policy 2014)
Ecosystem-based coastal protection		Develop aquaculture as a priority program (Papua New Guinea Vision 2050 (2009))	"The key strategic areas include research, information dissemination, easy access to credit services, surveillance and monitoring, improved market access, building institutional capacity to improve coastal fisheries management; and develop aquaculture as a priority program." (Papua New Guinea Vision 2050 (2009)).
Coastal NbS for other or general purpose			
Reduction of marine and coastal pollution		"Establish a Sustainable Development Policy in all sectors, especially forestry, agriculture, mining, energy and oceans by 2015" (p. 72) (Second National Communication 2014);	Following technical and institutional capacity building is necessary to manage mangrove responses to cc effects: 1) Strengthen management frameworks regulating coastal activities to develop a plan for adaptation to mangrove responses to climate change effects; 2) Predict climatic trends; 3) measure trends in changes; 4) assess mangrove positions margins changes; 5) PNG staff with training, experience and motivation is needed to conduct monitoring and assessments of mangrove parameters; 6) establish mangrove baselines and monitor changes; 7) produce maps. (Second National Communication 2014); Adaptation strategy: Identifying & Selecting Interventions: In conjunction with relevant sectoral stakeholders, analyze potential losses and benefits and examine feasibility of available adaptation measures (e.g., coastal early warning system, communitybased mangrove planting, coastal engineering protection, human settlements and migration) including identifying barriers and necessary actions. (National Climate Compatible Development Management Policy 2014).

Infrastructure-based coastal protection			
Relocation and diversifying of activities			
Relocation of people			
Multiple			

WORKING TABLE #14. PAPUA NEW GUINEA. From revised NDC 2020:



Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems	Enhance ambition in PNG's 2025 NDC by including blue carbon ecosystems in the GHG inventory and UNFCCC reporting, including: identify pathways to incorporating blue carbon by build upon existing AFOLU and REDD+ capacities considering how to reflect mangroves and seagrasses in climate policies, data collection, mapping and modelling.	Carbon Sequestration Initiatives: "With large mangrove areas along the coast of most provinces, special efforts to develop the programme is essential for adaptation and mitigation measures." (1st National Communication to the UNFCCC, 2000) "Link coastal rehabilitation projects to blue carbon and carbon market opportunities" (p18/66); Goal 30 by 30: conserved and rehabilitated coastal habitats: suggested reportable output: "Increased percentage of marine area protected to maintain & improve biological diversity from 0.21% (2017) to 9% (2022), to enhance emission reduction (Papua New Guinea's Sustainable Development Goal 13 Roadmap: An Empowering Response to Challenges and Opportunities Posed by Climate Change: 30 Actions by 2030, 2020)	
Marine renewable energy		"Clean energy will be generated from hydro, solar, wind, tide, geothermal and bio-fuels. The energy from fossil fuel is replaced by clean energy and environmental degradation and climate change is minimized" (National Strategy for the Responsible Sustainable Development for PNG, 2014).	
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management		"An ecosystem-based approach has been considered for adaptation to climate change for the fisheries sector." (p119/160). For that, the tool would be a network of marine reserves. (No clear target associated). "The marine protected areas proposed for fishery should include coral reefs in PNG as well as the rest of the ocean." (p120). COSTED: USD1 m will be required as initial investment. Annually USD 40k for monitoring of reef health will also be required. Coral reefs shall reduce damage from storm surges by more than 50% and help natural restoration and habitat rebuilding and will attract ecotourism (Second National Communication 2014); Action 27: Climate compatible national-level fisheries plans. National targets: KRA 7 – Responsible sustainable development Increase prawn catch by 25% by 2030 (DSP); Double tuna revenues and reach K120 million in 2008 prices by 2030 (DSP); Establish 4	

		<p>onshore tuna processing facilities by 2022 (MTDP). + suggested reportable output: Increased Marine Products Exports from K573.1 million (2016) to K1,113.47 million (2022)(MTDP); (p21/66). + Action 29: enhance the conservation and sustainable use of oceans and their resources by implementing international law" (Papua New Guinea's Sustainable Development Goal 13 Roadmap: An Empowering Response to Challenges and Opportunities Posed by Climate Change: 30 Actions by 2030 (2020))</p> <p>Action 28: Climate smart aquaculture: suggested reportable output: "Stock assessment of prawn fisheries under exploited to increase catch by 25% and raise stock assessment to fully exploited (2030)(DSP); Increased licence fees generated from tuna fisheries from K60 million (2008) to K120 million in 2008 prices (2030)(DSP)" (p20/66) (Papua New Guinea's Sustainable Development Goal 13 Roadmap: An Empowering Response to Challenges and Opportunities Posed by Climate Change: 30 Actions by 2030 (2020);</p> <p>MP: To improve coral restoration and conservation and sustain fisheries, "anthropogenic stresses such as pollution and overfishing will be managed through community based coastal area management approaches" (p120/160) (Second National Communication 2014);</p> <p>"A number of marine reserves are currently being proposed in Milne Bay and highlands provinces to support fisheries." Reduce post harvest losses to support fisheries" (1st National Communication to the UNFCCC, 2000).</p>	
Ecosystem-based coastal protection	Mangrove planting to adapt to coastal flooding and SLR	MP: "Consider seawall and soft measures for coastal protection" (1st National Communication to the UNFCCC, 2000) .	
Coastal NbS for other or general purpose	<p>Mangrove management to enhance adaptation by reducing damage on coral reefs;</p> <p>Establishment of MPAs, and locally managed marine areas (LMMAs) to reduce damage on coral reefs;</p> <p>Protection and promotion of biodiversity conservation through ecosystem based adaptation (EbA) approaches;</p> <p>Rehabilitate corals to reduce damage on coral reefs ;</p> <p>Plant mangroves, seagrasses, and corals to reduce damage on coral reefs.</p>	<p>To build resilience to CC (Strategy 4) (p.21/48):</p> <p>Objective 1: Support the protection and promotion of biodiversity conservation through ecosystem--based adaptation (EbA) approaches. Associated Key Performance Indicator (KIP): Carbon dioxide emissions from all sectors monitored, reported and verified; Environmental ecosystem corridors protected (rainforests, mangrove forests, coral reefs). Objective 2: Support the promotion of sustainable uses of non--renewable natural assets in [...] marine and biodiversity (Climate Change and Development Authority Corporate Plan 2018-2022 (2018));</p> <p>MP: Objectives 3, 4 and 5 in link with disaster risk management (support implementation and enforcement of building standards, support capacity to effectively plan and deal with natural disasters, support for improved access to safe water, sanitation and hygiene facilities". ; Projects include Mangrove Rehabilitation (Climate Change and Development Authority Corporate Plan 2018-2022 (2018));</p> <p>"Increased percentage of marine area protected to maintain & improve biological diversity from 0.21% (2017) to 9% (2022)(MTDP) (p20/66) + "Conserving and rehabilitating these areas will play an important role in increasing PNG's resilience to climate change, as well as enhancing emissions reductions, with opportunities to develop approaches to registered blue carbon approaches. + "By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve health and productive oceans. (Papua New Guinea's Sustainable Development Goal 13</p>	<p>Following technical and institutional capacity building is necessary to manage mangrove responses to cc effects: 1) Strengthen management frameworks regulating coastal activities to develop a plan for adaptation to mangrove responses to climate change effects; 2) Predict climatic trends; 3) measure trends in changes; 4) assess mangrove positions margins changes; 5) PNG staff with training, experience and motivation is needed to conduct monitoring and assessments of mangrove parameters; 6) establish mangrove baselines and monitor changes; 7) produce maps.</p>

		<p>Roadmap: An Empowering Response to Challenges and Opportunities Posed by Climate Change: 30 Actions by 2030 (2020))</p> <p>"For PNG, to protect biodiversity adaptive measures has to be taken for [...] Fisheries, Coral reefs and marine ecosystem ; Mangroves and fresh water Swamp ecosystem ; Sand dunes/sandy beaches (supporting sea turtle reproduction and other species in the ecotone)" (Second National Communication 2014)</p> <p>Mangrove protected areas proposed as adaptation options (p.120) (Second National Communication 2014);</p> <p>"Action 26: Climate resilient protected area network. National target (p.57): Increase percentage of protected marine areas from 0.21% to 9% by 2022 (MTDP); Enhance mangrove planting initiative by increasing 10,000 seedlings in 2009 to 50,000 seedlings in 2030 (DSP); (Increase percentage of pollution complaints investigated and resolved from 20% to 80% by 2022 (MTDP)) (Papua New Guinea's Sustainable Development Goal 13 Roadmap: An Empowering Response to Challenges and Opportunities Posed by Climate Change: 30 Actions by 2030, 2020);</p>	<p>(Second National Communication 2014).;</p> <p>Community based management:</p> <p>"There is a need to support and empower the island communities so that they can take a greater role in monitoring, caretaking, regulating harvest and post harvest use of turtles" (Second National Communication 2014).</p>
Reduction of marine and coastal pollution	Response measures for marine disposal to reduce damage to coral reefs	<p>"Identify waste site areas" ("All too often mangrove areas, oceans, rivers and/or beaches become landfills by default") (1st National Communication to the UNFCCC");</p> <p>MP: To improve coral restoration and conservation and sustain fisheries, "anthropogenic stresses such as pollution and overfishing will be managed through community based coastal area management approaches" (p120/160) (Second National Communication 2014).</p>	
Infrastructure-based coastal protection	Coastal defence structures	<p>"Goal: 2.1: "Improve infrastructure with sustainable and disaster resilient quality - Strategy 3: "Rehabilitate and upgrade major ports and strategic wharves and jetties along the coast and waterways." (Medium Term Development Plan III 2018-2022, 2018);</p> <p>Action 17 includes "Rehabilitate and upgrade major ports and strategic wharves and jetties along the coast and waterways." (Papua New Guinea's Sustainable Development Goal 13 Roadmap: An Empowering Response to Challenges and Opportunities Posed by Climate Change: 30 Actions by 2030, 2020);</p> <p>MP: "Consider seawall and soft measures for coastal protection" (1st National Communication to the UNFCCC, 2000);</p> <p>"Establishing and maintaining port facilities. These standards will ensure that climate change risks are taken into account" (National Transport Strategy 2020).</p>	<p>Action 17</p> <p>"enhanced private sector investment on climate resilient infrastructure" (Papua New Guinea's Sustainable Development Goal 13 Roadmap: An Empowering Response to Challenges and Opportunities Posed by Climate Change: 30 Actions by 2030, 2020);</p>
Relocation and diversifying of activities		<p>"Develop aquaculture" (1st National Communication to the UNFCCC, 2000);</p> <p>Promote climate smart aquaculture pilot projects between 2025 and 2030 (Papua New Guinea's Sustainable Development Goal 13 Roadmap: An Empowering Response to Challenges and Opportunities Posed by Climate Change: 30 Actions by 2030, 2020).</p>	
Relocation of people	Coastal rehabilitation and relocation/settlement to adapt to coastal flooding and SLR (cf point 5 p38)		



<p>Multiple</p>		<p>Objectives 3, 4 and 5 in link with disaster risk management (support implementation and enforcement of building standards, support capacity to effectively plan and deal with natural disasters, support for improved access to safe water, sanitation and hygiene facilities". ; Projects include Mangrove Rehabilitation, Enhancing capacity of communities to cc related floods, ... (Climate Change and Development Authority Corporate Plan 2018-2022 (2018)).</p>	<p>"Establish a Sustainable Development Policy in all sectors, especially forestry, agriculture, mining, energy and oceans by 2015" (p. 72) (Second National Communication 2014); Manage the preparation of guidelines for environmental impact assessment and control of modifications to the shoreline for the purposes of establishing and maintaining port facilities. These standards will ensure that climate change risks are taken into account" (National Transport Strategy 2020).</p>
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WORKING TABLE #15. SAMOA. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy		Develop other sources of renewable energy such as ocean energy: is a strategy identified to reduce mitigation measures to reduce GHG emissions (National Policy on Combating CC, 2007)	
Maritime transportation		Key strategies: T2.1 Regulate the importation and use of environmentally friendly and energy efficient vessels; 2.2 Promote fuel efficiency in sea transport and ensure systems are reliable, efficient and affordable: linked to Key Outcome 2 "Efficient, Sustainable, Safe and Cost-Effective Energy Use in the Transport Sector" (Samoa Energy Sector Plan 2012-2016, 2012).	
ADAPTATION			
Ecosystem-based fisheries management		Existing adaptation activities include: MPAs • Management strategies • Restocking depleted species. Potential adapt. act. include: • Monitoring and management • Establishment of MPAs. The activity "Identify and establish priority conservation areas for priority species protection (both marine and terrestrial)" is costed at US\$75000. (p.54) (NAPA, 2005).	"The state and trend in condition of fisheries (inshore and offshore) will be improved and monitored closely. Linked to Key objective 13 "Improved environmental sustainability and disaster resilience" (Strategy for the development of Samoa (SDS) 2016/17-2019/20 (2016)); Promote adaptation actions in fisheries (National Policy on Combating CC, 2007); Community-based marine resources management program • Research and monitoring programs (NAPA, 2005).
Ecosystem-based coastal protection			
Coastal NbS for other or general purpose		Strategic outcome: areas of marine sites protected increased. In link with the Key outcome 13: Environmental Resilience Improved. (Strategy for the development of Samoa (SDS) 2016/17-2019/20 (2016)); Potential activities: Management program for mangroves and marine resources, Establish marine protected areas, Reforestation program & establishment of nursery for coastal trees, Establish village laws for conservation of MPAs. (NAPA, 2005); Rehabilitation and/or restoration of degraded ecological areas from ridge to reef covering upper watershed and forest area will be improved by replanting native trees: In link with Key outcome 13 "Improved environmental sustainability and disaster resilience" (Strategy for the development of Samoa (SDS) 2016/17-2019/20: 'Accelerating Sustainable Development and Broadening Opportunities for All' (2016)).	Existing activities: Support and monitor marine reserves in communities. (NAPA, 2005).

Reduction of marine and coastal pollution			
Infrastructure-based coastal protection		Coastal Infrastructure Management Strategy • Coastal Implementation Plans • Coastal Management Plans • Integrated Coastal Zone Management • Coastal Infrastructure Protection measures. (NAPA, 2005).	Strategies to achieve the objective of implementing adaptation Measures to protect Samoa from CC impacts: "Promote adaptation actions in natural resources", "Implement the national coastal infrastructure management plans", "Implement community-based coastal adaptation projects through small grant schemes "(National Policy on Combating CC, 2007).
Relocation and diversifying of activities			
Relocation of people			
Multiple			



WORKING TABLE #16. SAMOA. From revised NDC 2021:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems		MP: "By 2030, mangrove forests are effectively protected or restored through national policy and through EBAs to maximize climate change adaptation and mitigation benefits for coastal communities" (Samoa Ocean Strategy 2020-2030, 2020).	
Marine renewable energy			
Maritime transportation		"By 2030, air and marine pollution from ships and ports are reduced by 50% compared with 2020 levels of carbon emissions levels" (Samoa Ocean Strategy 2020-2030, 2020).	"Examine the feasibility of emerging of government-owned shipping companies to improve efficiency" (p.46). "Ensuring that key infrastructure (includes ports) are located close to population centres, to minimise transport distances, synchronising and rationalising journeys" (to minimise fuel consumption) (p.50) (Transport Sector NAMA 2013-2018, 2013); "Promote fuel efficiency in sea transport and ensure systems are reliable, efficient and affordable." (p.38) (Energy Sector Plan, 2017-2022).
ADAPTATION			
Ecosystem-based fisheries management	MP: "Expand the area of mangrove forests in Samoa by 5 percent by 2030 relative to 2018, through mangrove restoration and planting programs in coastal areas. Increasing this area by 5 percent would require Samoa to plant 18.7 ha of new mangroves, while preventing any loss of current mangrove forests. Expanding the area of mangrove forest will help to protect coastal areas and communities against coastal flooding [...], provide valuable habitat for fish, help to protect marine ecosystems, and enhance ecosystem services." ("It is expected that expansion of mangrove forests will also contribute to climate change mitigation, however, Samoa's 2007 emissions inventory did not include data on marine sector emissions and removals, so it was not possible to set a percentage-based target for emissions reductions in this sector.").	Existing adaptation activities include: MPAs • Management strategies • Restocking depleted species. Potential adaptation actions include: • Monitoring and management • Establishment of MPAs. The activity "Identify and establish priority conservation areas for priority species protection (both marine and terrestrial)" is costed at US\$75000. (p.54) (NAPA, 2005). Adaptation measures related to fisheries include managing fisheries resources, establishing marine protected areas and reserves, restoring vital habitats like mangroves and coral reefs, improving public education and devising and implementing sound policy and regulation (p.13). (Second National Communication to the UNFCCC, 2009); "The state and trend in condition of fisheries (inshore and offshore) will be improved and monitored closely. Linked to Key obj 13 "Improved environmental sustainability and disaster resilience" (Strategy for the development of Samoa (SDS) 2016/17-2019/20 (2016));	Community-based marine resources management program • Research and monitoring programs (NAPA, 2005); Adaptation measures related to fisheries include [...] improving public education and devising and implementing sound policy and regulation (p13). (Second National Communication to the UNFCCC, 2009); Gender-fisheries related: "Strengthen collection of gender-related data on the management of marine and coastal resources, with a view to supporting gender equality, ecosystem conservation, sustainable livelihoods and climate resilience." (National Policy on Gender Equality and rights of Women and Girls 2021-2031 (2021));

		<p>Outputs/targets include i) 100% coverage of fishing and related activities managed within Samoa’s EEZ, ii) 100% (300) villages participating in Community-Based Fisheries management program through endorsement of Village Plans and Bye-laws (p42/48) (Agriculture Sector Plan 2016-2020).</p>	<p>(Linked to the TA of the same plan): Objective "Strengthen capacities of communities and private sector to use natural resources in a sustainable way and increase resilience to natural disasters and climate change (p10/48)". Action include "Strengthen the Community-based Fisheries Program" (Agricultural Sector Plan 2016-2020).</p>
Ecosystem-based coastal protection	<p>MP: "Expand the area of mangrove forests in Samoa by 5 percent by 2030 relative to 2018, through mangrove restoration and planting programs in coastal areas. Increasing this area by 5 percent would require Samoa to plant 18.7 ha of new mangroves, while preventing any loss of current mangrove forests. Expanding the area of mangrove forest will help to protect coastal areas and communities against coastal flooding, coastal erosion, and storm surges." ("It is expected that expansion of mangrove forests will also contribute to climate change mitigation, however, Samoa’s 2007 emissions inventory did not include data on marine sector emissions and removals, so it was not possible to set a percentage-based target for emissions reductions in this sector.")</p>	<p>Implement replanting of the coastal area with coastal vegetation in order to improve natural barriers and resilience of coastal area reduce coastal erosion (Community Integrated Management Plans, Aleipata Itupa I Labo-Upolu); "By 2025, 100% coastal management and community protection initiatives adopt an EBA and DRR strategies" (Samoa Ocean Strategy 2020-2030, 2020).</p>	<p>Adaptation measure that should be prioritized in the coming years include: "fund technology transfer to help the Government protect vital infrastructure climate proof coastal infrastructure with both soft and hard adaptation options, including mangroves and coastal wetlands." (p61/99) (Second National Communication to the UNFCCC, 2009);</p>
Coastal NbS for other or general purpose		<p>"Implementing adaptation actions to enhance the climate resilience of the 368 Communities of Samoa" (Samoa Climate Change Policy 2020-2030, 2020);</p> <p>Key adaptation actions linked to biodiversity include: "Replanting mangroves and restoring habitats; improving the way protection regimes for marine and terrestrial biodiversity are managed"(p.14). (Second National Communication to the UNFCCC, 2009);</p> <p>Implement coral gardening, to reduce coral bleaching and Improve resilience of coral reef ecosystem to combat climate change and support nature. Expand existing marine reserves. (Community Integrated Management Plans, Aleipata Itupa I Labo-Upolu);</p> <p>Strategic outcome: areas of marine sites protected increased. In link with the Key outcome 13: Environmental Resilience Improved. (Strategy for the development of Samoa (SDS) 2016/17-2019/20 (2016));</p> <p>MP: "By 2030, mangrove forests are</p>	<p>Key adaptation actions linked to biodiversity include: improving the way protection regimes for marine and terrestrial biodiversity are managed (p14/99). (Second National Communication to the UNFCCC, 2009);</p> <p>"By 2030, monitoring and enforcement are strengthened in order to effectively protect coral reefs and mangroves to enable positive trends in their area cover and recovery from die-back due to bleaching, acidification, and natural disasters." (Samoa Ocean Strategy 2020-2030, 2020)</p>



		<p>effectively protected or restored through national policy and through EBAs to maximize climate change adaptation and mitigation benefits for coastal communities" (Samoa Ocean Strategy 2020-2030, 2020);</p> <p>MP: "By 2030, mangrove forests are effectively protected or restored through national policy to maximize climate change adaptation and mitigation benefits for coastal communities" (Samoa Ocean Strategy 2020-2030, 2020);</p> <p>Rehabilitation and/or restoration of degraded ecological areas from ridge to reef covering upper watershed and forest area will be improved by replanting native trees: In link with Key outcome 13 "Improved environmental sustainability and disaster resilience" (Strategy for the development of Samoa (SDS) 2016/17-2019/20 (2016)).</p>	
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection		<p>Coastal Infrastructure Management Strategy • Coastal Implementation Plans - Coastal Management Plans • Integrated Coastal Zone Management • Coastal Infrastructure Protection measures. (NAPA, 2005);</p> <p>The building of seawalls is encouraged as a viable short-term protective measure. (p.86) (Second National Communication to the UNFCCC, 2009).</p>	<p>Adaptation measure that should be prioritized in the coming years include: "fund technology transfer to help the Government protect vital infrastructure climate proof coastal infrastructure with both soft and hard adaptation options, including mangroves and coastal wetlands." (p61/99) (Second National Communication to the UNFCCC, 2009);</p> <p>Need to incorporate vulnerabilities issues of roads linked to coastal exposure to SLR, wave action, into future investment plan and project design and construction (Transport Sector NAMA 2013-2018, 2013).</p>
Relocation and diversifying of activities			
Relocation of people			
Multiple			<p>"Explore the ocean – climate change nexus to amplify the role of oceans and coastal ecosystems can play in adaptation and mitigation efforts." (Samoa Climate Change Policy 2020-2030, 2020).</p>

WORKING TABLE #17. SOLOMON ISLANDS. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy			
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management	Fisheries and marine resource for adaptation		<p>Improve the understanding of the effects of climate change and climate variability including El Nino-Southern Oscillation on the inshore and tuna fishery resources (refers to the NAPA) (National Climate Change Policy 2012-2017, 2012);</p> <p>Produce country-driven guidelines/manuals for managing coastal and marine resources. (NAPA, 2008).</p>
Ecosystem-based coastal protection		<p>Outcome 3: Establish buffer zones and rehabilitate mangrove forests. (p.94) (NAPA, 2008);</p> <p>To improve communities' resilience to natural hazards: Replanting of foreshore vegetation ; Protection of lagoon and fringing reefs coral reefs ; Protection of forests and littoral vegetation; Protect and where relevant rehabilitate coral reefs and mangroves in build-up coastal areas. (NAPA, 2008).</p>	<p>3.1 Mangrove replanting encouraged and promoted. 3.2 Guidelines for mangrove replanting developed and disseminated. 3.3 Set-back zones established. 3.4 Monitoring system for mangrove encroachment established. (p.94) (NAPA, 2008).</p>
Coastal NbS for other or general purpose		<p>Protect and monitor coral reefs bleaching: actions include rehabilitation of coral reefs, sustainable fisheries promoted, sensitive habitats protected (p94) (NAPA, 2008).</p>	
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection	Coastal protection for adaptation	<p>Climate proofing of key infrastructure to risks including SLR. (refers to the NAPA) (National Climate Change Policy 2012-2017, 2012);</p> <p>Construction and climate-proofing of engineered coastal roads, bridges and other key infrastructure ; Construct seawalls or other protective measures in built-up areas or critical socio-economic infrastructure and activities ; Protective seawalls, revetments, culverts, bulkheads, jetties and floodgates constructed. ; And existing activities include a) Building on stilts on water, b) Seawall construction, c) Propping up of houses in the water (NAPA, 2008).</p>	<p>Establish infrastructure to support climate change research on coastal erosion (National Climate Change Policy 2012-2017, 2012).</p>
Relocation and diversifying of activities			



Relocation of people	Low-lying and artificially build up island for adaptation	Develop and implement plans for relocation of communities (p86/136); existing activities include "Moving inland or to higher ground" (NAPA, 2008).	
Multiple			Integrate climate change adaptation strategies and measures into tourism planning and development. (refers to the NAPA) ; SA: improve the capacity for managing impacts of climate change and SLR on human settlements; TA/MP: facilitate adequate adaptation to climate change and SLR rise in low lying and artificially built-up islands in Malaita and Temotu provinces; TA/MP: increase the resilience and enhance adaptive capacity of coastal communities, socio-economic activities and infrastructure ;increase the resilience of water resources management to impacts of climate change and SLR (National Climate Change Policy 2012-2017, 2012); Promote coastal zone management (ICZM) and integrate climate change adaptation into sustainable coastal development. (NAPA, 2008)

WORKING TABLE #18. SOLOMON ISLANDS. From revised NDC 2021:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems	Enhance carbon sink through sustainable management and protection ("protect at least 15% of coastal and marine areas enabling ecological, representative and well-connected system of protected area in the country, as provided in The National Biodiversity Strategic Action Plan 2016-2020") of coastal and marine ecosystems.	MP: Action which will be taken to achieve target 6 (by 2025, the SI have adopted a community based resource management): Reducing the anthropogenic stress on coastal ecosystems while promoting sustainable harvesting of coastal biodiversity for food security and as a mechanism for climate change adaptation and mitigation. (NBSAP, 2016).	Mention of mangrove in REDD+: Mangroves of Malaita could be eligible through a Mescal project; Activity: Establishment of PAs in four priority areas (including mangroves) (REDD+, readiness proposal, 2019).
Marine renewable energy			
Maritime transportation	Promote renewable energy and energy efficient technologies in the sea transport sub-sector. But "In respect of mitigation in the transport sector there is currently no clear plans to address land and marine transport. It is expected that the Third National Communication project and biennial update report...".		
ADAPTATION			
Ecosystem-based fisheries management			Improve the understanding of the effects of climate change and climate variability including El Nino-Southern Oscillation on the inshore and tuna fishery resources (refers to the NAPA) (National Climate Change Policy 2012-2017, 2012); Produce country-driven guidelines/manuals for managing coastal and marine resources. (NAPA, 2008); Diversify resources in the inshore and offshore in partnership with resource owners and fishing communities. Diversify and introduce appropriate aquaculture systems. (National Development Strategy 2016-2035).
Ecosystem-based coastal protection		Outcome 3: Establish buffer zones and rehabilitate mangrove forests. Related outputs: 3.1 Mangrove replanting encouraged and promoted. (p94) (NAPA, 2008); Improve communities' resilience to natural hazards: Replanting of foreshore vegetation ; Protection of lagoon and fringing reefs coral reefs ; Protection of forests and littoral vegetation; Protect and where relevant rehabilitate coral reefs and mangroves in build-up coastal areas. (NAPA, 2008).	3.2 Guidelines for mangrove replanting developed and disseminated. 3.3 Set-back zones established. 3.4 Monitoring system for mangrove encroachment established. (p94) (NAPA, 2008).



Coastal NbS for other or general purpose		Protect and monitor coral reefs bleaching: actions include rehabilitation of coral reefs, sustainable fisheries promoted, sensitive habitats protected (p94/136) (NAPA, 2008).	
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection		Climate proofing of key infrastructure to risks including SLR. (refers to the NAPA) (National Climate Change Policy 2012-2017, 2012) ; Construction and climate-proofing of engineered coastal roads, bridges and other key infrastructure ; Construct seawalls or other protective measures in built-up areas or critical socio-economic infrastructure and activities ; Protective seawalls, revetments, culverts, bulkheads, jetties and floodgates constructed. ; And existing activities include a) Building on stilts on water, b) Seawall construction, c) Propping up of houses in the water (NAPA, 2008).	Establish infrastructure to support climate change research on coastal erosion (National Climate Change Policy 2012-2017, 2012)
Relocation and diversifying of activities			
Relocation of people		Develop and implement plans for relocation of communities (p86/136); existing activities include "Moving inland or to higher ground" (NAPA, 2008).	
Multiple			Integrate climate change adaptation strategies and measures into tourism planning and development. (refers to the NAPA) ; improve the capacity for managing impacts of climate change and SLR on human settlements; facilitate adequate adaptation to climate change and SLR rise in low lying and artificially built-up islands in Malaita and Temotu provinces; increase the resilience and enhance adaptive capacity of coastal communities, socio-economic activities and infrastructure ;increase the resilience of water resources management to impacts of climate change and SLR (National Climate Change Policy 2012-2017, 2012) ; Promote coastal zone management and integrate climate change adaptation into sustainable coastal development. ; Reinforcing of the implementation of the NAPA on climate change particularly those priorities related to coastal environmental management (Target 11). Research: Documenting of coastal and marine species, their distributions, cultural and subsistence uses and if necessary undertake aquaculture assessment on viable invertebrate (Target 4) + other research (NAPA, 2008).

WORKING TABLE #19. TIMOR-LESTE. From original NDC 2017:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems	Plant mangrove to explore carbon sequestration in mangroves		
Marine renewable energy			
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management	Include ecosystem management in national planning to develop sustainable ongoing programme, nurseries and community awareness development - 1st year assessment, 2nd year plan, 3rd year implementation and maintenance.	Create artificial habitats to enable migration of critical coral reef, fisheries, fishery nursery habitats and shallow marine ecosystems as sea levels and sea temperatures rise (NAPA, 2010).	
Ecosystem-based coastal protection	Maintain mangrove plantations and promote awareness raising to protect coastal ecosystems from impacts of SLR.	MP: Mangrove plantations and awareness raising to protect coastal ecosystems from impacts of sea level rise). (NAPA, 2010) Reduce the impact of storms and flooding by reforestation in coastal areas. Focus on mobilizing communities. (NAPA, 2010) Build a vegetation barrier (mangrove) to minimize erosion impacts. (NAPA, 2010).	Establish a vulnerability-based prioritization system for identification of investments that promote ecosystem based coastal protection. (NAPA, 2010) Awareness raising at community level to understand the benefits of functioning coastal/mangrove ecosystems for sustainable livelihoods and in alleviating climate-related risks and the impacts of destructive and unsustainable methodologies. (NAPA, 2010) • Targeted technical scientific, socio economic and socio-cultural research to support strategic planning and management planning. Participatory research process using appropriate methodologies as a good starting point for other research. Higher scientific knowledge whilst valuing local knowledge. (NAPA, 2010); A policy for managing watershed areas and coastal zones will be developed that will include strategies to rehabilitate and protect mangroves in coastal areas, regulate sand exploration in various rivers, especially the Comoro River, and create buffer zones on river banks and around dams, lakes and coastlines to aid water resource conservation and floodplain control. (Strategic Development Plan 2011-2030).
Coastal NbS for other or general purpose	Plant and protect mangroves to enhance coastal resilience. Priority adaptation areas are	Maintain and restore mangrove and forests and promote awareness raising to protect coastal ecosystems and forests from climate change impacts (there are associated short-term objectives and	Review existing and traditional knowledgebased coastal protection systems and consider how to link this with scientific expertise. Awareness raising and capacity development for

	identified in relation to biodiversity and coastal ecosystem resilience	long-term objectives). (NAPA, 2010) National programme and strategy to combat Invasive alien species in relation to climate change: include research and laboratory, civic education, quarantine strengthening capacity (law & regulatory frameworks, capacity, institutional) and national programme of civic education, improve capacity of technical staff in relation to IAS Research IAS in relation to climate and climate change to reduce impact on land, water, marine ecosystems and productivity (Cost: \$2million). (NAPA, 2010). "The following activities are forbidden in protected areas: The pollution, draining, or destruction of naturally existing wetlands and mangrove areas; The cutting, damaging, removing of a mangrove; The intentional killing, damaging, or destruction of coral or coral reef; The use of explosives or poisons for fishing which results in the killing, damaging, or destroying of coral or coral reef; (Biodiversity Decree, 2012).	planning and operational level stakeholders (government and community representatives) on ecology, benefits, vulnerabilities and management of mangrove ecosystems, technical aspects of rehabilitation and sustainable management, etc. (NAPA, 2010).
Reduction of marine and coastal pollution		"The following activities are forbidden in protected areas: The pollution, draining, or destruction of naturally existing wetlands and mangrove areas; The cutting, damaging, removing of a mangrove; The intentional killing, damaging, or destruction of coral or coral reef; The use of explosives or poisons for fishing which results in the killing, damaging, or destroying of coral or coral reef; (Biodiversity Decree, 2012).	
Infrastructure-based coastal protection	Construction of seawalls in the vulnerable coastal areas to protect from SLR (and improve regulations and standards for climate-resilient infrastructure)	MP: Promote the use of climate resilient building material including local plantations etc. (NAPA, 2010) Develop appropriate physical infrastructure (sea walls, jetty etc) in target vulnerable areas to defend against impacts of sea level rise (loss of land, seawater intrusion, etc). (NAPA, 2010) Protect offshore infrastructure against strong wave damage that impacts the distribution of gas and oil, and reduce accidents and destruction of offshore oil and gas infrastructure. (NAPA, 2010).	
Relocation and diversifying of activities		Incomes in coastal areas to reduce pressure on vital and protected ecosystems. High priority given to the development of fuel wood lots; incentives-based approach to include development of alternative livelihood activities including small business approach such as nature-based tourism. (NAPA, 2010) Livelihood methodology and products adaptation and diversification to increase resilience and reduce dependence in face of sea level rise and increased storm impacts. (NAPA, 2010).	Establish an urbanization research centre to identify vulnerable areas (especially coastal) to formulate climate resilient urban planning. Integrate public interest in the management of natural disasters through design of an appropriate policy mechanism. (NAPA, 2010) Establish early warning systems in areas identified as vulnerable to risks of disasters such as floods and storms. (NAPA, 2010)
Relocation of people			
Multiple			



WORKING TABLE #20. TONGA. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems	PCB: Double the 2015 number of Marine Protected Areas by 2030 / (maintaining national parks, reserves and protected areas) (NB: PB : the document does not elaborate on how an increase in Marine Protected Areas would reduce GHG emissions or strengthen Tonga’s adaptive capacity towards the adverse impact of climate change).		
Marine renewable energy			
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management		<p>Improve fisheries and coral reef management in view of climate change (Climate Change Policy: a resilient Tonga by 2023, 2016).</p> <p>Goal 3: "objective Improve fisheries and coral reef management in view of climate change": associated outcome: Adequate supply of marine sea foods (JNAP, 2010-2015, 2010);</p> <p>Sub-obj 4.2. Strengthen the sustainable development and management of fisheries and aquaculture resources to increase these sectors' resilience to the impacts of cc. Expected outcome: improved resourcing for fisheries monitoring, extension and management, particularly for inshore areas, including for the monitoring of Special Management Areas (SMAs). (JNAP 2018-2028);</p> <p>MP: Where appropriate, mangroves and other tree species will be reestablished within degraded ecosystems to promote foreshore protection and food security. Extraction of non-wood forest products such as medicinal plants, handicraft plants and other cultural plants will be permitted from designated areas under strict controls. (National Forest Policy, 2009);</p> <p>Obj 2.3.: Sustainable management of marine biodiversity (p. 30-32, outcomes and indicators, p. 72), including: "8. Review existing</p>	<p>Activities such as resource environmentally sensitive fishery resources enhancement programmes including farmed coral and aquaculture giant clam. Strengthen the knowledge of fisheries managers about Fish Aggregation Devices.. (linked to a general objective costed but no cost at the activity scale) (JNAP 2018-2028);</p> <p>"The impact of climate change of marine biodiversity requires close monitoring and effective adaptation measures. Measures to address these impacts should be incorporated into new and existing marine resource management plans including the Tuna Management Plan" (p. 32) (National Biodiversity Strategy and Action Plan, 2006)</p>

		marine resources policies and plans and incorporate measures to address the impact of climate change on marine resources and environments" (p. 32) (National Biodiversity Strategy and Action Plan, 2006).	
Ecosystem-based coastal protection		MP: Where appropriate, mangroves and other tree species will be reestablished within degraded ecosystems to promote foreshore protection and food security. Extraction of non-wood forest products such as medicinal plants, handicraft plants and other cultural plants will be permitted from designated areas under strict controls. (National Forest Policy, 2009).	MP: Obj 5: Protect the populations, resources and assets, vulnerable areas at risk from cc impacts: action associated: 5.1 Identify vulnerable areas and develop adaptation options that are cost effective and culturally sensitive to reduce vulnerabilities (foreshore construction, tree planting) (Climate Change Policy: a resilient Tonga by 2035, 2016).
Coastal NbS for other or general purpose		Marine protected areas. 2018 target: 95% of terrestrial waters (compare to 93.7% in 2015), and 2025 target: 98%. (Tonga Strategic Development Framework 2015, 2025, 2015); "Target 1. Every coastal community has a special management area and protected coastal environment" (Climate Change Policy: a resilient Tonga by 2035, 2016); Tonga will halt all deforestation and degradation of all mangrove forests and wetland ecosystems (National Forest Policy for Tonga, 2009); To reduce vulnerability to cc: Effective plant rehabilitation at coastal areas. (JNAP, 2010-2015, 2010).	MP: Obj 5: To protect the populations, resources and assets, vulnerable areas at risk from climate change impacts. Action associated: "5.4 Enforce and enact new regulations to support the building code and all other relevant provisions prohibiting sand removal, mangrove cutting, smoking vehicles and free ranging animals." (p26/30) (Climate Change Policy: a resilient Tonga by 2035, 2016).
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection	Sea wall and foreshore protection (new initiative, investment in resilience), foreshore protection for climate resilience.	Target 2. Redesigned, resilient, roads, coastal areas, buildings, and other infrastructure; Implement appropriate coastal protection systems (Climate Change Policy: a resilient Tonga by 2035, 2016); Goal 3. Obj: Implement appropriate coastal protection systems, with associated outcome: Protection of coastal areas along the most vulnerable low-lying areas. ; Goal 4 "Enhanced community preparedness and resilience to impacts of all disasters" (JNAP, 2010-2015, 2010); Activity 4.1.1. Strengthen coastal infrastructures through the timely implementation of the Tonga Coastal Resilience Project and to replicate this project in the outer islands; activity 4.1.5. Design and implement appropriate, environmentally sensitive flood management responses in all low-lying areas around Tonga (p49/89). (Linked to a costed general obj but no cost at the activity scale) (JNAP 2018-2028).	MP: Obj 5: Protect the populations, resources and assets, vulnerable areas at risk from cc impacts: action associated: 5.1 Identify vulnerable areas and develop adaptation options that are cost effective and culturally sensitive to reduce vulnerabilities (foreshore construction, tree planting) (Climate Change Policy: a resilient Tonga by 2035, 2016).

<p>Relocation and diversifying of activities</p>			
<p>Relocation of people</p>			<p>5.5 Investigate alternative sites for possible relocation of settlements from low-lying vulnerable areas. (Climate Change Policy: a resilient Tonga by 2023, 2016). Activity 1.5.3 Conduct a study of scenarios of relocation due to cc and natural disasters impacts" (p43) (JNAP 2018-2028).</p>
<p>Multiple</p>		<p>MP: Goal 4 "Enhanced community preparedness and resilience to impacts of all disasters" (JNAP 2010-2015, 2010)</p>	<p>Objective 3: To improve and strengthen the collection, storage, management, analysis and use of data (including Greenhouse gases, vulnerability & climate data) to monitor climate, sea level change and their effects. (Climate Change Policy: a resilient Tonga by 2035, 2016);</p> <p>Integrated management: "Develop a national coastal zone management plan integrating the adapted JNAP targets for a Resilient Tonga (p42/89)" ; "1.4.1.: develop integrated water management plans for all rural villages, integrated with village specific information from the national coastal zone." (p43) +</p> <p>Research: Establish a monitoring system for currents, waves and ocean pH levels; Identified gaps in water, [...] coastal erosion plus related sectors and strengthen the monitoring and management systems for each sector (p.45) (JNAP 2018-2028).</p> <p>"It is clear from the above that more research is needed to establish better estimates of how much water is available throughout Tonga within the context of a precautionary approach to unfolding climate change and sea level rise" (p. 19) (Tonga Agriculture sector plan, 2016-2020);</p> <p>Regulation: Actions 2.1. (p29/98) Strengthen existing legislation and or introduce new ones to support effective EIA procedures as a means of regulating sand mining, land reclamation, coral quarrying, mangrove destruction and waste disposal; 2. Implement Environmental Impact Assessments procedures to assess and mitigate against adverse impacts of development activities on coastal environments." Linked to adaptation through food security and coastal protection, in a few sentences before (p28) (National Biodiversity Strategy and Action Plan, 2006).</p>



WORKING TABLE #21. TONGA. From revised NDC 2020:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems		<p>"Protect mangrove forests: protect all (100 percent) of intact mangrove forests and other coastal vegetation, as called for in the 2009 National Forest Policy and 2017 Forest Management Plan. Tree density and carbon stock are high per ha. This would include amending the current policy regarding mangrove management, and an approach to explore would be payment for ecosystem services. This action would also include rehabilitation of mangrove forests." (Long-Term Low Emission Development Strategy 2021-2050 (2021));</p> <p>MP: Support the expansion of MPAs and SMAs. GHG emissions reduction potential: Low. Description: This action aligns directly with the JNAP2 and Second NDC objectives to expand MPAs and SMAs to cover 30 percent of Tonga's EEZ. More broadly, it will also support resilient fisheries development and marine and coastal ecosystems conservation." (Long-Term Low Emission Development Strategy 2021-2050 (2021));</p> <p>MP: Coastal vegetation for mitigation and coastal protection: ("In line with climate change policy calling for coastal protection, this action prioritises the use of nature-based solutions for protection against storm surges and erosion. This entails leveraging traditional knowledge in plant selection for restoration of mangroves and replanting of foreshores. Restoration of mangroves, replanting and general strengthening of the coastal ecosystem will also have positive GHG emission sequestration outcomes although these cannot be quantified at the present time. Where vegetation is inadequate for blocking storm surges and sea level rise, revetments and seawalls may be needed to protect communities from the surrounding ocean incursions. Assessments and feasibility studies need to be conducted in each case to determine the most appropriate modality for coastal protection.") (Long-Term Low Emission Development Strategy 2021-2050 (2021)).</p>	<p>MP: "Establish SMA association and ensure its maintenance through financial support and capacity, in order to support the expansion of MPAs and SMAs. GHG emissions reduction potential: Low. Description: This action aligns directly with the JNAP2 and Second NDC objectives to expand MPAs and SMAs to cover 30 percent of Tonga's EEZ. More broadly, it will also support resilient fisheries development and marine and coastal ecosystems conservation." (Long-Term Low Emission Development Strategy 2021-2050 (2021));</p>
Marine renewable energy			
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management	<p>MP: Maintain the existing stocks of fish and other marine species through a commitment to expand the area covered by MPAs and Spacial Management Areas to 30% of the Tonga's EEZ.</p>	<p>Sub-obj 4.2. Strengthen the sustainable development and management of fisheries and aquaculture resources to increase these sectors' resilience to the impacts of cc. Expected outcome: improved resourcing for fisheries monitoring, extension and management, particularly for inshore areas, including for the monitoring of Special Management Areas (SMAs). (linked to a general objective costed but no cost at the activity scale) (JNAP 2018-2028);</p> <p>MP: Where appropriate, mangroves and other tree species will be reestablished within degraded ecosystems to promote foreshore protection and food security. Extraction of non-wood forest products such as medicinal plants, handicraft plants and other cultural plants will be permitted from designated</p>	<p>To strengthen the sustainable development and management of fisheries... activities such as resource environmentally sensitive fishery resources enhancement programmes including farmed coral and aquaculture giant clam. Strengthen the knowledge of fisheries managers about Fish Aggregation Devises.. (linked to a general objective costed but no cost at the activity scale) (JNAP 2018-2028);</p> <p>MP: "Establish SMA association and ensure its maintenance through</p>

		<p>areas under strict controls. (National Forest Policy, 2009);</p> <p>"Key JNAP2 targets relevant to the AFOLU sector of the LT-LEDS are (1) resilient fisheries development and marine and coastal ecosystems conservation, including special management areas (SMAs)" (p. 53, 99); "objective of 'Increasing sustainable shared benefits for the Kingdom from optimal use of its living marine resources" (p. 54) ;</p> <p>"The 2nd NDC sets a [...] fisheries target of maintaining existing stocks of fish and other marine species through a commitment to expand the area covered by Marine Protected Areas (MPAs) and Special Management Areas (SMAs) to 30 percent of Tonga's exclusive economic zone (EEZ)" (p. 54) ;</p> <p>"Rehabilitation of the Fanga'uta Lagoon of Tongatapu, which once provided abundant shellfish (Toó, Kuku, etc) and fish (particularly mullet) to its communities. First steps would be to survey the existing marine life and implement an SMA or MPA as appropriate."(Long-Term Low Emission Development Strategy 2021-2050 (2021));</p> <p>MP: "Establish strong waste strategy and integrate the strategy into community development plans. [...] will act as a road map with links to [...] fisheries. Associated GHG reduction emissions potential: low to medium. Start year: 2025. Links to Second NDC: Indirect link to the target of expanding formal Waste collection". "Thus, the proper collection and sorting of solid waste can reduce the risk of marine, coastal and ecosystem pollution, thus serving as a co-benefit towards adaptation." (Long-Term Low Emission Development Strategy 2021-2050 (2021)).</p>	<p>financial support and capacity, in order to support the expansion of MPAs and SMAs. GHG emissions reduction potential: Low.</p> <p>Description: This action aligns directly with the JNAP2 and Second NDC objectives to expand MPAs and SMAs to cover 30 percent of Tonga's EEZ. More broadly, it will also support resilient fisheries development and marine and coastal ecosystems conservation." (Long-Term Low Emission Development Strategy 2021-2050 (2021))</p>
<p>Ecosystem-based coastal protection</p>	<p>MP: Expand the area covered by Marine Protected Areas (MPAs) and Special Management Areas (SMAs) to 30% of the Tonga's Exclusive Economic Zone (EEZ) in order to prevent any permanent loss of land to rising sea levels on Tonga's four main islands.</p>	<p>MP: Where appropriate, mangroves and other tree species will be reestablished within degraded ecosystems to promote foreshore protection and food security. Extraction of non-wood forest products such as medicinal plants, handicraft plants and other cultural plants will be permitted from designated areas under strict controls. (National Forest Policy, 2009);</p> <p>MP: Coastal vegetation for mitigation and coastal protection: ("In line with climate change policy calling for coastal protection, this action prioritises the use of nature-based solutions for protection against storm surges and erosion. This entails leveraging traditional knowledge in plant selection for restoration of mangroves and replanting of foreshores. Restoration of mangroves, replanting and general strengthening of the coastal ecosystem will also have positive GHG emission sequestration outcomes although these cannot be quantified at the present time. Where vegetation is inadequate for blocking storm surges and sea level rise, revetments and seawalls may be needed to protect communities from the surrounding ocean incursions. Assessments and feasibility studies need to be conducted in each case to determine the most appropriate modality for coastal protection.") (Long-Term Low Emission Development Strategy 2021-2050 (2021));</p> <p>Action 11: "Foster the establishment of industry-based and community-based cooperatives for the establishment and management of forests and trees, including community coastal care committees to develop and implement management plans for the rehabilitation of degraded foreshores and for the improved management of foreshores, particularly in areas most vulnerable to rising sea levels and storm</p>	<p>Improve the enforcement of controls on illegal tree clearing on the coast for coastal protection. (Management Plan for the Forests and Tree resources of Tonga (2017)).</p>



		surges" (p. 9-10) (Management Plan for the Forests and Tree resources of Tonga (2017)).	
Coastal NbS for other or general purpose			"Strengthen and refine current policy on coastal protection in order to strengthen Marine Protected Areas" (p. 82) (Long-Term Low Emission Development Strategy 2021-2050 (2021)).
Reduction of marine and coastal pollution		MP: "Establish strong waste strategy and integrate the strategy into community development plans. [...] will act as a road map with links to [...] fisheries. Associated GHG reduction emissions potential: low to medium. Start year: 2025. Links to Second NDC: Indirect link to the target of expanding formal Waste collection". "Thus, the proper collection and sorting of solid waste can reduce the risk of marine, coastal and ecosystem pollution, thus serving as a co-benefit towards adaptation." (Long-Term Low Emission Development Strategy 2021-2050 (2021)).	
Infrastructure-based coastal protection		Activity 4.1.1. Strengthen coastal infrastructures through the timely implementation of the Tonga Coastal Resilience Project and to replicate this project in the outer islands. ; activity 4.1.5. Design and implement appropriate, environmentally sensitive flood management responses in all low-lying areas around Tonga (p.49). (Linked to a costed general obj but no cost at the activity scale) (JNAP 2018-2028).	Where vegetation is inadequate for blocking storm surges and sea level rise, revetments and seawalls may be needed to protect communities from the surrounding ocean incursions. Assessments and feasibility studies need to be conducted in each case to determine the most appropriate modality for coastal protection. (Long-Term Low Emission Development Strategy 2021-2050 (2021)); Actions to reduce coastal erosion and its effects: Develop guidelines under the Land Act 1988 and the Environmental Impact Assessment Act 2003 for circumstances under which developments, including roads, buildings and sand mining, may be permitted within the foreshore zone and conditions that must be applied to mitigate any adverse impacts. (Management Plan for the Forests and Tree resources of Tonga (2017)).
Relocation and diversifying of activities			
Relocation of people			Activity 1.5.3 Conduct a study of scenarios of relocation due to climate change and natural disasters impacts" (p.43) (JNAP 2018-2028).
Multiple			"Establish a monitoring system for currents, waves and ocean pH levels; Identified gaps in water, .. coastal erosion plus related sectors and strengthen the monitoring and management systems for each sector" (p.45). (JNAP 2018-2028); "It is clear from the above that more research is needed to establish better estimates of how much water is available throughout Tonga within the context of a precautionary approach to unfolding climate change and sea level rise" (p.19) (Tonga Agriculture sector plan, 2016-2020).

WORKING TABLE #22. TUVALU. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems			
Marine renewable energy			
Maritime transportation			
ADAPTATION			
Ecosystem-based fisheries management		<p>Strategy 1.4: "1.4 Coordinated planning and management of marine [...] and coastal resources and systems (Whole Island Systems Management/ Ecosystem base management) (p. 45) (National strategic Action Plan for Climate change and disaster risk management 2012-2016 (2012) & in Te Kaniva (National Climate Change Policy, 2012-2021 (2012));</p> <p>Goal of the project called "Increasing resilience of Coastal Areas and Community Settlement to cc": Coastal communities protection enhanced. Associated activities include development of nursery. Budget allocated: 15,000 each year during 3 years. (NAPA, 2007).</p>	<p>Strategy 1.7: "1.7 Legislation and policies to govern sustainable resource management, (marine, coastal and land) in the context of climate change impacts"; (National strategic Action Plan for Climate change and disaster risk management 2012-2016 (2012) & Te Kaniva (National Climate Change Policy) 2012-2021 (2012)).</p>
Ecosystem-based coastal protection		<p>Planting vegetation close to shorelines (ongoing); protecting existing shoreline vegetation (ongoing); (Te Kakeega III National strategy for sustainable development, 2016)</p>	<p>Strategy 1.2: "1.2 Assessment and analysis of salt and/ or heat tolerant food crops (e.g. pulaka) and tree species for coastal protection". (National strategic Action Plan for Climate change and disaster risk management 2012-2016 (2012) & Te Kaniva (National Climate Change Policy) 2012-2021 (2012)).</p>
Coastal NbS for other or general purpose			<p>Action 1.4.8: "Assess and seek international support for reducing the impacts of climate change (such as temperature increase, ocean acidification, changing pattern of circulation and ocean saturation) on coral reef, seagrass, algae, mangroves and other ecosystems"; Strategy 7.1: "7.1 Secure the EEZ of Tuvalu (approved coordinates) as belonging to the Government and People of Tuvalu regardless of any loss of coastal areas or islands due to impacts of climate change such as sea level rise" (National strategic Action Plan for Climate change and disaster risk management 2012-2016 (2012) & Te Kaniva (National Climate Change Policy) 2012-2021 (2012));</p>
Reduction of marine and coastal pollution			<p>Action 4.2.10: "4.2.10 Conduct site specific assessment (including assessment of lagoon water quality, circulation and lagoon water chemistry) to inform planning for coastal protections and causeways constructions" (p. 50) (National</p>

			strategic Action Plan for Climate change and disaster risk management 2012-2016 (2012)).
Infrastructure-based coastal protection		<p>"Goal of the project called ""Increasing resilience of Coastal Areas and Community Settlement to cc"": Coastal areas protected. Associated activities will include: 2) Construction of coastal defenses (costed 600,000 USD year 1 and 2 each year, and 400,000 year 3); and 3) Construction of channel current breakers (costed 40,000 year 1 and 2 each year, and 30,000 year 3) (NAPA, 2007);</p> <p>Construction of seawalls (as needed) (Te Kakeega III National strategy for sustainable development, 2016)" .</p>	<p>"Goal of the project called "Increasing resilience of Coastal Areas and Community Settlement to cc": Coastal areas protected. Associated activities will include: 1) Training of local Kaupule/Government personnel on construction of Coastal defenses and Channel Breakers structures (costed 50,000 USD year 1). (NAPA, 2007);</p> <p>"Coastal protections and causeways constructions followed best practices appropriate for Tuvalu's situation and reduce vulnerability to the impacts of climate change, climate variability and geological hazards" (National strategic Action Plan for Climate change and disaster risk management 2012-2016 (2012) & Te Kaniva (National Climate Change Policy) 2012-2021 (2012));</p> <p>"To forestall manmade interference, elements of the coastal zone management in Tuvalu will include:</p> <ul style="list-style-type: none"> • introducing more stringent building codes (difficult considering local building customs, the regulatory oversight involved, and enforcement cost – see Section 9.5); • increasing community awareness (on-going); and • monitoring sea levels (on-going, see above)." (Te Kakeega III National strategy for sustainable development, 2016)".
Relocation and diversifying of activities			
Relocation of people			
Multiple			



WORKING TABLE #23. VANUATU. From original NDC 2016:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems		"Enhance Vanuatu's natural resource status through carbon mitigation opportunities" (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)).	Enhance Vanuatu's natural resource status through carbon mitigation opportunities by: "developing and strengthening planning and legal frameworks to avoid damage to high carbon natural resources and ecosystems (e.g. mangroves, coral reefs and sea grasses) and developing partnerships on blue and green carbon sinks with other countries in the region to accelerate progress and build capacity and expertise." (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)).
Marine renewable energy			
Maritime transportation		"Support implementation of the Vanuatu National Energy Road Map and energy considerations for climate change adaptation and risk reduction by: "exploring the possibility of powering sea-going vessels with renewable energy"; "ensuring improvements in the fuel efficiency for the transport sector (land, sea and air) by standardising engine fuel efficiency" (p30) (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)).	
ADAPTATION			
Ecosystem-based fisheries management	Ecosystem based approaches to enhance the national adaptation efforts, including marine resource management and aquaculture (is one of the 11 top adaptation priorities of the NAPA) (including Community based marine resource management (which is one of the 5 top priorities for support and implementation of the NAPA))	"Encourage establishment of protected areas to ensure sustainability of marine resources". (NAPA, 2007);	Community based marine resource management programmes (modern & traditional aquaculture) (p. 44 and following). Considered as a priority adaptation action. (NAPA, 2007); "1) Improved fisheries management through: • Preparing a sector strategy; • Implementing the tuna management plan; • Revision of fisheries legislation; • Institutional capacity building within the fisheries Department; • Strengthening Provincial capacity for coastal fishery management. ; 2) Sustainable coastal and reef management through: • Mobilising communities to manage their coastal and reef fishery resources; • Facilitating the marketing of reef fish; • Improving stakeholder involvement in the sector; • Mobilising local communities to arrange their own fish

			<p>aggregating devices; • Assessment of the sustainable management of the live reef fish trade.</p> <p>3) Sustainable offshore management through • Effective monitoring of catches and enforcement of Total Allowable Catch limits; • Maximising the resource rental from the oceanic tuna; • Promoting local investment in value-adding activities and fish exports. 4) Expand employment of seafarers through • Seafarer training." (Priorities and Action Agenda, 2006);</p> <p>MP: "The need for 'ridge to reef' actions to maintain coastal fisheries production was widely recognized by ni-Vanuatu stakeholders and should help build resilience of coral reefs, mangroves and sea grasses to climate change." (Second National Communication to the UNFCCC, 2014).</p>
Ecosystem-based coastal protection		<p>"Prioritising "soft" ecosystem based adaptation over "hard" engineered infrastructure for ecosystem function maintenance (e.g. coastal revegetation versus sea walls)." (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015));</p> <p>MP: "Support ecosystem adaptation and risk reduction services by prioritising actions that incorporate threats and solutions from the 'ridge to the reef' of island communities." (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015));</p> <p>In the Panama Province, a possible adaptation option to reduce coastal erosion and flooding that treats tourism, infrastructures... is the "Replanting of coastal vegetation to protect coastline". In the Malampa Province, possible adaptation options to reduce coastal erosion and flooding is to "Encourage the re-vegetation of coastal species with the assistance of the department of Forests to curb coastal erosion (NAPA, 2007).</p>	
Coastal NbS for other or general purpose	Protection and conservation of Vanuatu's natural resources and biodiversity, taking climate change issues in consideration.	MP: "Support ecosystem adaptation and risk reduction services by prioritising actions that incorporate threats and solutions from the 'ridge to the reef' of island communities; (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)).	MP: "The need for 'ridge to reef' actions to maintain coastal fisheries production was widely recognized by ni-Vanuatu stakeholders and should help build resilience of coral reefs, mangroves and sea grasses to climate change." (Second National Communication to the UNFCCC, 2014)
Reduction of marine and coastal pollution			

Infrastructure-based coastal protection		MP: Possible adaptation options include: Relocation of settlements and relevant infrastructures • Demarcation of hazard and risk areas • Develop provincial adaptation plans or incorporation of climate change into provincial planning. (NAPA, 2007).	
Relocation and diversifying of activities			
Relocation of people		MP: Possible adaptation options include: Relocation of settlements and relevant infrastructures • Demarcation of hazard and risk areas • Develop provincial adaptation plans or incorporation of climate change into provincial planning. (NAPA, 2007).	
Multiple	Integrated coastal zone management		Outcome 2: "Mainstreaming of adaptation into policies and programmes. Output 2.1: Coastal management activities integrated across sectors, programmes and at various levels of society in the programme sites." (NAPA, 2007); Output 3.1 "Improved capacity of institutions and human resources to develop and implement adaptation strategies and measures in coastal environment; development of expertise in application of climate and ocean models to forecast impacts and vulnerability; improved managerial skills for decision-makers and coastal stakeholders" (p. 46). (NAPA, 2007).

WORKING TABLE #24. VANUATU. From revised NDC 2020:

Categories of OBCAs	Actions from NDC	Actions from the policies referenced in NDCs	
		Targeted Actions 	Supporting actions 
MITIGATION			
Protection or restoration of blue carbon ecosystems		Enhance Vanuatu’s natural resource status through carbon mitigation opportunities. (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)).	Enhance Vanuatu’s natural resource status through carbon mitigation opportunities by: "developing and strengthening planning and legal frameworks to avoid damage to high carbon natural resources and ecosystems (e.g. mangroves, coral reefs and seagrasses) and developing partnerships on blue and green carbon sinks with other countries in the region to accelerate progress and build capacity and expertise. (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)).
Marine renewable energy	Improve transport (land and marine) energy efficiency by 10% by 2030.		
Maritime transportation		<p>"Support implementation of the Vanuatu National Energy Road Map and energy considerations for climate change adaptation and risk reduction by: "exploring the possibility of powering sea-going vessels with renewable energy"; "ensuring improvements in the fuel efficiency for the transport sector (land, sea and air) by standardising engine fuel efficiency;" (p30). (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015))</p> <p>Improve transport (land and marine) energy efficiency. For that, need of data. Target: 2% in 2020, and 10% in 2030 (compare to a BAU projections). Reform import duties, tariffs, and VAT to encourage imports of energy efficient and renewable energy equipment, such as spare parts in marine vessels. (National Energy Road Map (2016-2030) Implementation Plan (2019));</p> <p>A priority target is: "Improve transport (land and marine) energy efficiency." (p46/86); A proposed investment/action is: "Spare parts for vehicles and marine vessels to encourage imports of energy efficient and renewable energy equipment." (p76) (Updated Vanuatu National Energy Road Map 2016 - 2030 (2016)).</p>	<p>A proposed investment/action is: "Support the Department of Agriculture to develop a policy for the coconut industry, which would cover coconut oil for electricity generation, coconut oil-based fuel for land and sea transport" (estimated cost is US\$0.06m). (p77) (Updated Vanuatu National Energy Road Map 2016 - 2030 (2016)).</p>
ADAPTATION			
Ecosystem-based fisheries management		MP: "Maintaining a pristine natural environment at sea that serves our food, cultural, economic and ecological needs, with enhanced resilience and adaptive capacity to climate change and natural disasters" (p10). (National Sustainable Development Plan 2016 to 2030: Vanuatu 2030 The People's Plan (2016)).	

Ecosystem-based coastal protection		<p>"Prioritising "soft" ecosystem based adaptation over "hard" engineered infrastructure for ecosystem function maintenance (e.g. coastal revegetation versus sea walls). (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015));</p> <p>MP: "Support ecosystem adaptation and risk reduction services by prioritising actions that incorporate threats and solutions from the 'ridge to the reef' of island communities; (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015));</p> <p>MP: "Maintaining a pristine natural environment at sea that serves our food, cultural, economic and ecological needs, with enhanced resilience and adaptive capacity to climate change and natural disasters" (p10) (National Sustainable Development Plan 2016 to 2030: Vanuatu 2030 The People's Plan (2016)).</p>	<p>"The actions identified [in the National Ocean Policy 2016] under the category on climate change and disaster risk reduction include to: (i) promote and support efficient, effective Climate Change & Disaster Risk Reduction efforts using Ecosystem-based Approaches" (Third National Communication to the UNFCCC (2020)).</p>
Coastal NbS for other or general purpose		<p>MP: "Support ecosystem adaptation and risk reduction services prioritising actions that incorporate threats and solutions from the 'ridge to the reef' of island communities." (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)).</p>	
Reduction of marine and coastal pollution			
Infrastructure-based coastal protection			<p>MP: "Support ecosystem adaptation and risk reduction services by: 1) prioritising actions that incorporate threats and solutions from the 'ridge to the reef' of island communities" (Vanuatu Climate Change and Disaster Risk Reduction Policy 2016-2030 (2015)).</p>
Relocation and diversifying of activities			
Relocation of people			
Multiple			
Other	<p>« Vanuatu is committed to maintaining its forest cover in the country and is expected to remain net carbon negative in future as well. The REDD+ programme is currently being implemented in Vanuatu to improve sustainable forest management practices. » 0 specific NDC actions identified for forestry sub-sector as the measures to reduce deforestation and promote good land care to accepted mitigation practices are still under development under the REDD+ initiative. « Based on the results and outcome from the REDD+ initiative, potential mitigation interventions shall be included in future NDC update. »</p>		

Appendix 2.A: Criteria and indicators of the IUCN Global Standard for Nature-based Solutions

Table 2.A.1. Criteria and indicators of the IUCN Global Standard for Nature-based Solutions. From: “IUCN (2020). Guidance for using the IUCN Global Standard for NbS. A user-friendly framework for the verification, design and scaling up of nature-based solutions. First edition. Gland, Switzerland: IUCN.”

CRITERIA	INDICATORS
Criterion 1: Societal challenges	<ul style="list-style-type: none"> • 1.1. The most pressing societal challenge(s) for rights-holders and beneficiaries are prioritized; • 1.2. The societal challenge(s) addressed are clearly understood and documented; • 1.3. Human well-being outcomes arising from the NbS are identified, benchmarked and periodically assessed Guidance: NbS must deliver tangible and substantive benefits to human well-being. Specific, measurable, attainable, realistic and timely (SMART) targets should be used as appropriate, as they are important for accountability and informing adaptive management.
Criterion 2: Design at scale	<ul style="list-style-type: none"> • 2.1. The design of the NbS recognizes and responds to interactions between the economy, society and ecosystems; • 2.2. The design of the NbS is integrated with other complementary interventions and seeks synergies across sector; • 2.3. The design of the NbS incorporates risk identification and risk management beyond the intervention site.
Criterion 3: Biodiversity net gain	<ul style="list-style-type: none"> • 3.1. The NbS actions directly respond to evidence-based assessment of the current state of the ecosystem and prevailing drivers of degradation and loss; • 3.2. Clear and measurable biodiversity conservation outcomes are identified, benchmarked and periodically assessed; • 3.3. Monitoring includes periodic assessments of unintended adverse consequences on nature arising from the NbS; • 3.4. Opportunities to enhance ecosystem integrity and connectivity are identified and incorporated into the NbS strategy.
Criterion 4: Economic feasibility	<ul style="list-style-type: none"> • 4.1. The direct and indirect benefits and costs associated with the NbS, who pays and who benefits, are identified and documented; • 4.2. A cost-effectiveness study is provided to support the choice of NbS including the likely impact of any relevant regulations and subsidies; • 4.3. The effectiveness of the NbS design is justified against available alternative solutions, taking into account any associated externalities; • 4.4. NbS design considers a portfolio of resourcing options such as market-based, public sector, voluntary commitments and actions to support regulatory compliance.
Criterion 5: Inclusive governance	<ul style="list-style-type: none"> • 5.1. A defined and fully agreed upon feedback and grievance resolution mechanism is available to all stakeholders before an NbS intervention is initiated;

	<ul style="list-style-type: none"> • 5.2. Participation is based on mutual respect and equality, regardless of gender, age or social status, and upholds the right of Indigenous Peoples to Free, Prior and Informed Consent; • 5.3. Stakeholders who are directly and indirectly affected by the NbS have been identified and involved in all processes of the NbS intervention; • 5.4. Decision-making processes document and respond to the rights and interests of all participating and affected stakeholders; • 5.5. Where the scale of the NbS extends beyond jurisdictional boundaries, mechanisms are established to enable joint decision-making of the stakeholders in the affected jurisdictions.
Criterion 6: Balance trade-offs	<ul style="list-style-type: none"> • 6.1. The potential costs and benefits of associated trade-offs of the NbS intervention are explicitly acknowledged and inform safeguards and any appropriate corrective actions; • 6.2. The rights, usage of and access to land and resources, along with the responsibilities of different stakeholders, are acknowledged and respected; • 6.3. The established safeguards are periodically reviewed to ensure that mutually-agreed trade-off limits are respected and do not destabilize the entire NbS.
Criterion 7: Adaptive management	<ul style="list-style-type: none"> • 7.1. A NbS strategy is established and used as a basis for regular monitoring and evaluation of the intervention; • 7.2. A monitoring and evaluation plan is developed and implemented throughout the intervention lifecycle; • 7.3. A framework for iterative learning that enables adaptive management is applied throughout the intervention lifecycle.
Criterion 8: Mainstreaming and sustainability	<ul style="list-style-type: none"> • 8.1. The NbS design, implementation and lessons learnt are shared to trigger transformative change; • 8.2. The NbS informs and enhances facilitating policy and regulation frameworks to support its uptake and mainstreaming; • 8.3. Where relevant, the NbS contributes to national and global targets for human well-being, climate change, biodiversity and human rights, including the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

Table 2.A.2. Links between the elements required for the global stocktake (UNFCCC, 2018) and the indicators of the IUCN Global Standard for NbS.

Elements of the global stocktake (UNFCCC, 2018*)	Relevant indicators of the IUCN Global Standard for NbS
(a) The state of greenhouse gas emissions and removals	<ul style="list-style-type: none"> • 1.3 Human well-being outcomes arising from the NbS are identified, benchmarked and periodically assessed
(b) The overall effect of countries' NDCs and overall progress made towards the implementation of NDCs	<ul style="list-style-type: none"> • 1.3 Human well-being outcomes arising from the NbS are identified, benchmarked and periodically assessed; • 3.2 Clear and measurable biodiversity conservation outcomes are identified, benchmarked and periodically assessed; • 3.3 Monitoring includes periodic assessments of unintended adverse consequences on nature arising from the NbS ; • 7.1 NbS strategy is established and used as a basis for regular monitoring and evaluation of the intervention; • 7.2 A monitoring and evaluation plan is developed and implemented throughout the intervention lifecycle
(c) The state of adaptation efforts, support, experience and priorities	<ul style="list-style-type: none"> • 1.1 The most pressing societal challenge(s) for rights-holders and beneficiaries are prioritized; • 1.3 Human well-being outcomes arising from the NbS are identified, benchmarked and periodically assessed
(d) Finance flows	<ul style="list-style-type: none"> • 4.1 The benefits and costs associated with the NbS, who pays and who benefits, are identified and documented; • 4.4 NbS design considers a portfolio of resourcing options
(e) Efforts to enhance understanding, action and support to minimize loss and damage	<ul style="list-style-type: none"> • 2.3 The design of the NbS incorporates risk identification and risk management beyond the intervention site; • 6.1 The potential costs and benefits of associated trade-offs of the NbS intervention are explicitly acknowledged and inform safeguards and any appropriate corrective actions
(f) Barriers and challenges	<ul style="list-style-type: none"> • 1.2 The societal challenges addressed are clearly understood and documented; • 4.1 The benefits and costs associated with the NbS, who pays and who benefits, are identified and documented
(g) Sharing good practices to enhance international cooperation	<ul style="list-style-type: none"> • 8.1 The NbS design, implementation and lessons learnt are shared to trigger transformative change; • 8.2 The NbS informs and enhances facilitating policy and regulation frameworks to support its uptake and mainstreaming
(h) Fairness consideration, including equity, as communicated by countries in their NDCs	<ul style="list-style-type: none"> • 5.2 Participation is based on mutual respect and equality; • 5.3 Stakeholders who are affected by the NbS have been identified and involved in all processes of the NbS intervention; • 5.4 Decision-making processes document and respond to the rights and interests of all participating and affected stakeholders; • 6.2 The rights, usage of and access to land and resources of different stakeholders are acknowledged and respected.

*UNFCCC (2018). Decision 19/CMA.1. Matters relating to Article 14 of the Paris Agreement and paragraphs 99–101 of decision 1/CP.21

Appendix 2.B: Statistical analysis to test the robustness of results

We applied statistical tests to our results to test their robustness. Results are in Table 2.B.1 below. We wanted to know if there was a significant difference regarding the alignment with the IUCN Global Standard for NbS, between coastal nature-based solutions (NbS) included in the original Nationally Determined Contributions (NDCs) of Pacific Small Island Developing States (PSIDS), versus those included in their revised NDCs. We also tested the significance of the differences in alignment found between the four categories of solutions (see Table 2.2.1 in the Materials and Method section of the paper. The statistical tests applied were student tests.

Student tests (“t.test” in excel) are used as followed: t.test(sample 1; sample 2; uni/bilateral; variance type). We selected the bilateral distribution (“2” in the equation), and the unequal variance distribution (heteroscedastic, “3” in the equation). We applied the following equations:

t.test(sample 1; sample 2; 2; 3)

t.test(sample 3 ; sample 4 ; 2 ; 3)

t.test(sample 3 ; sample 5 ; 2 ; 3)

t.test(sample 3 ; sample 6 ; 2 ; 3)

t.test(sample 4 ; sample 5 ; 2 ; 3)

t.test(sample 4 ; sample 6 ; 2 ; 3)

t.test(sample 5 ; sample 6 ; 2 ; 3)

Sample 1 is composed of the coastal NbS included in the original NDCs of PSIDS; it contains 12 observations (i.e., 12 coastal NbS). Sample 2 is composed of the coastal NbS included in the revised NDCs of PSIDS and contains 10 observations. Sample 3, sample 4, sample 5 and sample 6 refer to coastal NbS from category A (6 observations), category B (8 observations), category C (3 observations) and category D (5 observations), respectively.

The null hypothesis was that the means of the two samples are not significantly different. We rejected the null hypothesis if the student test was less or equal to 5%. The number of stars in Table 2.B.1 represents the significance level of the test: one star (*) if significant at 5%; two stars (**) if significant at 1%; and three stars (***) if significant at 1%.

Table 2.B.1. Statistical tests (*t*.test) across the four categories of coastal nature-based solutions, and between coastal nature-based solutions included in the original Nationally Determined Contributions of the Pacific Small Island Developing States versus those included in their revised ones. C1 to C8 correspond to the eight criteria of the IUCN Global Standard for NbS (see Table 2.A.1 for detail on the criteria). Ov (“overall match”) corresponds to the average of the criteria.

	C1	C2	C3	C4	C5	C6	C7	C8	Ov
Original NDCs mean	1.75	2.06	1.44	1.33	1.46	1.19	1.36	2.11	1.59
Revised NDCs mean	2.23	2.63	1.83	1.35	1.90	1.23	1.53	2.37	1.88
T.test origina vs. revised	.0004***	.0005***	.0129*	.8716	.7263	.7263	.2260	.2415	.0019**
Cat. A mean	1.83	2.17	1.58	1.33	1.63	1.17	1.33	2.28	1.66
Cat. B mean	2.13	2.38	1.53	1.41	1.66	1.21	1.33	2.25	1.74
Cat. C mean	2.11	2.56	1.83	1.25	1.67	1.33	1.44	2.11	1.79
Cat. D mean	1.80	2.27	1.65	1.30	1.70	1.20	1.73	2.20	1.73
T.test cat. A vs. B	0.0863	0.4847	0.7835	0.5833	0.8636	0.7384	1.000	0.9244	0.5874
T.test cat. A vs. C	0.0680	0.2048	0.4273	0.6149	0.8315	0.3955	0.6038	0.6343	0.3199
T.test cat. A vs. D	0.8468	0.6618	0.7520	0.8180	0.7506	0.8468	0.0600	0.8079	0.6961
T.test cat. B vs. C	0.9383	0.5327	0.3224	0.3323	0.9563	0.5160	0.6045	0.6684	0.6973
T.test cat. B vs. D	0.1143	0.6111	0.5382	0.4431	0.8500	0.9608	0.0460	0.8634	0.9804
T.test cat. C vs. D	0.1023	0.3301	0.5609	0.7680	0.8904	0.5531	0.2307	0.7982	0.7415
T.test cat. C vs. A, B, D		0.3113							
T.test cat. D vs. A, B, C							0.0362*		

Table 2.B.2. Criteria scores for coastal nature-based solutions (NbS) in the original and revised Nationally Determined Contributions (NDC) of the Pacific Small Island Developing States. C1 to C8 correspond to the eight criteria of the IUCN Global Standard for NbS (Table 2.A.1 precisely describes the criteria). “Ov” (“overall match”) corresponds to the average of the criteria.

NDC	Category	Coastal NbS	C1	C2	C3	C4	C5	C6	C7	C8	Ov
In original NDCs											
Timor-Leste original NDC (2017)	A	Mangrove planting	2.00	2.00	1.25	1.25	1.50	1.00	1.00	2.00	1.50
Kiribati original NDC (2016)	A	Mangrove, seagrass protection/enhancement	1.67	2.33	2.00	1.50	1.75	1.33	2.00	2.00	1.82
Marshall Islands original NDC (2016)	A	Mangrove rehabilitation	2.00	2.00	1.00	1.00	1.50	1.33	1.00	2.00	1.48
Timor-Leste original NDC (2017)	B	Mangrove conservation	2.00	2.00	1.25	1.25	1.50	1.00	1.00	2.00	1.50
Solomon Islands original NDC (2016)	B	Management of fisheries and marine resources	1.67	1.67	1.25	1.50	1.25	1.33	1.33	2.33	1.54
Cook Islands original NDC (2016)	B	Designate the entire EEZ as a marine park	1.33	1.67	1.25	1.25	1.00	1.00	1.00	2.33	1.35
Tonga original NDC (2016)	B	Double the 2015 number of MPAs by 2030	1.67	2.00	1.50	1.50	1.75	1.33	1.33	2.00	1.64
Fiji original NDC (2016)	C	Mangrove planting	2.00	2.33	1.50	1.25	1.25	1.33	1.33	2.00	1.63
Fiji original NDC (2016)	D	Sustainable management of fisheries	2.00	2.33	1.75	1.00	1.00	1.00	1.67	2.00	1.59
Timor-Leste original NDC (2017)	D	Ecosystem management to develop nurseries	1.33	1.67	1.50	1.25	1.50	1.00	1.00	2.00	1.41
Vanuatu original NDC (2016)	D	Community-based marine resource management	1.67	2.67	1.75	2.00	2.25	1.67	2.00	2.67	2.08
Niue original NDC (2016)	D	Ecosystems approach to fisheries management	1.67	2.00	1.25	1.25	1.25	1.00	1.67	2.00	1.51
Average			1.75	2.06	1.44	1.33	1.46	1.19	1.36	2.11	1.59
In revised NDCs											
Fiji revised NDC (2020)	A	Marine biodiversity protection and restoration	2.00	2.33	2.00	1.75	2.25	1.00	1.33	3.00	1.96
Papua New Guinea revised NDC (2020)	A	Include BC ecosystems in GHG inventory	1.67	2.00	1.25	1.25	1.75	1.33	1.33	2.33	1.61
Solomon Islands revised NDC (2021)	A	Sustainable management & protection of coastal ecosystems	1.67	2.33	2.00	1.25	1.00	1.00	1.33	2.33	1.61
Fiji revised NDC (2020)	B	Conservation of critical ocean ecosystems	2.67	3.00	1.75	1.75	2.50	1.33	1.33	2.33	2.08
Papua New Guinea revised NDC (2020)	B	Conservation, establish MPAs and locally managed marine areas	2.33	3.00	1.75	1.25	1.75	1.33	1.33	2.33	1.89
Nauru revised NDC (2021)	B	Implement coastal NbS to increase resilience	2.67	2.67	1.50	1.50	1.50	1.00	1.00	2.00	1.73
Tonga revised NDC (2020)	B	Expand MPAs and SMAs to 30% of the EEZ	2.67	3.00	2.00	1.25	2.00	1.33	2.33	2.67	2.16
Papua New Guinea revised NDC (2020)	C	Coastal ecosystem planting/rehabilitation	2.33	3.00	1.75	1.25	1.75	1.33	1.33	2.33	1.89
Samoa revised NDC (2021)	C	Expand the area of mangrove forests	2.00	2.33	2.25	1.25	2.00	1.33	1.67	2.00	1.85
Fiji revised NDC (2020)	D	Sustainable fishing practices	2.33	2.67	2.00	1.00	2.50	1.33	2.33	2.33	2.06
Average			2.23	2.63	1.83	1.35	1.90	1.23	1.53	2.37	1.88

Appendix 2.C: Detailed list of coastal NbS identified in the Nationally Determined Contributions of Pacific Small Island Developing States

Table 2.C.1. Detailed list of coastal nature-based solutions identified in the Nationally Determined Contributions of the Pacific Small Island Developing States (PSIDS). AFOLU: Agriculture, Forestry and Other Land Use. REDD+: Reducing Emissions from Forest Reduction and Forest Degradation. Category A refers to the conservation, restoration and sustainable management of coastal vegetation for climate mitigation. Category B refers to the conservation of coastal ecosystems for climate adaptation. Category C refers to their restoration for climate adaptation. Category D refers to the community-based sustainable management of coastal fisheries for climate adaptation.

PSIDS	Categ.	Coastal nature-based solutions
Fiji revised NDC (2020)	A	Marine biodiversity protection and restoration: “Marine biodiversity (mangrove, seagrass) protection (including 30% of the exclusive economic zone in marine protected areas (MPAs) and restoration for mitigation purpose (enhance sinks of greenhouse gases).”
Papua New Guinea revised NDC (2020)	A	Include BC ecosystems in GHG inventory: “Include blue carbon (BC) ecosystems in the greenhouse gas (GHG) inventory and UNFCCC reporting, including: identify pathways to incorporating blue carbon by build upon existing AFOLU and REDD+ capabilities considering how to reflect mangroves and seagrasses in climate policies, data collection, mapping and modelling.”
Timor-Leste original NDC (2017)	A	Mangrove planting: “Plant mangrove to explore carbon sequestration in mangroves and enhance coastal resilience.”
Solomon Islands revised NDC (2021)	A	Sustainable manag. & protect coastal ecosystems: “Enhance carbon sink through sustainable management and protection (“protect at least 15% of coastal and marine areas enabling ecological, representative and well-connected system of protected area in the country, as provided in The National Biodiversity Strategic Action Plan 2016-2020”) of coastal and marine ecosystems.”
Kiribati original NDC (2016)	A	Mangrove, seagrass protection/enhancement: “Kiribati will proactively protect and sustainably manage its mangrove resources, as well as protect and enhance coastal vegetation and seagrass beds. Together these actions represent effective stewardship of more than 6 million tonnes of carbon dioxide stored, more than 100 times the current annual national emissions inventory.”
Republic of Marshall Islands original NDC (2016)	A	Mangrove rehabilitation: “Mangrove rehabilitation programs to enhance carbon sinks as well as assist with protection of water resources and the health of the RMI people.”
Fiji revised NDC (2020)	B	Conservation of critical ocean ecosystems: “Protection and conservation of critical ocean ecosystems (mangroves, coral reefs) to mitigate the impact of flooding and cyclones. / Prioritize nature-based solutions to mitigate the impact of flooding and cyclones.”
Papua New Guinea revised NDC (2020)	B	Conservation, Establish MPAs and LMMAs: “Protection and promotion of biodiversity conservation through ecosystem-based approaches / Establish MPAs and locally managed marine areas (LMMAs) to reduce damage on coral reefs.”

Timor-Leste original NDC (2017)	B	Mangrove conservation: “(a): Maintain mangrove plantations and promote awareness raising to protect coastal ecosystems from impacts of sea-level rise; (b): Protect mangroves to enhance coastal resilience.”
Solomon Islands original NDC (2016)	B	Management of fisheries and marine resources: “Management of fisheries and marine resources for adaptation.”
Nauru revised NDC (2021)	B	Implement coastal NbS to increase resilience: “Implement nature-based solutions to increase the protection against coastal erosion and the resilience of coastal zone ecosystems and biodiversity” (“The protection of marine ecosystems as a nature-based solution will augment efforts to reduce coastal erosion.”)
Cook Islands original NDC (2016)	B	Designate the entire EEZ as a marine park: “Designating its entire exclusive economic zone of almost two million sq km as a marine park is evidence of national commitment to the global effort to building the resilience of marine ecosystems / coastal protection / marine conservation.”
Tonga original NDC (2016)	B	Double the 2015 number of MPAs by 2030: “Double the 2015 number of Marine Protected Areas by 2030 / (maintaining national parks, reserves and protected areas).”
Tonga revised NDC (2020)	B	Expand MPAs and SMAs to 30% of the Tonga’s EEZ: “Expand the area covered by Marine Protected Areas (MPAs) and Special Management Areas (SMAs) to 30% of the Tonga’s Exclusive Economic Zone (EEZ) in order to prevent any permanent loss of land to rising sea levels on Tonga's four main islands, and to Maintain the existing stocks of fish and other marine species.”
Fiji original NDC (2016)	C	Mangrove planting: “The planting of mangroves is part of ongoing initiatives to build resilience.”
Papua New Guinea revised NDC (2020)	C	Coastal ecosystems planting/rehabilitation: “Plant mangrove to adapt to coastal flooding and sea-level rise/ Plant mangroves, seagrasses and corals, manage mangrove, and rehabilitate corals to reduce damage on coral reefs.”
Samoa revised NDC (2021)	C	Expand the area of mangrove forests: “Expand the area of mangrove forests in Samoa by 5 percent by 2030 relative to 2018, through mangrove restoration and planting programs in coastal areas. Increasing this area by 5 percent would require Samoa to plant 18.7 ha of new mangroves, while preventing any loss of current mangrove forests.”
Fiji original NDC (2016)	D	Sustainable management of fisheries: “Fisheries policies have been developed on the sustainable management of Fiji's natural marine resources.”
Fiji revised NDC (2020)	D	Sustainable fishing practices: “Adopt sustainable fishing practices taking climate change into account.”
Timor-Leste original NDC (2017)	D	Ecosystem management to develop nurseries: “Include ecosystem management in national planning to develop nurseries.”
Vanuatu original NDC (2016)	D	Community-based marine resource management: “Marine resource management and aquaculture to adapt to climate change (through the National Adaptation Programme of Actions)/community based marine resource management” (through the National Adaptation Programme of Actions).”
Niue original NDC (2016)	D	Ecosystems Approach to fisheries management.

Table 2.C.2. Two examples of how coastal nature-based solutions are described in the Nationally Determined Contributions.

Information in the NDC	Scale	Criteria informed
<p><u>EXAMPLE 1: Conservation of critical ocean ecosystems for adaptation.</u> In Fiji revised NDC (2020).</p> <p>Main quote in the text:</p> <p>“Protection and conservation of critical ocean ecosystems (mangroves, coral reefs) to mitigate the impact of flooding and cyclones. Prioritize nature-based solutions to mitigate the impact of flooding and cyclones.”</p> <p>Other quotes in the text:</p> <ul style="list-style-type: none"> - “Fiji will take appropriate steps to protect its social infrastructure against climate change and prioritise gender, disability, and the needs of the children and elderly in disaster management and in climate action.” - “Fiji will take measures to ensure that public infrastructure is resilient to cyclones and floods.” - “Development of a monitoring and evaluation systems, the development of a communication plan and the formation of a financing plan to ensure effectiveness of its planned adaptations measures.” “Transparent communication and robust monitoring system [...] to ensure [...] accountability in all climate actions”. - “Fiji is facing loss and degradation of vital ecosystems [...] including its coral reefs, coasts and catchments.” - “Fiji will take measures to ensure that public infrastructure is resilient to cyclones and floods, prioritizing nature-based economically viable solutions.” - “The NDC planning process was guided by the principle of gender-responsiveness as articulated in the National Climate Change Policy. The Policy emphasises and makes a specific call to ensure that all approaches and methods for adaptation and mitigation are guided by the consideration of gender issues, [...] and achieve outcomes which ensure that gender is a key consideration when programming finance and capacity-building.” - “Ensure equity, justice, inclusion, transparency, and accountability in all climate actions.” 	<p>NDC</p> <p>NDC</p> <p>NAP</p> <p>Country</p> <p>NDC/NbS</p> <p>NDC</p> <p>NDC/NbS</p>	<p>C1 and C5</p> <p>C2</p> <p>C4 and C7</p> <p>C3</p> <p>C4</p> <p>C5 and C6</p> <p>C5 and C6</p>
<p><u>EXAMPLE 2: Expand the area of mangrove forests.</u> In Samoa revised NDC (2021).</p> <p>Main quote in the text:</p> <p>“Expand the area of mangrove forests in Samoa by 5 percent by 2030 relative to 2018, through mangrove restoration and planting programs in coastal areas. Increasing this area by 5 percent would require Samoa to plant 18.7 ha of new mangroves, while preventing any loss of current mangrove forests.”</p>	<p>NbS</p>	<p>C2 and C3</p>

<p>Other quotes in the text:</p> <ul style="list-style-type: none"> - “Expanding the area of mangrove forest will help to protect coastal areas and communities against coastal flooding, coastal erosion, and storm surges. It will also provide valuable habitat for fish, help to protect marine ecosystems, and enhance ecosystem services.” “Citizens rely on the productivity of primary industries such as agriculture and fishing, which have been adversely impacted by changing weather patterns and natural disasters.” - “It is expected that expansion of mangrove forests will also contribute to climate change mitigation, however, Samoa’s 2007 emissions inventory did not include data on marine sector emissions and removals, so it was not possible to set a percentage-based target for emissions reductions in this sector.” - “The success of mangrove restoration and planting [...] requires external financial support.” - “The consent from various stakeholders (including coastal villages) has been identified as a key of success for mangrove enhancement.” 	<p>NbS</p> <p>NbS</p> <p>NbS</p> <p>NbS</p>	<p>C1 and C2</p> <p>C1 and C2</p> <p>C4</p> <p>C5 and C6</p>
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Appendix 2.D: Trends in Global Environment Facility climate and biodiversity funding for Pacific Small Island Developing States between 1994 and 2022

We analyzed the evolution of the Global Environment Facility (GEF) funding (amount) to PSIDS in relation to both (i) biodiversity, (ii) climate, and (iii) cross-cutting biodiversity/climate projects, between 1994 (start of GEF 1) and 2022 (end of GEF 7). An excel spreadsheet containing all GEF-funded projects is downloadable on the GEF website (<https://www.thegef.org/projects>). It contains the following information referring to funded projects: “ID”, “Title”, “Focal Areas”, “Grant and Cofinancing”, “Implementing Agencies”, “Countries”, “Fund source”, “Period”, “Status”. We only retained for analysis projects related to the fifteen PSIDS part of our scope. In most cases, the available information did not allow for a distinction between terrestrial and marine projects, so our analysis of GEF funding considers both types of projects. First, we classified projects according to their focal area (i.e., Biodiversity, Climate change, International waters, Land degradation). Sometimes a project referred to several focal areas. We only considered projects referring to biodiversity only, climate only, or both biodiversity and climate: these are the three focal areas selected for analysis. This last category (“biodiversity and climate”) is not exclusive, which means that we also considered in this category projects whose focal areas referred to, for example, "biodiversity, climate and international waters ". This is why we called this category “Biodiversity & Climate change (+ others)”. We then categorized projects by countries and GEF phases (GEF 1 to GEF 7). Sometimes projects were solely funded by the GEF, but more often they were co-financed (for instance, by the GEF and another entity such as the World Bank). If a project was co-financed, we only considered the GEF funding contribution, not the total amount of funding associated with the project. Finally, we summed the GEF contributions for each of the three focal areas examined (biodiversity, climate, biodiversity and climate change + others), by GEF phase (1-7), and by country (the 15 PSIDS). The results on GEF funding trends over time are presented below in Fig. 2.D.

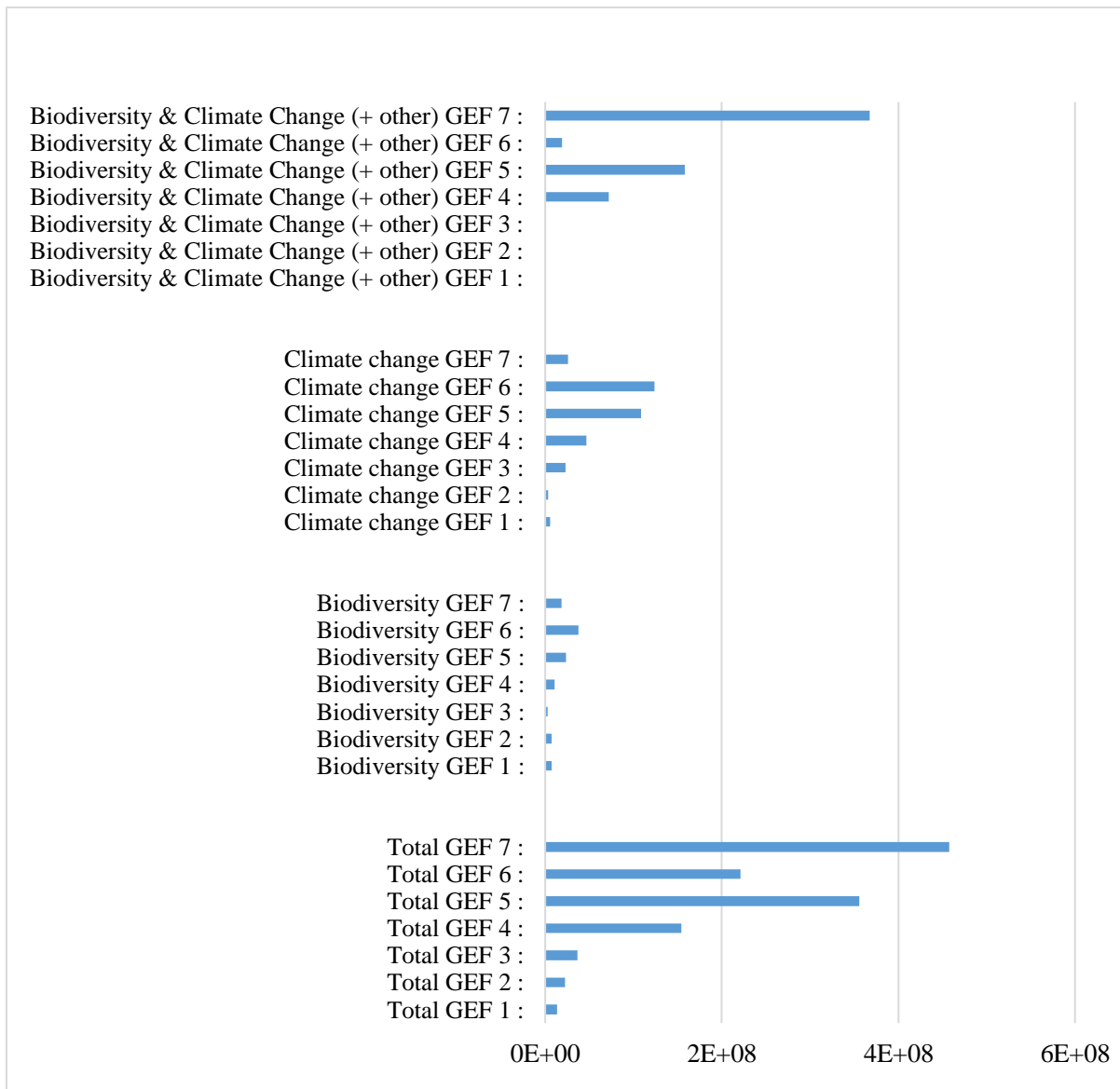


Fig.2.D: Trends in Global Environment Facility (GEF) funding (in US\$) between 1994 and 2022 for the Pacific Small Island Developing States. Data used for analysis is from the website <https://www.thegef.org/projects>. GEF Periods: GEF 1: 1994-1998, GEF 2: 1998-2002; GEF 3: 2002-2006; GEF 4: 2006-2010; GEF 5: 2010-2014; GEF 6: 2014-2018; GEF 7: 2018-2022.

Appendix 2.E: Assessment spreadsheet

The entire assessment spreadsheet is a detailed version of Fig. 2.4 and contains justifications for each indicator of the IUCN Global Standard for each coastal NbS in each PSIDS' NDC. This spreadsheet can be found in the Supplementary Material of the online version of the published article, at: [doi:10.1016/j.nbsj.2022.100034](https://doi.org/10.1016/j.nbsj.2022.100034).

Appendix 3.A: Search equations to identify relevant literature

- (i) In the Scopus engine search we used the following search equations:

Equation 1:

TITLE-ABS-KEY (*mangrove** OR *coral** OR *reef** OR *seagrass** AND "cultural ecosystem service*" OR "cultural service*" OR "cultural benefit*" OR "traditional us*" OR "cultural valu*" OR "cultural us*" OR "non-economic val*" OR "intangible val*" OR "social val*" OR "immaterial val*" OR "non-economic service*" OR "intangible service*" OR "social service*" OR "immaterial service*" AND *Fiji* OR "Federated States of Micronesia" OR *Kiribati* OR "Marshall Islands" OR *Palau* OR "Papua New Guinea" OR *Nauru* OR *Niue* OR "Cook Islands" OR *Samoa* OR "Solomon Islands" OR *Tonga* OR *Tuvalu* OR *Vanuatu* OR *Timor* OR "South Pacific")

Equation 2:

ALL ("nature's contribution" AND *mangrove** OR *coral** OR *reef** OR *seagrass**) AND TITLE-ABS-KEY (*Fiji* OR "Federated States of Micronesia" OR *Kiribati* OR "Marshall Islands" OR *Palau* OR "Papua New Guinea" OR *Nauru* OR *Niue* OR "Cook Islands" OR *Samoa* OR "Solomon Islands" OR *Tonga* OR *Tuvalu* OR *Vanuatu* OR *Timor* OR "South Pacific")

Equation 3:

ALL (*valu** AND *mangrove** OR *coral** OR *reef** OR *seagrass**) AND TITLE-ABS-KEY ("ecosystem service*" OR "ecological service" AND *Fiji* OR "Federated States of Micronesia" OR *Kiribati* OR "Marshall Islands" OR *Palau* OR "Papua New Guinea" OR *Nauru* OR *Niue* OR "Cook Islands" OR *Samoa* OR "Solomon Islands" OR *Tonga* OR *Tuvalu* OR *Vanuatu* OR *Timor* OR "South Pacific")

- (ii) In the Google scholar engine search and in the Pacific Hub Database, we used the following search equations:

Equation 1:

[country] + *mangrove** OR *coral** OR *reef** OR *seagrass** + "nature's contribution*" OR "ecosystem service*" OR "ecological service*" OR "ecosystem goods and service*" OR "ecosystem benefit*"

Equation 2:

[country] + *mangrove** OR *coral** OR *reef** OR *seagrass** + "cultural service*" OR "intangible valu*" OR "cultural us*" OR "social val*" OR "immaterial val*" OR "traditional us*"

Equation 3:

[country] + *mangrove** OR *coral** OR *reef** OR *seagrass** + *valu** ;

Where "[country]" refers to the 15 PSIDS part of the scope of the study.

Appendix 3.B: List of the 57 studies reviewed

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Appendix 3.C: Categorization of ecosystem services according to (i) The Economics of Ecosystems and Biodiversity (TEEB, 2010)* and (ii) in the literature review of Chapter 3

	Classification of The Economics of Ecosystems and Biodiversity (TEEB, 2010)	Classification used in the systematic literature review
Category of ecosystem services	Type of ecosystem services	Type of ecosystem services
Provisioning	Food	Food
	Water	Water
	Raw materials	N/A
	Genetic resources	Genetic resources
	Medicinal resources	N/A
	Ornamental resources	Ornamental resources
Regulating and maintenance	Air quality regulation	Air quality regulation
	Climate regulation	Climate regulation
	Moderation of extreme events	Moderation of extreme events
	Regulation of water flows	Regulation of water flows
	Waste treatment	Waste treatment
	Erosion prevention	Erosion prevention
	Maintenance of soil fertility	Maintenance of soil fertility
	Pollination	Pollination
	Biological control	Biological control
	Maintenance of life cycles	Maintenance of life cycles
	Maintenance of genetic diversity	Maintenance of genetic diversity
Cultural	Aesthetic information	Aesthetic information
	Opportunities for recreation and tourism	Opportunities for recreation and tourism
	Inspiration for culture, art and design	Inspiration for culture, art and design
	Spiritual experience	Spiritual experience
	Information for cognitive development	Information for cognitive development
	Existence, bequest values	Existence, bequest values
	N/A	Raw materials
	N/A	Medicinal resources

*TEEB, (2010). The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.

Appendix 3.D.1. Coastal ecosystem services in the Pacific Small Island Developing States from our systematic literature review.

ES: ecosystem service; ESVD: Ecosystem Services Valuation Database; FJD: Fijian dollar; PNG: Papua New Guinea; SBD: Solomon Islands dollar; USD: United States dollar; WST: Samoan Tala (Samoa’s currency). The accronyms and descriptions of the valuation methods are available in Appendix 3.D.2.

ES text	Ecosystem	TTEB ES	ES category	Region	Country	Site name	Site Area	Monetary Value	Value temporal	Value spatial unit	Currency	Value year	Quantitative non monetary value	Quantitative indicator	Qualitative value	INT\$ 2022 ha yr ⁵⁷	Valuation method	Authors	Year publi	Type publi
Habitat function	Mangrove	Maint. of life cycles	R&M	Mela.	Fiji	Viti Levu	18,500 ha	116 - 389	/year	/ha	USD	2014				315		Agrawala et al.	2003	Report
Medicinal plants	Mangrove	Medicinal resources	C	Mela.	Fiji	Viti Levu	18,500 ha	116 - 233	/year	/ha	USD	2014				218		Agrawala et al.	2003	Report
Subsistence fisheries	Mangrove	Food	P	Mela.	Fiji	Viti Levu	18,500 ha	116 - 233	/year	/ha	USD	2014				218		Agrawala et al.	2003	Report
Coastal protect.	Mangrove	Coastal protect.	R&M	Mela.	Fiji	Viti Levu	18,500 ha	1,940	/year	/ha	USD	2014				2,428		Agrawala et al.	2003	Report
Subsistence and cash economy from reef	Coral reef	Food	P	Mela.	Solomon Islands	Western prov. and Central isl. prov.	20,400 ha	5,173	/year	/capita	USD	2011		Reefs are of critical importance as a source of food [...]			CV	Albert et al.	2015	Peer-reviewed
Aquarium and coral products: Sand, rubble, stone, lime...	Coral reef	Ornamental resources	P	Mela.	Solomon Islands	Western prov. and Central isl. prov.	20,400 ha	2,213	/year	/capita	USD	2011					CV	Albert et al.	2015	Peer-reviewed
Food	Coral reef	Food	P	Mela.	Solomon Islands		575,000 ha	940,000	/year	Total area	SDB	2010				2	MP	Albert et al.	2012	Peer-reviewed
Shoreline protection	Coral reef	Erosion prevention	R&M	Mela.	Solomon Islands		575,000 ha	144,000	/year	Total area	SDB	2010				0	RC	Albert et al.	2012	Peer-reviewed
Non-use	Coral reef	Existence & bequest	C	Mela.	Solomon Islands		575,000 ha	35,000	/year	Total area	USD	2010				0	CD	Albert et al.	2012	Peer-reviewed
Coral reef and demersal fisheries	Coral reef	Food	P	Mela.	Solomon Islands			9,320,000	/year	Total area	USD	2013					MP	Arena et al.	2015	Report
Aquarium trade	Coral reef	Ornamental resources	P	Mela.	Solomon Islands			163,747	/year	Total area	USD	2013						Arena et al.	2015	Report
Subsistence fisheries	Coral reef	Food	P	Mela.	Solomon Islands			58,800,000	/year	Total area	USD	2013					MP	Arena et al.	2015	Report
Multiple (Mariculture, handicrafts, bioremediation, cultural ident., aesthetic beauty)	Coastal eco.	Multiple	All	Mela.	Solomon Islands									In Malaita, [...] very important because of the tradition of tafuli'ae [...]			Arena et al.	2015	Report	

⁵⁷ The inflation calculator is available at: <https://www.in2013dollars.com/us/inflation/2014?amount=1>

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Shoreline protection	Coral reef	Erosion prevention	R&M	Mela.	Solomon Islands	Prov. Of Guadalcanal	10,380 ha	3,300,000 – 5,600,000 /year	Total area	USD	2013		584	DC	Arena et al.	2015	Report
Beche de mer	Coastal eco.	Food	P	Mela.	Solomon Islands			446,000 /year	Total area	USD	2013		58	MP	Arena et al.	2015	Report
Tourism	Coastal eco.	Recreation & tourism	C	Mela.	Solomon Islands			15,000,000 /year	Total area	USD	2013		1,939			2015	Report
Carbon sequestration	Mangrove	Climate regulation	R&M	Mela.	Solomon Islands			21,000,000 /year	Total area	USD	2013		2,715	MP		2015	Report
Spiritual significance	Coral reef	Spiritual exp.	C	Mela.	Solomon Islands	Roviana and Vonavona isl.									Aswani	2014	Peer-reviewed
Subsistence fisheries	Mangrove	Food	P	Poly.	Samoa	Fugalei, Vaitolo, Sataoa, Pata			50 house holds		2001	80% of the population still rely on fish as a source of protein			Boon	2001	Peer-reviewed
Making decorations	Mangrove	Inspir. for culture, art design	C	Poly.	Samoa	As above			As above		2001	Uses of mangroves construction (19%), making decoration (14%), collecting firewood (12%), making fishing equipment (12%), making tools (12%), extracting marine food (11%), canoe making (9%), domestic (3%), recreation (3%), medicinal herbs (3%), tannin (2%).			Boon	2001	Peer-reviewed
Medicines	Mangrove	Medicinal resources	C	Poly.	Samoa	As above			As above		2001	As above	As above		Boon	2001	Peer-reviewed
Construction, firewood, canoes, equipment, tannin	Mangrove	Raw materials	C	Poly.	Samoa	As above			As above		2001	As above	As above		Boon	2001	Peer-reviewed
Cyclones wind barriers	Mangrove	Mod. extreme events	R&M	Poly.	Samoa	As above			As above		2001	As above			Boon	2001	Peer-reviewed
Habitats for species	Mangrove	Maint. of life cycles	R&M	Poly.	Samoa	As above			As above		2001	As above			Boon	2001	Peer-reviewed
Erosion control	Mangrove	Erosion prevention	R&M	Poly.	Samoa	As above			As above		2001	As above			Boon	2001	Peer-reviewed
Soil improvement	Mangrove	Waste treatment	R&M	Poly.	Samoa	As above			As above		2001	As above			Boon	2001	Peer-reviewed
Shades and food for	Mangrove	Food	P	Poly.	Samoa	As above			As above		2001	As above			Boon	2001	Peer-reviewed

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Air quality regulation	Mangrove	Air quality regulation	R&M	Mela.	Vanuatu	1,665 ha	236	/year	/ha	USD	2016	291	VT	Buckwell et al.	2020	Peer-reviewed	
Climate regulation	Mangrove	Climate regulation	R&M	Mela.	Vanuatu	1,665 ha	3,064	/year	/ha	USD	2016	3,782	VT	Buckwell et al.	2020	Peer-reviewed	
Moderation of disturbance	Mangrove	Mod. extreme events	R&M	Mela.	Vanuatu	1,665 ha	316	/year	/ha	USD	2016	390	VT	Buckwell et al.	2020	Peer-reviewed	
Medicinal resources	Mangrove	Medicinal resources	C	Mela.	Vanuatu	1,665 ha	3	/year	/ha	USD	2016	4	VT	Buckwell et al.	2020	Peer-reviewed	
Climate regulation	Coral reef	Mod. extreme events	R&M	Mela.	Vanuatu	70,238 ha	213	/year	/ha	USD	2016	267	VT	Buckwell et al.	2020	Peer-reviewed	
Moderation of disturbance	Coral reef and mangrove	Mod. extreme events	R&M	Mela.	Vanuatu	70,238 ha	188	/year	/ha	USD	2016	232	VT	Buckwell et al.	2020	Peer-reviewed	
Raw materials and energy	Coral reef	Raw materials	P	Mela.	Vanuatu	70,238 ha	1	/year	/ha	USD	2016	1	VT	Buckwell et al.	2020	Peer-reviewed	
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	Tanna	2,493 ha	16,375	/year	Total area	USD	2016		VT	Buckwell et al.	2020	Peer-reviewed
Recreation	Mangrove	Recreation & tourism	C	Mela.	Vanuatu	1665 ha	282	/year	/ha	USD	2016	348	VT	Buckwell et al.	2020	Peer-reviewed	
Food	Seagrass	Food	P	Mela.	Vanuatu	124,038 ha	21	/year	/ha	USD	2016	26	VT	Buckwell et al.	2020	Peer-reviewed	
Climate regulation	Seagrass	Climate regulation	R&M	Mela.	Vanuatu	124,038 ha	45	/year	/ha	USD	2016	56	VT	Buckwell et al.	2020	Peer-reviewed	
Historical, cultural and recreational central value	Coral reef	Recreation & tourism	C	Poly.	Cook isl.	112,000 ha		/year	Total area		2017			Butler	2017	Report	
Tourism	Coral reef	Recreation & tourism	C	Poly.	Cook isl.	112,000 ha		/year	Total area		2017		CE	Butler	2017	Report	
Fishing commercially for the local market	Coral reef	Food	P	Poly.	Cook isl.	Rarotonga		/year	Total area		2017			Butler	2017	Report	
Fishing commercially for the local market	Coral reef	Food	P	Poly.	Cook isl.	Pa Enuu fishing		/year	Total area		2017			Butler	2017	Report	
Subsistence fishing	Coral reef	Food	P	Poly.	Cook isl.		112,000 ha	/year	Total area		2017			Butler	2017	Report	

Marine resources and environments occupy a central place in the historical, cultural and recreational life of Cook Island society and are valued highly.

[...] A 'beautiful natural environment' was the highest rating 'most appealing factor' for international visitors surveyed. [...] 100% and 80% ...

4% of households in Rarotonga fishing commercially for the local market

10% in Pa Enuu fishing commercially for the local market

38% of all households fishing for subsistence.

% of visitors coming for beaches and reefs

% of households

% of households

% of households

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Historical, cultural and recreational central value	Coral reef	Inspir. for culture, art design	C	Poly.	Cook isl.	112,000 ha	/year	Total area	2017	Occupy a central place in the historical, cultural and recreational life of Cook Island society & are accordingly valued highly.	Butler	2017	Report		
Habitat for threatened species	Seagrass	Maint. of life cycles	R&M	Mela.	Fiji					Fiji's extensive pastures of seagrass and algae appear to be a significant resource for many green turtles.	Craig et al.	2004	Peer-reviewed		
Habitat for species	Seagrass	Maint. of life cycles	R&M	Mela.	Fiji	Nubuko reef in Laucala Bay				Provision of critical habitat for fish and invertebrates, provision of habitat for endangered species.	Cullen-Unsworth et al.	2014	Peer-reviewed		
Not specific	Mangrove	Multiple	All	Mela.	PNG	Western prov.				Over 50% of the population of the Western Province utilized mangrove biota, either directly, man-or through market.	Ellison	1997	Peer-reviewed		
Subsistence fishing (crabs, spiny lobsters, prawns)	Mangrove	Food	P	Mela.	PNG	Gulf of Papua				Annual level of subsistence fishing in the Purari-Kikori: 600 tonnes of fish and 300 tonnes of crabs. [...] lobsters is a major commercial activity in the Gulf of Papua.	Ellison	1997	Peer-reviewed		
Timber, construction of tools and weapons	Mangrove	Raw materials	C	Mela.	PNG	Western prov.				Wood from the Rhizophoraceae commonly used for construction of tools and weapons among coastal communities of the Western Province.	Ellison	1997	Peer-reviewed		
Textile treatment, tannin production	Mangrove	Inspir. for culture, art design	C	Mela.	PNG	Western and Gulf prov.				Commonly used for tannin production. Use of mangrove for dyes has largely declined with introduction of commercial dyes.	Ellison	1997	Peer-reviewed		
Medicines (stop pain and women contraceptive)	Mangrove	Medicinal resources	C	Mela.	PNG	Western and Gulf prov.				Rau (1984) described from the Central Province how chewed roots and boiled leaves of mangroves [...] To stop pain and swelling and on strained ankles to ease pain; [...] Used by women as a contraceptive.	Ellison	1997	Peer-reviewed		
Firewood, cooking	Mangrove	Raw materials	C	Mela.	PNG	Western and Gulf prov.				Mangrove is a popular firewood for cooking.	Ellison	1997	Peer-reviewed		
Thatching and house walls	Mangrove	Raw materials	C	Mela.	PNG	Western and Gulf prov.				Nypa fronds for thatching and house walls	Ellison	1997	Peer-reviewed		
Carbon sequestration	Mangrove	Climate regulation	R&M	Mela.	Fiji	Rewa Delta	8,600 ha	8,500 – 25,000 /year	/ha	FJD	2013	21,303 MP	Ellison et al.	2018	Peer-reviewed

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Species refugia and natural and cultural value	Coral reef	Inspir. for culture, art design	C	Poly.	Niue	Beneridge Reef											Beveridge Reef is of extraordinary natural and cultural value to Niueans.	Friedlander et al.	2017	Report	
Subsistence from inshore fisheries	Coastal eco.	Food	P	Mela.	Fiji		38,500 ha	29,500,000 /year	Total area	USD	2014						947	MP	Gonzales et al.	2015	Report
Species refugia and extraordinary natural and cultural value for the people of Niue	Coral reef	Maint. Of life cycles	R&M	Poly.	Niue	Beneridge Reef													Friedlander et al.	2017	Report
Coastal protect.	Coastal eco.	Coastal protect.	R&M	Mela.	Fiji		38,500 ha	6,360,000-10,610,000 /year	Total area	USD	2014						271	DC (damage cost)	Gonzales et al.	2015	Report
Small-scale inshore commercial fishery	Coastal eco.	Food	P	Mela.	Fiji		675,926 ha	10.8 - 40.9 /year	/ha	USD	2014						33	VT MP	Gonzales et al.	2015	Report
Sand and coral aggregate mining	Sand and coral aggregates	Raw materials	P	Mela.	Fiji		300,000 m ²	760,000 /year	Total area	USD	2014							MP	Gonzales et al.	2015	Report
Tourism	Coral reef and lagoons	Recreation & tourism	C	Mela.	Fiji			684.52 /year	/ha	USD	2014						857	MP	Gonzales et al.	2015	Report
Tourism	Mangrove	Recreation & tourism	C	Mela.	Fiji		38,500 ha	2,980 /year	/ha	USD	2014						3,729	MP	Gonzales et al.	2015	Report
Tourism	Mangrove	Recreation & tourism	C	Mela.	Fiji		38,500 ha	2,980 /year	/ha	USD	2014						3,729	MP	Gonzales et al.	2015	Report
Tourism (coral reefs or lagoon)	Coral reef	Recreation & tourism	C	Mela.	Fiji		670,400 ha	684.52 /year	/ha	USD	2014						856	MP	Gonzales et al.	2015	Report
Tourism and lifestyle (swimming, snorkeling, scuba diving, ...)	Coral reef	Recreation & tourism	C	Mela.	Fiji		670,400 ha	55,410,000 – 250,610,000 /year	Total area (Fiji)	USD	2014							TC	Gonzales et al.	2015	Report
Carbon sequestration	Mangrove	Climate regulation	R&M	Mela.	Fiji		38,500 ha	73,930,000 /year	Total area	USD	2014						2,373	MP	Gonzales et al.	2015	Report
Carbon sequestration	Mangrove	Climate regulation	R&M	Mela.	Fiji		38,500 ha	1,920.19 /year	/ha	USD	2014								Gonzales et al.	2015	Report
Aggregate mining	Coral reef	Raw materials	P	Mela.	Fiji		300,000 m ²	760,000 /year	Total area	USD	2014							MP	Gonzales et al.	2015	Report
Aquarium trade (live rocks and coral products)	Coral reef	Ornamental resources	P	Mela.	Fiji		NA	7,700 000 /year	Total area (Fiji)	USD	2014							MP	Gonzales et al.	2015	Report
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Fiji		261,500 ha	6,360,000 to 10,610,000 /year	Total area (Fiji)	USD	2014							DC	Gonzales et al.	2015	Report

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Carbon sequestration	Seagrass	Climate regulation	R&M	Mela.	Fiji	NA	758.66	/year	/ha	USD	2014		Gonzales et al.	2015	Report	
Subsistence catch from reefs	Coral reef	Food	P	Mela.	Fiji	670,400 ha	44	/year	/ha	USD	2014	Dependence on coral reefs for the vast bulk of their protein; subsistence catches from reefs are estimated at approximately 1 7 000 tons per year. Gleaning at low tide is also important for shellfish, sea cucumbers, sea urchins and octopus.	Tons of seafood caught	Gonzales et al.	2015	Report
Multiple (gleaning for peace, enjoy nature, share)	Coastal eco.	Recreation & tourism	C	Mela.	Timor-Leste	Coastal community located on the western coast of Atauro Island							CV	Grantham et al.	2020	Peer-reviewed
Multiple (gleaning)	Coastal eco.	Food	P	Mela.	Timor-Leste	As above							CV	Grantham et al.	2020	Peer-reviewed
Habitat for threatened species	Seagrass	Maint. of life cycles	R&M	Mela.	Solomon Islands	6,600 ha								Green et al.	2006	Report
Traditional food and ceremony use	Seagrass	Inspir. for culture, art design	C	Mela.	Solomon Islands	6,600 ha								Green et al.	2006	Report
Building materials	Coral reef	Raw materials	C	Mela.	Solomon Islands	On the mainland eastern coast of Malaita								Green et al.	2006	Report
Fibers	Seagrass	Raw materials	C	Micro.	Kiribati	Yap island								Green et al.	2003	Report
Habitat	Seagrass	Maint. of life cycles	R&M	Micro.	Palau	8,000 ha								Green et al.	2003	Report
Habitat for threatened species	Coral reef	Maint. of life cycles	R&M	Mela.	Fiji	1,000,000 ha								Heaps et al.	2005	Report
All services	Mangrove	Multiple	All	Mela.	Regional (Mela.)	NA	145,700,000,000	Present value	Total area	USD	2015		Hoegh-Guldberg et al.	2016	Report	

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All services	Seagrass	Multiple	All	Mela.	Regional (Mela.)	NA	151,400,000,000	Present value	Total area	USD	2015							Hoegh-Guldberg et al.	2016	Report
All services	Coral reef	Multiple	All	Mela.	Regional (Mela.)	NA	109,600,000,000	Present value	Total area	USD	2015							Hoegh-Guldberg et al.	2016	Report
Habitat for species	Seagrass	Maint. of life cycles	R&M	Mela.	Fiji		1,600 ha											https://www.seagrasswatch.org/fiji/		Internet site/report
Habitat for species	Seagrass	Maint. of life cycles	R&M	Mela.	Timor-Leste		4,266 ha											https://www.seagrasswatch.org/timor-leste/#Timor		Internet site/report
Infrastructure protection by coral reefs, and changes in coastal infrastructure investment and construction in response to changes in on-reef and reef-adjacent tourism.	Coral reef	Mod. extreme events	R&M	Coral Triangle	Indonesia, East Timor, SI, Malaysia, PNG, the Philippines	Coral triangle	10,080,000 ha	1,323,000,000 /year	Total area	USD	2017		156	HP (hedonic pricing)	ICRI				2018	Report
As above	Coral reef	Mod. extreme events	R&M	Coral Triangle	As above	Coral triangle	10,080,000 ha	1,094,000,000 /year	Total area	USD	2017		129	IO	ICRI				2018	Report
Reef-associated capture fisheries in each region.	Coral reef	Food	P	Coral Triangle	As above	Coral triangle	10,080,000 ha	2,925,000,000 /year	Total area	USD	2017		346	MP (market prices, ie gross revenue)	ICRI				2018	Report
Reef-associated capture fisheries in each region.	Coral reef	Food	P	Coral Triangle	As above	Coral triangle	10,080,000 ha	2,925,000,000 /year	Total area	USD	2017		346	IO	ICRI				2018	Report
Tourism	Coral reef	Recreation & tourism	C	Coral Triangle	As above	Coral triangle	10,080,000 ha	3,113,000,000 /year	Total area	USD	2017		367	MP (market prices, ie gross revenue)	ICRI				2018	Report
Tourism	Coral reef	Recreation & tourism	C	Coral Triangle	As above	Coral triangle	10,080,000 ha	3,113,000,000 /year	Total area	USD	2017		367	IO (input-output model.)	ICRI				2018	Report

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Diving and snorkeling	Coral reef	Recreation & tourism	C	Micro.	Marshall isl.		4,855	/year	/square km	USD	2013		VT	Jungwiwattanaporn et al.	2015	Report	
Aquarium trade	Coral reef	Ornamental resources	P	Micro.	Marshall isl.	611,000 ha	1,830,000	/year	Total area	USD	2013	4	VT	Jungwiwattanaporn et al.	2015	Report	
Erosion prevention	Coral reef	Erosion prevention	R&M	Micro.	Marshall isl.	Majuro atoll	25,440,000 - 44,770,000	/year	Total area	USD	2013		VT MP	Jungwiwattanaporn et al.	2015	Report	
Export of live and dead coral cultured coral	Coral reef	Ornamental resources	P	Mela.	Solomon Islands		1,370,000	/year	Total area	USD	2014			Jungwiwattanaporn et al.	2015	Report	
Tourism	Coral reef	Recreation & tourism	C	Mela.	Fiji	Vatu-i-Ra	107,102 ha	47,240,000	/year	Total area	FJD	2007	622	MP	Kastl & Gow	2014	Report
Subsistence fisheries	Coral reef	Food	P	Mela.	Fiji	Vatu-i-Ra	107,102 ha	15,615,000	/year	Total area	FJD	2007	205	FI	Kastl & Gow	2014	Report
Carbon sequestration	Mangrove	Climate regulation	R&M	Micro.	FSM	Near the northwest corner of the island of Yap			/ha		2008			Kauffman et al.	2011	Peer-reviewed	
Carbon sequestration	Mangrove	Climate regulation	R&M	Micro.	Palau	The island of Babeldoab, Airai State			/ha		2008			Kauffman et al.	2011	Peer-reviewed	
Multiple (fisheries, coastal protect., tourism and recreation, existence, biodiv. values)	Coral reef	Multiple	All	Pics	Pics		4,110,000,000	/year	Total area	USD	2014			Kinch et al.	2010	Peer-reviewed	
Recreational services	Coral reef	Recreation & tourism	C	Mela.	Fiji		166,100,000 – 786,200,000	/year	Total area (Fiji)	FJD	2013			Korovulavula et al.	2008	Report	
Existence and bequest	Coral reef	Existence & bequest	C	Mela.	Fiji	Suva	1,000 ha	13.9	For a one time payment /capita	USD	2007		CV	Kronen et al.	2006	Report	
Carbon sequestration	Seagrass	Climate regulation	R&M	Mela.	Vanuatu		1,500 ha	400,000	/year	Total area	USD	2014	330		Laffoley et al.	2013	Report
Nutrient filter	Mangrove	Waste treatment	R&M	Mela.	Fiji		32 ha	5,820	/year	/ha	USD	1989	13,736		Lal et al.	1990	Report
Fisheries	Mangrove	Food	P	Mela.	Fiji	Raviravi	350 ha	52,000	Present value	Total area	USD	1989	349	OC	Lal et al.	1990	Report
Raw materials	Mangrove	Raw materials	P	Mela.	Fiji	Raviravi	350 ha	3,000	Present value	Total area	USD	1989	21	OC	Lal et al.	1990	Report

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Traditional uses (fish nets, tannins...)	Mangrove	Inspir. for culture, art design	C	Mela.	Fiji			Tannin for fishing, stakes for husking coconuts, timber for scaffolding buildings, tool handles, fish fences, tapa clothes, medicine, poles for fish traps...	Lal et al.	1990	Report	
Traditional uses (medicine)	Mangrove	Medicinal resources	C	Mela.	Fiji			As above	Lal et al.	1990	Report	
Multiple	Coral reef	Cognitive dev.	C	Mela.	PNG	Muluk, Wadau and Athus		Education, then tradition, then bequest values were all valued higher than shoreline protection of reef materials, but lower than fisheries and habitat. Although cultural ecosystem services were usually ascribed low importance, many people expressed that cultural ecosystem services could only be realised through provisioning services. [...] importance to ecosystem services that directly contributed to [...] fisheries.	CV	Lau et al.	2019	Peer-reviewed
Multiple	Coral reef	Existence & bequest	C	Mela.	PNG	As above		As above	CV	Lau et al.	2019	Peer-reviewed
Creation myths (magical practices)	Seagrass	Spiritual exp.	C	Mela.	Solomon Islands	Rovina		Entwined with creation myths of Roviana people. Twine made from seagrass leaves is used in medicinal/magical practices.	Lauer and Aswani	2010	Peer-reviewed	
Creation myths (medicinal)	Seagrass	Medicinal resources	C	Mela.	Solomon Islands	Rovina		As above	Lauer and Aswani	2010	Peer-reviewed	
Raw materials	Seagrass	Raw materials	C	Mela.	Solomon Islands	Rovina		Seagrass leaves provide raw materials for ropes, fishing lures, fishing nets, Pillow stuffing. Roots can be eaten.	Lauer and Aswani	2010	Peer-reviewed	
Food use other than fisheries	Mangrove	Food	P	Mela.	PNG			Uses: fruit, honey, nectar, sugar, alcohol, vinegar, roots, worm	Liebezeit et al.	2006	Peer-reviewed	
Medical use	Mangrove	Medicinal resources	C	Mela.	PNG			Uses: fish stings, ulcers, sores and infections, itch treatment, antihemorrhagic, aphrodisiac, acne, insect bites...	Liebezeit et al.	2006	Peer-reviewed	
Raw materials and energy	Mangrove	Raw materials	C	Mela.	PNG			Uses: shields, charcoal, fuel, construction timber, wood smoke as mosquito repellent, oil for lams.	Liebezeit et al.	2006	Peer-reviewed	
Art	Mangrove	Inspir. for culture, art design	C	Mela.	PNG			Uses: tanning, carving	Liebezeit et al.	2006	Peer-reviewed	
Raw materials for marine embarcation	Mangrove	Raw materials	C	Mela.	PNG			Uses: boomerangs, paddles, canoes	Liebezeit et al.	2006	Peer-reviewed	

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Gleaning seafood	Seagrass	Food	P	Mela.	Timor-Leste		4,266 ha										Reef gleaning (meti fai, tono fai) of nearshore seagrass meadows during low tide targeting juvenile fishes, crabs, molluscs, and sea urchins.	McWilliam	2011	Report			
Fisheries	Coral reef	Food	P	Poly.	Samoa		49000 ha	15,000,000 /year	Total area	WST	1999							538	MP	Mohd-Shahwahid et al.	2001	Report	
Tourism	Coral reef	Recreation & tourism	C	Poly.	Samoa	Palolo Deep Marine reserve	137.5 ha	19,625 /year	Total area	USD	2014								177	CV	Mohd-Shahwahid et al.	2001	Report
Tourism	Coral reef	Recreation & tourism	C	Poly.	Samoa		49,000 ha	1,776,724 /year	Total area	USD	2014									VT	Mohd-Shahwahid et al.	2001	Report
Conservation of indirect use values for future generations	Coral reef	Existence & bequest	C	Poly.	Samoa	All marine sites		277,242 /year	Total area	WST	1999									CV	Mohd-Shahwahid et al.	2001	Report
Climate regulation	Coral reef	Climate regulation	R&M	Poly.	Samoa	All marine sites		40,007 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Nutrient sink and cycling	Coral reef	Waste treatment	R&M	Poly.	Samoa	All marine sites		64,868 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Biological control	Coral reef	Biological control	R&M	Poly.	Samoa	All marine sites		5,118 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Disturbance regulation	Coral reef	Mod. extreme events	R&M	Poly.	Samoa	All marine sites		235,263 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Waste treatment	Coral reef	Waste treatment	R&M	Poly.	Samoa	All marine sites		60,585 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Habitat/refugia	Coral reef	Maint. Of life cycles	R&M	Poly.	Samoa	All marine sites		418 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Construction material	Coral reef	Raw materials	P	Poly.	Samoa	All marine sites		5,432 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Aquarium trade	Coral reef	Ornamental resources	P	Poly.	Samoa	All marine sites		3,029 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Premium estate value	Coral reef	Aesthetic information	C	Poly.	Samoa	All marine sites		669 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Books/films	Coral reef	Inspir. for culture, art design	C	Poly.	Samoa	All marine sites		21 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report
Education/research	Coral reef	Cognitive dev.	C	Poly.	Samoa	All marine sites		731 /year	Total area	WST	1999									VT	Mohd-Shahwahid et al.	2001	Report

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Snorkeling recreation	Coral reef	Recreation & tourism	C	Poly.	Samoa	Palolo Deep Marine reserve	137.5 ha	24,278 /year	Total area	WST	1999	309	CV	Mohd-Shahwahid et al.	2001	Report		
Snorkeling recreation	Coral reef	Recreation & tourism	C	Poly.	Samoa	All marine sites		1,390,329 /year	Total area	WST	1999		VT	Mohd-Shahwahid et al.	2001	Report		
Multiple	Marine ecosystems	Multiple	All	Poly.	Samoa			185,098,240 /year	Total area	USD	1999		CV VT	MP VT	Mohd-Shahwahid et al.	2001	Report	
Seafood	Seagrass	Food	P	Mela.	Solomon Islands	Tetepare, Randova isl.									Moseby et al.	2020	Peer-reviewed	
Multiple	Seagrass	Multiple	All	Mela.	Regional (Mela.)										Mtwana Nordlund et al.	2016	Peer-reviewed	
Subsistence fisheries	Coral reef	Food	P	Mela.	PNG											Population of approximately 4.5 million in PNG that rely on food, shelter and livelihoods from coral reefs.	2020	Report
Firewood	Mangrove	Raw materials	C	Micro.	FSM	Kosrae island	1,562 ha	278,500 /year	Total area	USD	1996	332	CV	Naylor, Drew	1998	Peer-reviewed		
Multiple	Mangrove	Food	P	Micro.	FSM	Kosrae island	1,562 ha	666,000 - 1,000,000 /year	Total area	USD	1996	990	MP	Naylor, Drew	1998	Peer-reviewed		
Fish, crab products	Mangrove	Food	P	Micro.	FSM	Kosrae island	1,562 ha	725,000 /year	Total area	USD	1996	865	MP	Naylor, Drew	1998	Peer-reviewed		
Existence and ecosystem functioning	Mangrove	Existence & bequest	C	Micro.	FSM	Kosrae island	1,562 ha	1,000,000 - 1,260,000 /year	Total area	USD	1996	1,349	CV	Naylor, Drew	1998	Peer-reviewed		
Coastal protect.	Mangrove	Coastal protect.	R&M	Mela.	Fiji	Navakavu LMMA	1,562 ha	133,392 /year	Total area	USD	2014	89	VT	O'Garra	2007	Report		
Multiple (fisheries, research, coastal protect., bequest values)	Coastal eco.	Multiple	All	Mela.	Fiji	Navakavu LMMA	1,850 ha	1,764,221 - 1,786,885 /year	Total area	USD	2006	392	NA	O'Garra	2007	Report		
Bequest value	Coral reef	Existence & bequest	C	Mela.	Fiji	Navakavu LMMA	1,850 ha				2006		CV	O'Garra	2009	Peer-reviewed		
																People were willing to pay a significant % of household income to protect the bequest values of coral reef fisheries, but unwilling to accept loss of fishing grounds to future tourism ventures.		

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Bequest value	Coral reef	Existence & bequest	C	Mela.	Fiji	Navakavu LMMA	1,850 ha	0.64 – 0.73 /week	/individual	USD	2006		CV	O'Garra	2009	Peer-reviewed	
Fisheries	Coral reef	Food	P	Mela.	Fiji	Navakavu LMMA	1,850 ha	353 /year	/ha	USD	2020	404	MP	O'Garra	2012	Peer-reviewed	
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Fiji	Navakavu LMMA	1,850 ha	664,905 /year	Total area	USD	2006	521	VT	O'Garra	2012	Peer-reviewed	
Bequest value	Coral reef	Existence & bequest	C	Mela.	Fiji	Navakavu LMMA	1,850 ha	42.77 /year	/individual	USD	2006		CV	O'Garra	2012	Peer-reviewed	
Multiple(fisheries, bequest, coastal protect.)	Coral reef and mangrove	Multiple	All	Mela.	Fiji			1,853,464 /year	Total area	USD	2006		CV, MP, DC	O'Garra	2012	Peer-reviewed	
Subsistence	Coral reef and mangrove	Food	P	Mela.	Vanuatu		71,904 ha	6,490,000 /year	Total area	USD	2013	113	MP CV	Pascal et al.	2015	Report	
																	Source of regular protein for 15,500 households, approximately 30% of households in Vanuatu, equivalent to a population of > 74,000 individuals.
																	% (& number) of households/inhab.
Coastal aggregate mining	Sand and coral aggregates	Raw materials	P	Mela.	Vanuatu		15,000 ha	170,000 /year	Total area	USD	2013	14	MP	Pascal et al.	2015	Report	
Commercial fisheries (reef fish, deep slope fish, crabs and lobsters)	Coral reef	Food	P	Mela.	Vanuatu		70,238 ha	3,300,000 /year	Total area	USD	2013	59	MP CV RC	Pascal et al.	2015	Report	
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu		70,238 ha	18,370,000 /year	Total area	USD	2013	329	DC	Pascal et al.	2015	Report	
Carbon sequestration	Seagrass	Climate regulation	R&M	Mela.	Vanuatu		124,038 ha	402,600 /year	Total area	USD	2013	4	VT	MP Pascal et al.	2015	Report	
Lifestyle values	Coral reef	Inspir. for culture, art design	C	Mela.	Vanuatu												Coral rock to pound kava
Marine aquarium trade	Coral reef	Ornamental resources	P	Mela.	Vanuatu		NA	150,000 /year	Total area	USD	2013		VT	Pascal et al.	2015	Report	
Research, management and education	Coastal eco.	Cognitive dev.	C	Mela.	Vanuatu			4,900,000 /year	Total area	USD	2013		VT	Pascal et al.	2015	Report	
Tourism	Coral reef	Recreation & tourism	C	Mela.	Vanuatu		70,238 ha	9,590,000 /year	Total area	USD	2013	171	VT, CV, SP	(stated preference) Pascal et al.	2015	Report	
																	For the majority of snorkellers (53%), the beauty of the seascapes (e.g. Coral reefs, caves) was the most decisive factor of satisfaction [...]
Carbon sequestration	Mangrove	Climate regulation	R&M	Mela.	Vanuatu		1,665 ha	1,040,904 /year	Total area	USD	2013	785	VT	MP Pascal et al.	2015	Report	
Carbon sequestration	Mangrove	Climate regulation	R&M	Mela.	Vanuatu		1,665 ha	1,000,000 /year	Total area	USD	2013	754		Pascal et al.	2015	Report	

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Subsistence fisheries	Coastal eco.	Food	P	Mela.	Vanuatu	71,904 ha	6,490,000 /year	Total area	USD	2013		113	Pascal et al.	2015	Report	
Tourism and recreation	Coastal eco.	Recreation & tourism	C	Mela.	Vanuatu	71,904 ha	9,590,000 /year	Total area	USD	2013		167	Pascal et al.	2015	Report	
Commercial fisheries linked to coral reefs	Coastal eco.	Food	P	Mela.	Vanuatu	71,904 ha	7,010,000 /year	Total area	USD	2013		122	Pascal et al.	2015	Report	
Beche de mer	Coastal eco.	Food	P	Mela.	Vanuatu		50,000 /year	Total area	USD	2013			Pascal et al.	2015	Report	
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	West coast of Efate	NA	8,400,000 – 14,000,000 /year	Total area	USD	2013		DC	Pascal et al.	2015	Report
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	East coast of Efate	NA	765,000 – 1,270,000 /year	Total area	USD	2013		DC	Pascal et al.	2015	Report
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	Malekula	NA	784,000 – 1,300,000 /year	Total area	USD	2013		DC	Pascal et al.	2015	Report
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	Espiritu Santo	NA	2,900,000-4,800,000 /year	Total area	USD	2013		DC	Pascal et al.	2015	Report
Subsistence fisheries	Mangrove	Food	P	Mela.	Vanuatu	5 MPAs in North Efate	76 ha	147 /year? /ha	USD	2009		203	MP	Pascal	2011	Report
Commercial fisheries	Mangrove	Food	P	Mela.	Vanuatu	As above	76 ha	88 /year? /ha	USD	2009		122	MP	Pascal	2011	Report
Coastal protect.	Mangrove	Coastal protect.	R&M	Mela.	Vanuatu	As above	76 ha	38 /year? /ha	USD	2009		52	DC	Pascal	2011	Report
Tourism	Mangrove	Recreation & tourism	C	Mela.	Vanuatu	As above	76 ha	179 /year?	Total area	USD	2009	3	CV	Pascal	2011	Report
Subsistence fisheries	Coral reef	Food	P	Mela.	Vanuatu	Emua village	24 ha	9,400 /year	Total area 240 residents	EU	2009	533	FI OT	Pascal et al. 2011	2011	Report
Commercial fisheries	Coral reef	Food	P	Mela.	Vanuatu	Emua village	24 ha	2,700 /year	As above	EU	2009	153	FI OT	Pascal et al. 2011	2011	Report
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	Emua village	24 ha	136 /year	As above	EU	2009	8	DC	Pascal et al. 2011	2011	Report
Biodiversity	Coral reef	Existence & bequest	C	Mela.	Vanuatu	Emua village	24 ha	1,064 /year	Total area (1 village)	EU	2009	60	VT	Pascal et al. 2011	2011	Report
Social capital	Coral reef	Inspir. for culture, art design	C	Mela.	Vanuatu	Emua village	24 ha	1,800 /year	Total area: 110 residents	EU	2009	102	PP	Pascal et al. 2011	2011	Report
Subsistence fisheries	Coral reef	Food	P	Mela.	Vanuatu	Piliura village	13 ha	4,300 /year	As above	EU	2009	450	FI OT	Pascal et al. 2011	2011	Report
Commercial fisheries	Coral reef	Food	P	Mela.	Vanuatu	Piliura village	13	2,700 /year	As above	EU	2009	282	FI OT	Pascal et al. 2011	2011	Report
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	Piliura village	13 ha	816 /year	As above	EU	2009	85	DC	Pascal et al. 2011	2011	Report

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Biodiversity	Coral reef	Existence & bequest	C	Mela.	Vanuatu	Piliura village	13 ha	488	/year	Total area (1 village)	EU	2009	51	VT	Pascal et al. 2011	2011	Report
Social capital	Coral reef	Inspir. for culture, art design	C	Mela.	Vanuatu	Piliura village	13 ha	1,800	/year	Total area: 110 residences	EU	2009	188	PP	Pascal et al. 2011	2011	Report
Subsistence fisheries	Coral reef	Food	P	Mela.	Vanuatu	Unakap village	12 ha	2,700	/year	Total area: 90 residences	EU	2009	306	FI OT	Pascal et al. 2011	2011	Report
Commercial fisheries	Coral reef	Food	P	Mela.	Vanuatu	Unakap village	12 ha	800	/year	As above	EU	2009	91	FI OT	Pascal et al. 2011	2011	Report
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	Unakap village	12 ha	816	/year	As above	EU	2009	92	DC	Pascal et al. 2011	2011	Report
Biodiversity	Coral reef	Existence & bequest	C	Mela.	Vanuatu	Unakap village	12 ha	399	/year	Total area (1 village)	EU	2009	45	VT	Pascal et al. 2011	2011	Report
Social capital	Coral reef	Inspir. for culture, art design	C	Mela.	Vanuatu	Unakap village	12 ha	1,800	/year	Total area: 90 residences	EU	2009	204	PP	Pascal et al. 2011	2011	Report
Subsistence fisheries	Coral reef	Food	P	Mela.	Vanuatu	Laonamoa village	14 ha	8,800	/year	Total area: 250 residences	EU	2009	866	FI OT	Pascal et al. 2011	2011	Report
Commercial fisheries	Coral reef	Food	P	Mela.	Vanuatu	Laonamoa village	14 ha	7,200	/year	As above	EU	2009	699	FI OT	Pascal et al. 2011	2011	Report
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	Laonamoa village	14 ha	1,088	/year	As above	EU	2009	106	DC	Pascal et al. 2011	2011	Report
Biodiversity	Coral reef	Existence & bequest	C	Mela.	Vanuatu	Laonamoa village	14 ha	1,131	/year	Total area (1 village)	EU	2009	110	VT	Pascal et al. 2011	2011	Report
Social capital	Coral reef	Inspir. for culture, art design	C	Mela.	Vanuatu	Laonamoa village	14 ha	1,800	/year	Total area 250 residences	EU	2009	175	PP	Pascal et al. 2011	2011	Report
Subsistence fisheries	Coral reef	Food	P	Mela.	Vanuatu	Worasifu village	13 ha	3,500	/year	Total area 50 residences	EU	2009	366	FI OT	Pascal et al. 2011	2011	Report

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Commercial fisheries	Coral reef	Food	P	Mela.	Vanuatu	Worasifu village	13 ha	3,800	/year	As above	EU	2009	398	FI	OT	Pascal et al. 2011	2011	Report
Coastal protect.	Coral reef	Coastal protect.	R&M	Mela.	Vanuatu	Worasifu village	13 ha	272	/year	As above	EU	2009	28	DC		Pascal et al. 2011	2011	Report
Biodiversity	Coral reef	Existence & bequest	C	Mela.	Vanuatu	Worasifu village	13 ha	200	/year	Total area: 1 village	EU	2009	21	VT		Pascal et al. 2011	2011	Report
Social capital	Coral reef	Inspir. for culture, art design	C	Mela.	Vanuatu	Worasifu village	13 ha	1,800	/year	Total area: 50 residents	EU	2009	188	PP		Pascal et al. 2011	2011	Report
Tourism	Coral reef	Recreation & tourism	C	Mela.	Vanuatu	Emua village	24 ha	5,397	/year	Total area: 1565 tourists	EU	2009	306	FI	OT	Pascal et al. 2011	2011	Report
Tourism	Coral reef	Recreation & tourism	C	Mela.	Vanuatu	Piliura village	13 ha	14,558	/year	Total area (12,518 tourists)	EU	2009	1,523	FI	OT	Pascal et al. 2011	2011	Report
Tourism	Coral reef	Recreation & tourism	C	Mela.	Vanuatu	Unakap village	12 ha	3,870	/year	Total area 90 residents	EU	2009	439	FI	OT	Pascal et al. 2011	2011	Report
Tourism	Coral reef	Recreation & tourism	C	Mela.	Vanuatu	Laonamoa village	14 ha	5,745	/year	Total area 250 residents	EU	2009	558	FI	OT	Pascal et al. 2011	2011	Report
Tourism	Coral reef	Recreation & tourism	C	Mela.	Vanuatu	Worasifu village	13 ha	5,402	/year	Total area: 50 residents	EU	2009	565	FI	OT	Pascal et al. 2011	2011	Report
Subsistence fisheries	Mangrove	Food	P	Mela.	Vanuatu	Crab Bay	136.5 ha	79,161	/year	Total area	USD	2012	739	MP		Pascal et al.	2013	Report
Coastal protect. Against flood	Mangrove	Mod. extreme events	R&M	Mela.	Vanuatu	Crab Bay	136.5 ha	5,644	/year	Total area	USD	2012	53	DC		Pascal et al.	2013	Report
Commercial fisheries	Mangrove	Food	P	Mela.	Vanuatu	Crab Bay	136.5 ha	47,283	/year	Total area	USD	2012	442	MP		Pascal et al.	2013	Report
Carbon sequestration	Mangrove	Climate regulation	R&M	Mela.	Vanuatu	Crab Bay	136.5 ha	414,411	/year	Total area	USD	2012	3,871	MP		Pascal et al.	2013	Report
Wood extraction	Mangrove	Raw materials	P	Mela.	Vanuatu	Crab Bay	136.5 ha	39,233	/year	Total area	USD	2012	366	MP		Pascal et al.	2013	Report

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Subsistence fisheries	Mangrove	Food	P	Mela.	Vanuatu	Eratap	31.2 ha	37,006	/year	Total area	USD	2012	1,512	MP	Pascal et al.	2013	Report
Coastal protect. Against flood	Mangrove	Mod. extreme events	R&M	Mela.	Vanuatu	Eratap	31.2 ha	47,278	/year	Total area	USD	2012	1,932	DC	Pascal et al.	2013	Report
Recreational fisheries	Mangrove	Food	P	Mela.	Vanuatu	Eratap	31.2 ha	1,000	/year	Total area	USD	2012	41	MP	Pascal et al.	2013	Report
Commercial fisheries	Mangrove	Food	P	Mela.	Vanuatu	Eratap	31.2 ha	17,500	/year	Total area	USD	2012	715	MP	Pascal et al.	2013	Report
Carbon sequestration	Mangrove	Climate regulation	R&M	Mela.	Vanuatu	Eratap	31.2 ha	99,461	/year	Total area	USD	2012	4,065	MP	Pascal et al.	2013	Report
Tourism	Mangrove	Recreation & tourism	C	Mela.	Vanuatu	Eratap	31.2 ha	47,172	/year	Total area	USD	2012	1,928	MP	Pascal et al.	2013	Report
Wood extraction	Mangrove	Raw materials	P	Mela.	Vanuatu	Eratap	31.2 ha	16,800	/year	Total area	USD	2012	687	MP	Pascal et al.	2013	Report
Wood for building	Mangrove	Raw materials	C	Mela.	Fiji	Bua prov.								CV	Pearson et al.	2019	Peer-reviewed
Subsistence seafood	Mangrove	Food	P	Mela.	Fiji	Bua prov.								CV	Pearson et al.	2019	Peer-reviewed
Wood for cooking	Mangrove	Food	P	Mela.	Fiji	Bua prov.								CV	Pearson et al.	2019	Peer-reviewed

Coastal protect.	Mangrove	Coastal protect.	R&M	Mela.	Fiji	Bua prov.											Participants (n = 12) acknowledged the ability of mangroves to prevent soil or coastal erosion, with many recognising that they 'hold the soil together' and 'stop soil from washing away.	Number of persons recognizing ES importance	CV	Pearson et al.	2019	Peer-reviewed				
Medicinal plants	Mangrove	Medicinal resources	C	Mela.	Fiji	Bua prov.											Assist children with coughing, soothe pain and prevent infection ("Tradi. medicine was frequently mentioned (n = 15) as another valuable use of mangroves.") "Mangrove dye" used for cloth, painting, etc. Traditional garlands worn by local people during ceremonies (n = 6); [...] cultural benefit of mangroves; [...] Chief ceremonies; [...] Building social cohesion in communities.	Number of persons recognizing ES importance	CV	Pearson et al.	2019	Peer-reviewed				
Seafood market	Coral reef	Food	P	Mela.	Fiji	Nakawaqa and Labeka											Reef fisheries are the primary source of revenue for 96% of all households in Lakeba and for 81% in Nakawaqa. [...]	Proportion of revenue for a trip to sell fish	MP	Rao et al.	2013	Report				
Storm protection	Mangrove	Mod. extreme events	R&M	Mela.	Fiji	200 households in Lami Town	320 ha	158,920	/year	Total area	FJD	2010												Rao et al.	2013	Report
Subsistence fishery	Coastal eco.	Food	P	Micro.	Kiribati		NA	8,600,000-31,000,000	/year	Total area	USD	2013								MP VT	Rouatu et al.	2017	Report			
Small scale fishery	Coastal eco.	Food	P	Micro.	Kiribati		NA	2,500,000-9,000,000	/year	Total area	USD	2013								MP VT	Rouatu et al.	2017	Report			
Sand and coral aggregate mining	Sand and coral aggregates	Raw materials	P	Micro.	Kiribati		294,000 ha	700,000 – 1,000,000	/year	Total area (en m3)	USD	2013								MP VT	Rouatu et al.	2017	Report			
Tourism	Coastal eco.	Recreation & tourism	C	Micro.	Kiribati		NA	3,900,000	Net economic	Total area	USD	2013								CV	Rouatu et al.	2017	Report			

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											profit						
											/year						
Tourism	Coral reef	Recreation & tourism	C	Micro.	Kiribati	294,000 ha	3,900,000	/year	Total area	USD	2013	17	MP	Rouatu et al.	2017	Report	
Subsistence fishing	Coral reef	Food	P	Micro.	Kiribati	294,000 ha	8,600 - 31,000,000	/year	Total area	USD	2013	85	MP	Rouatu et al.	2017	Report	
Small scale fisheries - sale	Coral reef	Food	P	Micro.	Kiribati	294,000 ha	2,500,000-9,000,000	/year	Total area	USD	2013	25	MP	Rouatu et al.	2017	Report	
Carbon sequestration	Mangrove	Climate regulation	R&M	Micro.	Kiribati	790	304,000	/year	Total area	USD	2013	483	MP VT	Rouatu et al.	2017	Report	
Sand and coral aggregate mining	Sand and coral aggregate	Raw materials	P	Poly.	Tonga	NA	45,000	/year	Total area	USD	2013			Salcone et al.	2015	Report	
Subsistence fishery from mangroves, reefs, non reef habitats (seagrasses, lagoond, sandy areas, ...)	Coastal eco.	Food	P	Poly.	Tonga	586,902 ha	3,050,000	/year	Total area	USD	2013	7		Salcone et al.	2015	Report	
Domestic commercial inshore fishery	Coastal eco.	Food	P	Poly.	Tonga	600,000 ha	2,300,000 – 4,100,000	/year	Total area	USD	2013	7		Salcone et al.	2015	Report	
Coastal protect.	Coastal eco.	Coastal protect.	R&M	Poly.	Tonga	583,881 ha	6,500,000-10,900,000	/year	Total area	USD	2013	19	DC	Salcone et al.	2015	Report	
Aquarium trade	Coral reef	Ornamental resources	P	Poly.	Tonga	Not compatible	140,000	/year	Total area	USD	2013		MP	Salcone et al.	2015	Report	
Fish food	Coral reef	Food	P	Poly.	Tonga	320,000 ha		/year	Total area		2013		VT	Salcone et al.	2015	Report	
											Tonga reef areas could produce 16,000 tonnes of seafood annually.						
Sand and coral aggregate	Coral reef	Raw materials	P	Poly.	Tonga	320,000 ha	45,000	/year	Total area	USD	2013	0	VT	Salcone et al.	2015	Report	
Aquarium fish trade	Coral reef	Ornamental resources	P	Poly.	Tonga	320,000 ha	443,000	/year	Total area	USD	2013	2	VT	Salcone et al.	2015	Report	
Tourism	Coastal eco.	Recreation & tourism	C	Poly.	Tonga	NA	2,000,000-4,900,000	/year	Total area	USD	2013			Salcone et al.	2015	Report	
Traditional dancing costumes, celebration attire, gifts for chiefs	Coral reef	Ornamental resources	C	Poly.	Tonga	320,000 ha								Salcone et al.	2015	Report	
											Tongans use coral stones to bleach their mats for important traditional occasions. [...] The Tongan people used to make necklaces, bracelets and other traditional handicrafts from corals, pearl oysters, tortoise-shell, and whale tooth (lei) from the ocean. These products are of high cultural value to Tongan people.						

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Traditional dancing costumes, celebration attire, gifts for chiefs	Coral reef	Inspir. for culture, art design	C	Poly.	Tonga		320,000 ha				As above			Salcone et al. 2015	Report		
Protection from flood and erosion from coral reefs	Coral reef	Coastal protect.	R&M	Poly.	Tonga	Tongatapu	NA	11,700,000 - 19,500,000 /year	Total area	T (tonga n)			DC	Salcone et al. 2015	Report		
International tourism	Coral reef	Recreation & tourism	C	Poly.	Tonga		320,000 ha	1,220,993-3,052,458 /year	Total area	USD	2013	8	MP OP CV	Salcone et al. 2015	Report		
Carbon sequestration	Mangrove	Climate regulation	R&M	Poly.	Tonga		2,000 ha	770,000 /year	Total area	USD	2013	483	VT MP	Salcone et al. 2015	Report		
Coral rubble and sand to build sea walls	Coral reef	Raw materials	C	Poly.	Tonga	Halaika Beach	NA							1020 t of coral rubble extracted in Halaika Beach for household uses	Tons of coral	Salcone et al. 2015	Report
Bêche de mer	Coastal eco.	Food	P	Poly.	Tonga			450,000 /year	Total area	USD	2013		MP	Salcone et al. 2015	Report		
Tourism	Coral reef	Recreation & tourism	C	Poly.	Cook isl.		112,000 ha	/year	Total area		1996			Tourism is an important industry for the Cook Isl.: 100 000 visitors /year. Snorkelling and diving are popular activities.	Number of visitors	Spalding et al. 2001	Report
Pearl and ornamental fish	Coral reef	Ornamental resources	P	Poly.	Cook isl.		112,000 ha		Total area		1996			Large black pearl farms in Manihiki Atoll providing the main source of export income. [...] trochus and ornamental fish.		Spalding et al. 2001	Report
Subsistence fishing	Coral reef	Food	P	Poly.	Cook isl.		112,000 ha		Total area		1996			About 70% of all households undertook at least some form of subsistence fishing (gleaning from reef flats and boat-based fishing). + Exports + black pearl.	Proportion of households	Spalding et al. 2001	Report
Artisanal reef fisheries	Coral reef	Food	P	Poly.	Tonga									70% of the artisanal catch is made up of reef fish, artisanal fisheries being an important activity in the country.	Percentage of catch from reef	Spalding et al. 2001	Report
Commercial sea products	Coral reef	Food	P	Poly.	Tonga									Important commercial fisheries, notably an aquarium trade dealing in fish, coral and live rock (small pieces of reef rock housing many species)		Spalding et al. 2001	Report

Appendices – Supplementary Material

Source of seafood	Coral reef	Food	P	Micro.	FSM	434,000 ha							Reefs are of critical importance as a source of food [...]. Trochus harvesting is also an important economic activity in all areas.	Spalding et al. 2001	Report	
Seafood direct consumption	Coral reef	Food	P	Micro.	Palau	115,000 ha	Total area	1996	1200			Tons		Spalding et al. 2001	Report	
Seafood local markets	Coral reef	Food	P	Micro.	Palau	115,000 ha	Total area	1996	360			Tons		Spalding et al. 2001	Report	
Seafood export	Coral reef	Food	P	Micro.	Palau	115,000 ha	Total area	1996	250			Tons		Spalding et al. 2001	Report	
High value species	Coral reef	Maint. Of life cycles	R&M	Micro.	Marshall isl. Majuro atoll								Some high value species are also being exploited, including trochus, giant clams and marine turtles.	Spalding et al. 2001	Report	
Subsistence fisheries	Coral reef	Food	P	Mela.	PNG								The most widespread use of coral reefs in PNG is for subsistence fisheries.	Spalding et al. 2001	Report	
Building materials, firewood, timber	Mangrove	Raw materials	C	Mela.	PNG	410,000 ha							Mangroves have been used for building materials, firewood, medicinal purposes and the production of tannins.	Spalding et al. 2001	Report	
Medicinal purposes	Mangrove	Medicinal resources	C	Mela.	PNG	410,000 ha							As above	Spalding et al. 2001	Report	
Production of tannin	Mangrove	Inspir. for culture, art design	C	Mela.	PNG	410,000 ha							As above	Spalding et al. 2001	Report	
Tatching, weaving													Mangrove fruit <i>Nyta fruticans</i> remains one of the most useful of the mangroves, and is used for thatching, weaving.			
Production of sugar	Mangrove	Food	C	Mela.	PNG	410,000 ha							<i>Nyta fruticans</i> are used for the production of sugar.	Spalding et al. 2001	Report	
Subsistence gleaning	Coastal eco.	Food	P	Mela.	Fiji, PNG, Solomon Islands								75 species of mollusks collected by subsistence gleaners in the SI, PNG and Fiji from mangroves, reefs & seagrasses. Other mollusks such as the trochus shell & holothurians are valuable source of cash income.	Spalding et al. 2001	Report	
Households	Mangrove	Multiple	All	Mela.	Fiji	886,650 000	/year	Total area	USD	2014				VT	Thaman et al. 2001	Report
Shark dive	Coral reef	Recreation & tourism	C	Micro.	Palau	NA	18,000 000	/year	Total area	USD	2011			CV MP	Vianna et al. 2012	Peer-reviewed

Appendices – Supplementary Material

Strong relation to coastal species	Coral reef	Spiritual exp.	C	Mela.	Solomon Islands	Bellona												The Bellonese have names for at least 8 whales and dolphins, 7 reptiles, over 500 finfish, 191 molluscs, 48 crustaceans, 29 echinoderms and a range of corals, [...], most of which have commercial, subsistence or cultural value.	Number of species named	Thaman et al.	2010	Peer-reviewed	
Coral reef for fishery (consumption and sale)	Coral reef	Food	P	Mela.	Solomon Islands	3 villages (Buri, Rnongga Island Boeboe, Choiseul prov. Talakali, Malaita prov.)	NA	12,000	/year	/house hold	SBD	April 2008		MP	Warren-Rhodes et al.	2011	Peer-reviewed						
Firewood	Mangrove	Raw materials	C	Mela.	Solomon Islands	As above	NA	2,000-5,000	/year	/house hold	SBD	April 2008		MP	Warren-Rhodes et al.	2011	Peer-reviewed						
Building materials	Mangrove	Raw materials	C	Mela.	Solomon Islands	As above	NA	100-150	/year	/house hold	SBD	April 2008		MP	Warren-Rhodes et al.	2011	Peer-reviewed						
Propagules for food and cash	Mangrove	Food	P	Mela.	Solomon Islands	As above	NA	100-200	/week	/house hold	SDB	April 2008		MP	Warren-Rhodes et al.	2011	Peer-reviewed						
Mangrove for fishery (consumption and sale)	Mangrove	Food	P	Mela.	Solomon Islands	As above	NA	4,000	/year	/house hold	SBD	April 2008		MP	Warren-Rhodes et al.	2011	Peer-reviewed						
Medicinal remedy	Mangrove	Medicinal resources	C	Mela.	Solomon Islands	As above	NA											Mangrove leaves, fruit, bark and roots were exploited as medicinal remedies. Boat materials, jetties, honey, seaweed, [...] were other widely acknowledged goods.		Warren-Rhodes et al.	2011	Peer-reviewed	
Coral rock trade	Coral reef	Ornamental resources	P	Mela.	Fiji				/year	Total area (Fiji)		2000 - 2010	1200 tonnes a year in 2000-2010						Number of tons	Wood et al.	2012	Report	
Live coral trade	Coral reef	Ornamental resources	P	Mela.	Fiji				/year	Total area (Fiji)		2000 - 2010	70 000 - 120 000						Number of pieces of live corals	Wood et al.	2012	Report	

Appendix 3.D.2. Valuation methods in ecosystem services assessments

ES: ecosystem service. Source: Brander, L.M., van Beukering P., Balzan, M., Broekx, S., Liekens, I., Marta-Pedroso, C., Szkop, Z., Vause, J., Maes, J., Santos-Martin F. and Potschin-Young M. (2018). *Report on economic mapping and assessment methods for ecosystem services.*

Valuation method	Acronym	Approach	Application to ecosystem services
Choice Modelling (Discrete Choice Experiment; Conjoint Analysis)	CE	Ask people to make trade-offs between ES and other goods or income to elicit willingness to pay	All ecosystem services
Contingent Valuation	CV	Ask people to state their willingness to pay for an ES through surveys	All ecosystem services
Damage Cost Avoided	DC	Estimate damage avoided due to ecosystem service	Ecosystems that provide storm, flood or landslide protection to houses or other assets
Defensive Expenditure	DE	Expenditure on protection of ES	ES for which there is public or private expenditure for its protection
Group Valuation (Participatory Valuation)	GV	Ask groups of stakeholders to state their willingness to pay for an ES through group discussion	All ecosystem services
Hedonic Pricing	HP	Estimate influence of environmental characteristics on price of marketed goods	Environmental characteristics that vary across goods (usually houses)
Input-Output Modelling	IO	Quantifies the interdependencies between economic sectors in order to measure the impacts of changes in one sector to other sectors in the economy. Ecosystems can be incorporated as distinct sectors.	Ecosystem services with direct and indirect use values, particularly inputs into production
Market Prices (Gross Revenue)	MP	Prices for ES that are directly observed in markets	ES that are traded directly in markets
Net Factor Income (Residual Value; Resource Rent)	FI	Revenue from sales of ecosystem-related good minus cost of other inputs	Ecosystems that provide an input in the production of a marketed good
Opportunity Cost	OC	The next highest valued use of the resources used to produce an ecosystem service	All ecosystem services
Production Function	PF	Statistical estimation of production function for a marketed good including an ES input	Ecosystems that provide an input in the production of a marketed good
Public Pricing	PP	Public expenditure or monetary incentives (taxes/subsidies) for ES as an indicator of value	ES for which there are public expenditures
Replacement Cost	RC	Estimate the cost of replacing an ES with a man-made service	ES that have man-made equivalents
Restoration Cost	RT	Estimate cost of restoring degraded ecosystems to ensure provision of ES	Any ES that can be provided by restored ecosystems
Social Cost of Carbon	SC	The monetary value of damages caused by emitting one tonne of CO ₂ in a given year. The social cost of carbon (SCC) therefore also represents the value of damages avoided for a one tonne reduction in emissions.	Carbon storage and sequestration
Travel Cost	TC	Estimate demand for ecosystem recreation sites using data on travel costs and visit rates	Recreational use of ecosystems
Value Transfer (Benefits Transfer)	VT	Estimate the ES value for a "policy site" using existing information from a different "study site(s)".	All ecosystem services
Other	OT		



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French thesis summary – Résumé en français de la thèse

Les solutions fondées sur les écosystèmes côtiers pour l'atténuation et l'adaptation au changement climatique dans les politiques publiques nationales des Petits États insulaires en développement du Pacifique

Glossaire

AMP : Aire marine protégée

AOSIS : Alliance des petits États insulaires

BCESL : Blue Carbon Ecosystem Services and Livelihoods (Services écosystémiques de carbone bleu et modes de vie)

CDN : Contribution nationale déterminée (ou Contribution déterminée au niveau national)

CNUCCC : Convention-cadre des Nations unies sur les changements climatiques

FEM : Fonds pour l'environnement mondial

GIEC : Groupe d'experts intergouvernemental sur l'évolution du climat

IPBES : Plateforme intergouvernementale scientifique et politique sur la biodiversité et les services écosystémiques

OBCA : Action basée sur l'océan pour le climat

ONG : Organisation non gouvernementale

PANA : Programmes d'action nationaux d'adaptation

PEIDP : Petits États insulaires en développement du Pacifique

SFN : Solution fondée sur la nature

SFN côtière : Solution fondée sur les écosystèmes côtiers

UICN : Union internationale pour la conservation de la nature

Résumé de l'Introduction générale de thèse

Le changement climatique et la dégradation de la nature sont deux des principaux défis de notre siècle (GIEC, 2022 ; IPBES, 2022). Les modes de vie humains basés sur l'exploitation non soutenable des ressources naturelles accroissent les inégalités humaines, déséquilibrent et mettent en danger le vivant sur Terre, de par la dégradation et la perte des habitats naturels, le changement climatique et la pollution (GIEC, 2022 ; IPBES, 2022). Ces déséquilibres touchent fortement les écosystèmes et les populations humaines des Petits États insulaires en développement du Pacifique (PEIDP).

La vulnérabilité des Petits États insulaires en développement du Pacifique

Les PEIDP, situés dans le Pacifique Sud-Ouest, comptent parmi les pays les plus vulnérables aux effets du changement climatique dans le monde (GIEC, 2022). La vulnérabilité accrue de ces pays s'explique, d'une part, par leur forte exposition aux effets du changement climatique, notamment en zone côtière. Ces effets se traduisent principalement par l'élévation du niveau des mers et l'augmentation de la fréquence et de l'intensité des événements climatiques extrêmes (ex. : tempêtes et vagues de chaleur) (GIEC, 2019 ; Kelman, 2009). L'élévation du niveau des mers accentue l'érosion côtière, en particulier dans les atolls composant les Iles Marshall, Kiribati, Tonga et Tuvalu, et augmente les risques d'inondation et la salinisation des nappes phréatiques et des terres cultivées (Duvat et al., 2021 ; Martyr-Koller et al., 2021 ; GIEC, 2019). Cette vulnérabilité est d'autant plus importante que 90 % de la population des PEIDP vit à moins de 10 km de l'océan (Andrew et al., 2019).

D'autre part, les PEIDP dépendent fortement des ressources naturelles côtières comme les ressources de pêches pour leur subsistance (comptant pour 50-90 % des protéines animales dans leur régime alimentaire). La pêche côtière participe également indirectement à la sécurité alimentaire des PEIDP grâce aux revenus générés par la vente du poisson, des crustacés et des coquillages (Grantham et al., 2020 ; Bell et al., 2018 ; Hills et al., 2013). Cette sécurité alimentaire est néanmoins menacée puisque plus de la moitié des PEIDP devraient expérimenter un déclin d'au moins 50 % des captures de pêche d'ici 2050 du fait du changement climatique, de la pollution côtière, de la destruction des habitats côtiers et de la surexploitation des ressources de pêche (Asch et al., 2018). Par ailleurs, un manque de ressources financières, humaines et techniques adéquates limite la capacité des PEIDP à s'adapter aux changements environnementaux en cours et à venir (GIEC, 2022 ; Vince et al., 2017 ; Campbell & Barnett, 2010).

L'émergence des Solutions fondées sur les écosystèmes côtiers pour répondre au changement climatique de manière intégrée et durable

Dans un rapport récent (Pörtner et al., 2021), les groupes d'experts internationaux sur le climat (GIEC) et la biodiversité (IPBES) reconnaissent l'existence du lien étroit entre les crises climatiques et de la

biodiversité, et soulignent la nécessité de les traiter de manière holistique (c'est-à-dire de façon globale, intégrée) pour ne pas accentuer les « déplacements de problèmes »⁵⁸. Les Solutions fondées sur la nature (SFN) font partie des mesures prioritaires identifiées par le GIEC et l'IPBES pour endiguer la crise climat-biodiversité de manière durable, avec des bénéfices simultanés pour la biodiversité et les populations humaines. Les SFN sont des actions qui s'appuient sur la protection, la restauration et plus généralement la gestion durable des écosystèmes naturels pour répondre aux défis environnementaux et sociétaux (UNEA-5).

Parmi les SFN, celles basées sur les écosystèmes côtiers (SFN côtières) sont de plus en plus reconnues par les communautés scientifiques et politiques comme essentielles pour atténuer durablement le changement climatique et surtout renforcer l'adaptation des écosystèmes et des populations humaines aux effets des crises climatique et de la biodiversité (Griscom et al., 2017). Appliquant la définition de l'UNEA-5 aux écosystèmes côtiers, les SFN côtières se réfèrent dans cette thèse aux **actions visant à protéger, conserver, restaurer, utiliser et gérer durablement les écosystèmes côtiers pour répondre aux défis sociétaux, économiques et environnementaux de manière efficace et adaptative**. Cette définition fait écho aux trois types de SFN marines que le GIEC (2022) distingue : (i) les aires marines protégées, (ii) la restauration des écosystèmes côtiers et (iii) la gestion durable des pêches.

Les écosystèmes côtiers tels que les mangroves, les herbiers marins et les prés-salés capturent le dioxyde de carbone atmosphérique et contribuent ainsi à l'**atténuation** du changement climatique. On estime que la contribution annuelle de ces écosystèmes à l'atténuation équivaut à 0,5–2 % des émissions annuelles mondiales anthropiques de gaz à effet de serre (GIEC, 2019). Ils sont pour cette raison appelés « écosystèmes de carbone bleu ». Avec les récifs coralliens (qui, eux, ne stockent pas de carbone), ces écosystèmes fournissent d'autres nombreux services aux populations humaines, contribuant à renforcer leur **adaptation** aux effets du changement climatique (GIEC, 2022). Les écosystèmes côtiers contribuent ainsi au maintien de la biodiversité et de la sécurité alimentaire humaine, car ils sont des habitats cruciaux pour les espèces marines et côtières (à titre d'exemple, les coraux ne couvrent que 0,2 % des fonds océaniques, mais abritent plus de 25 % des espèces marines) (Souter et al., 2021) ; ils constituent des barrières naturelles face à l'érosion et la submersion côtière, en absorbant l'énergie de la houle (Cameron et al., 2021 ; Earp et al., 2018) ; ils sont source de matières premières (ex. : bois de la mangrove pour usages domestiques) et de médicaments ; ils concourent au maintien de l'économie locale à travers le tourisme notamment, et à l'amélioration de la qualité des eaux côtières en retenant les

⁵⁸ Le concept de « déplacement de problème » fait référence à la situation dans laquelle une action visant à résoudre un problème dans un endroit donné peut causer l'apparition d'un autre problème ou entraîner le déplacement du problème vers un autre endroit. Par exemple, la construction d'un barrage pour produire de l'énergie peut résoudre le problème de la demande énergétique dans une région donnée, mais peut également entraîner la perte et la fragmentation des habitats naturels, déséquilibrer les flux d'eau et perturber les modes de vie des populations humaines locales.

métaux lourds et les pesticides (Barbier et al., 2011) ; enfin, ils revêtent une importance culturelle et spirituelle essentielle pour les PEIDP (Cullen-Unsworth & Unsworth, 2018 ; Veitayaki et al., 2011). Ces bénéfices que l'homme retire des écosystèmes sont appelés « services écosystémiques ». Bien que les écosystèmes côtiers aient développé au fil du temps une capacité d'adaptation aux changements environnementaux (Earp et al., 2018), leur capacité à fournir ces nombreux services diminue aujourd'hui du fait des menaces qu'ils subissent (ex. : défrichage des mangroves pour construire des fermes aquacoles, effets du changement climatique et de la pollution) (Doney et al., 2012). En parallèle, l'augmentation de la population urbaine et côtière dans les PEIDP⁵⁹ exacerbe les pressions sur les ressources disponibles pour répondre aux besoins (Remling & Veitayaki, 2016).

Comme les SFN terrestres, les SFN côtières sont dans de nombreux contextes des options peu coûteuses (Seddon et al., 2020a ; Seddon et al., 2020b) et peu risquées (Gattuso et al., 2021) par rapport aux options d'ingénierie climatique. Leurs avantages sont considérés comme plus importants en moyenne que leurs coûts. Par exemple, Narayan et al. (2016) ont estimé que les actions de restauration de la mangrove sont deux à cinq fois moins chères qu'un brise-lames submergé pour des hauteurs de vagues allant jusqu'à un demi-mètre et peuvent devenir plus rentables à des profondeurs plus importantes. Les SFN côtières sont considérées par Gattuso et al. (2021) comme des actions prioritaires et à faible risque pour le climat. Ce n'est pas le cas de nombreuses autres actions climatiques basées sur les océans, telles que l'alcalinisation des océans (considérée comme « risquée ») et la bioénergie marine avec capture et stockage du carbone (effet non prouvé) pour atténuer le changement climatique, ou encore l'adaptation basée sur les infrastructures (risquée) (Gattuso et al., 2021).

L'inclusion des SFN côtières dans les politiques publiques nationales : un focus sur les contributions nationales déterminées dans le cadre de l'Accord de Paris

Selon la communauté scientifique, la mise en œuvre des SFN côtières devrait être intensifiée de toute urgence pour faire face aux crises conjointes du climat et de la biodiversité d'une manière plus efficace et plus cohérente (GIEC, 2022 ; IPBES, 2022 ; Gattuso et al., 2021 ; Pörtner et al., 2021 ; Seddon et al., 2020a). Incorporer les SFN côtières dans les plans climatiques est une façon de développer et d'accélérer la mise en œuvre de ces actions, pour renforcer l'action climatique, la santé de l'océan et les bénéfices sociétaux via les services écosystémiques. En particulier, l'inclusion des SFN côtières dans les Contributions nationales déterminées (CDN) est une démarche promue dans un nombre grandissant d'études scientifiques (ex. : dans Dencer-Brown et al., 2022 ; Lecerf et al., 2021 ; Northrop et al., 2020 ; Cooley et al., 2019 ; Seddon et al., 2019 ; Herr & Landis, 2016), mais aussi par des organisations (ex. :

⁵⁹ On estime notamment que les capitales des Iles Marshall (Majuro), de Tuvalu (Funafuti) et de Kiribati (Tawara-Sud), qui sont toutes situées sur les côtes, devraient voir leur population doubler tous les 13 ans (Remling & Veitayaki, 2016).

le Programme des Nations unies pour l'environnement, ou l'Union internationale pour la conservation de la nature) et des initiatives internationales (ex. : « Because the Ocean »).

Les CDN sont les plans climat nationaux que les pays s'engagent à élaborer et à mettre en œuvre dans le cadre de l'Accord de Paris sur le climat adopté en 2015 par la communauté internationale pour contenir le réchauffement planétaire à 1,5 °C maximum par rapport à l'ère préindustrielle et s'adapter efficacement à ses effets. Les CDN sont des documents contenant des objectifs climatiques et des actions spécifiques pour atteindre ces objectifs. Ils constituent les plans climat de référence sur la scène internationale (Stephenson et al., 2019). Chaque pays membre de l'Accord de Paris est tenu de mettre à jour tous les cinq ans sa CDN avec une ambition toujours croissante et qui doit refléter l'ambition la plus élevée possible du pays compte tenu de ses responsabilités (liées aux émissions actuelles et historiques) et de ses capacités (économiques, institutionnelles, techniques, environnementales) (Accord de Paris, article 4, paragraphe 3) (figure FR-1). D'après les objectifs et actions contenus dans les CDN de tous les États membres (193 pays plus l'Union européenne), le réchauffement planétaire atteindrait 2,8 °C en 2100 (UNEP, 2022), avec des conséquences potentiellement dramatiques pour le vivant sur Terre (GIEC, 2022 ; UNEP, 2022). Les comparaisons entre les CDN initiales (soumises entre 2015 et 2017) et révisées (soumises généralement entre 2018 et 2021) au niveau mondial ont montré que les CDN incorporent de plus en plus de SFN côtières au fil du temps (Khan et al., 2022 ; Lecerf et al., 2021). Malgré cette reconnaissance croissante, les SFN côtières sont encore largement sous-exploitées dans les politiques climatiques telles que les CDN, selon Gattuso et al. (2022).

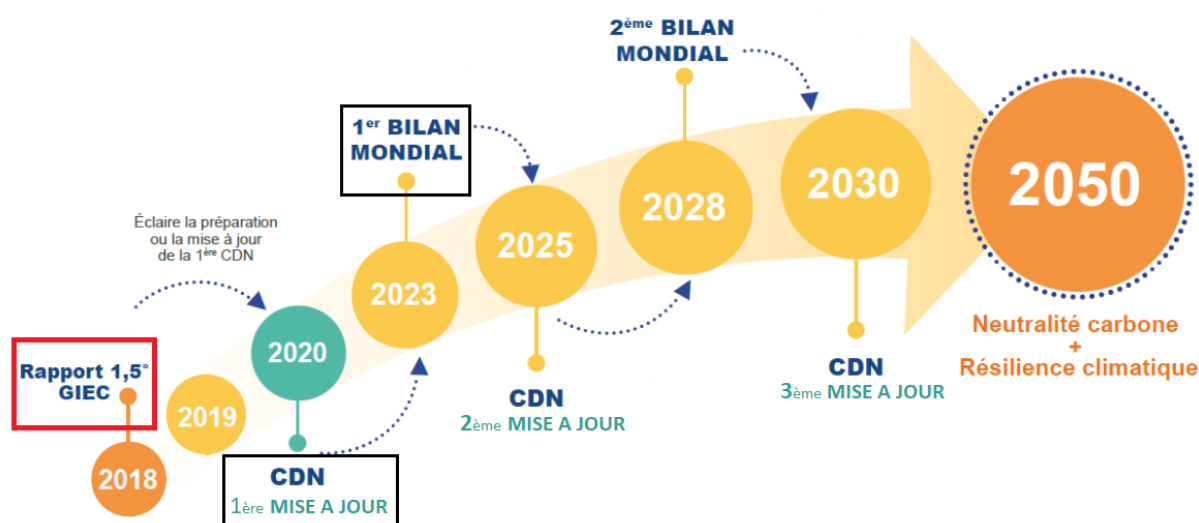


Figure FR-1 : Les mécanismes à l'œuvre dans l'ambition climatique de l'Accord de Paris sur le climat. Adapté du World Resources Institute (wri.org/publication/NDC-enhancement-by-2020).

Périmètre de la thèse : les PEIDP

La mise en œuvre des SFN côtières est particulièrement pertinente dans les pays qui sont vulnérables à la fois aux impacts climatiques et à la dégradation et à la perte des écosystèmes côtiers. C'est le cas des PEIDP qui (i) sont fortement exposés aux impacts climatiques (GIEC, 2022 ; GIEC, 2014), (ii) sont fortement dépendants des ressources et écosystèmes côtiers pour leurs moyens de subsistance (Buckwell et al., 2020 ; Veron et al., 2019 ; Veitayaki & Ledua, 2016) et (iii) ont une capacité d'adaptation limitée pour faire face à ces menaces (Asch et al., 2018).

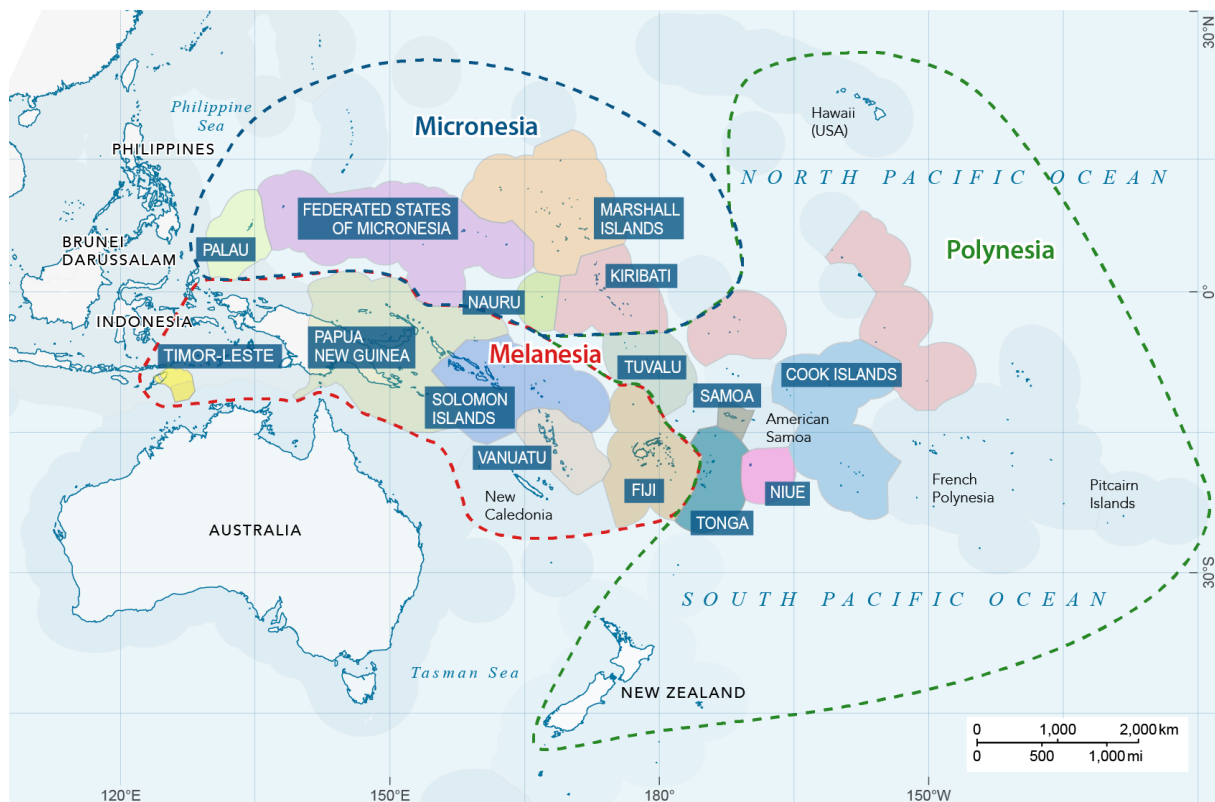


Figure FR-2 : Les Petits États insulaires en développement du Pacifique, leurs zones économiques exclusives et les macro-régions.

Le champ géographique de la thèse correspond aux quinze PEIDP répartis dans les trois macro-régions du Pacifique Sud-Ouest, à savoir la Mélanésie, la Micronésie et la Polynésie (figure FR-2). Les PEIDP sont des pays indépendants des Nations unies et membres de l'Alliance des petits États insulaires (AOSIS). Ils incluent les Iles Cook, les États fédérés de Micronésie, Fidji, Kiribati, Nauru, Niue, Palau, la Papouasie-Nouvelle-Guinée, la République des Iles Marshall, Samoa, les Iles Salomon, Timor-Leste, Tonga, Tuvalu et Vanuatu. Bien qu'il soit géopolitiquement et culturellement situé au carrefour de l'Asie du Sud-Est et de la région des Iles du Pacifique (Sousa-Santos, 2015), Timor-Leste est inclus dans le champ d'étude car il fait partie du groupe des PEID du Pacifique (et non des PEID de l'océan Indien) selon les Nations unies et l'AOSIS. Dans les chapitres 1, 2 et 3 de la thèse, les quinze PEIDP sont

considérés. Le chapitre 4 se concentre en revanche sur l'échelle locale (un village) dans un PEIDP spécifique : Fidji.

Les Territoires du Pacifique Sud-Ouest (tels que les Samoa américaines, la Polynésie française, la Nouvelle-Calédonie ou Tokelau) ne font pas partie du champ d'étude, car ce travail de thèse est basé sur une analyse des CDN ; or, ces Territoires ne sont pas membres des Nations unies et ne développent donc pas de CDN.

Les PEIDP abritent au total une population d'environ 12 millions d'habitants, la Papouasie-Nouvelle-Guinée comptant pour 80 % du total. Le territoire terrestre des PEIDP consiste en approximativement 200 îles « hautes » et 2 500 îles « basses » (ex. : les atolls). Une diversité de caractéristiques sociales, économiques, géographiques et écologiques caractérise les PEIDP. Par exemple, Niue est composé d'un seul atoll avec une population de 1 591 habitants, tandis que les Iles Salomon sont composées de 900 îles (dont le point culminant avoisine les 2 335 mètres) et comptent environ 712 000 habitants. Dans chaque PEIDP, l'océan occupe une place centrale, tant physiquement qu'économiquement et culturellement. Le territoire maritime total des PEIDP représente 98 % de leur territoire total. Les habitants du Pacifique ne considèrent pas l'océan comme un espace qui sépare les peuples, mais plutôt comme un espace qui les relie les uns aux autres ainsi qu'aux autres êtres vivants, l'océan permettant notamment le transport des personnes et des biens, garantissant la sécurité alimentaire et étant un espace de loisir, de spiritualité et de réconfort (Prasad, 2022). Les PEIDP s'identifient parfois comme de « grands États océaniques » (« Large Ocean States » en anglais) pour souligner le fait qu'ils sont les gardiens de ces vastes territoires maritimes auxquels leur économie, leur culture, leur identité et leurs moyens de subsistance sont inextricablement liés (Chan, 2018). Dans cette thèse, le terme « PEIDP » sera préféré par souci de cohérence avec la terminologie largement utilisée dans le cadre de la Convention-cadre des Nations unies sur les changements climatiques (CNUCCC) et dans la littérature scientifique.

Périmètre de la thèse : les écosystèmes considérés

Dans cette thèse, les écosystèmes considérés dans les SFN côtières sont (i) les récifs coralliens, (ii) les mangroves, (iii) les herbiers marins et (iv) les pêcheries côtières associées. Ces écosystèmes côtiers sont des écosystèmes pouvant être gérés et qui fournissent des biens et des services écosystémiques précieux à différentes échelles spatiales (Himes-Cornell et al., 2018 ; Howard et al., 2017 ; Gilman et al., 2006). Il convient de rappeler ici que les mangroves et les herbiers marins jouent un rôle important à la fois dans l'atténuation et l'adaptation climatique, alors que les récifs coralliens contribuent à l'adaptation climatique uniquement car ils ne stockent pas de carbone (Howard et al, 2017 ; Gattuso et al, 1999 ; Ware et al, 1992). Malgré leur rôle dans l'atténuation et l'adaptation climatique, les marais salés ne sont pas inclus dans le champ de recherche car leur abondance dans les PEIDP est en grande partie inconnue

et probablement très faible (Himes-Cornell et al., 2018 ; Mcowen et al., 2017). Les phytoplanctons et les algues ne sont pas non plus inclus car il existe actuellement des lacunes dans les connaissances sur la façon dont ces écosystèmes marins contribuent à l'atténuation du changement climatique (Ross et al., 2022 ; Lovelock & Duarte, 2019), et leur potentiel de gestion est limité car ils sont difficiles à observer et s'étendent au-delà des frontières nationales (Lovelock & Duarte, 2019).

L'abondance et la diversité d'espèces de mangroves (Bhattarai et al., 2011), coraux (Chin et al., 2010) et herbiers marins (McKenzie et al., 2021) diffèrent fortement entre les PEIDP. En moyenne, l'abondance de ces écosystèmes diminue au fur et à mesure que la distance au continent le plus proche (l'Australie) augmente : ils sont beaucoup plus abondants dans les PEIDP de Mélanésie (Fidji, Papouasie-Nouvelle-Guinée, Iles Salomon, Timor-Leste, Vanuatu) que dans les PEIDP de Micronésie (États fédérés de Micronésie, Kiribati, Iles Marshall, Nauru, Palau) et de Polynésie (Iles Cook, Niue, Samoa, Tonga, Tuvalu).

Les défis liés aux SFN

Alors que le concept de SFN est de plus en plus reconnu dans les sphères politiques et scientifiques internationales (Seddon et al., 2021), des études mettent en garde contre les potentielles dérives et défis liés à la mise en œuvre des SFN (ex. Chausson et al., 2020 ; Seddon et al., 2021). De nombreuses communautés indigènes et des organisations non gouvernementales expriment également leur inquiétude quant à une possible dégradation des modes de vie locaux liée aux projets SFN (ILO, 2022). Selon le rapport « Decent Work in nature-based solutions, 2022 » (ILO et al., 2022), ces préoccupations sont principalement liées à, d'une part, la crainte de voir la nature transformée en une marchandise commercialisable, en raison du manque de garanties en matière de droits humains et de la biodiversité dans les projets SFN. D'autre part, le focus actuel sur les SFN pourrait détourner l'attention de la nécessité de réduire radicalement les émissions de gaz à effet de serre au niveau mondial (Melanidis & Hagerman, 2022). Quand bien même les intentions pour préserver la biodiversité et les droits humains sont réelles, le succès de la mise en œuvre d'un projet SFN n'est pas garanti (Seddon et al., 2020b), en raison de potentielles contraintes de mise en œuvre. Ces contraintes (non spécifiques aux SFN) incluent la difficulté à évaluer l'efficacité des mesures, à mobiliser les financements et l'expertise pour la mise en œuvre, et à relever les défis de gouvernance (ex. : collaboration des parties prenantes). L'élaboration et la mise en œuvre de projets SFN réussis nécessitent l'implication à long terme de différents groupes de parties prenantes (qui n'est parfois pas compatible avec la durée des mandats politiques), la recherche de compromis entre ces groupes aux intérêts souvent divergents et le suivi des changements à la fois écologiques, économiques et sociaux au moyen d'indicateurs pertinents (Gattuso et al., 2021 ; Dutra et al., 2019). Ces défis sont particulièrement aigus dans les PEIDP, où les ressources et les capacités limitées empêchent le déploiement large et efficace des actions climatiques, y compris des SFN côtières (GIEC, 2022 ; SPREP, 2020 ; Campbell et Barnett, 2010 ; Manoa & Veitayaki, 2009).

Questions de recherche

Certains outils et principes, tels que les normes, les évaluations des services écosystémiques et les recommandations de pratiques relatives à l'intégration des politiques, à la transparence et à l'engagement des parties prenantes, sont promus au niveau mondial pour concevoir des politiques efficaces qui soutiennent la mise en œuvre de SFN solides. Dans ce contexte, ce travail de thèse s'attache à (i) mieux comprendre quelles SFN côtières sont promues dans les PEIDP, via quels types de politiques publiques et à quelles fins, et (ii) examiner la pertinence pour les PEIDP de certains outils promus pour concevoir des politiques environnementales efficaces. Les questions principales de recherche traitées dans cette thèse sont les suivantes :

Q1 : Comment les PEIDP intègrent-ils les SFN côtières dans leurs politiques publiques pour traiter les questions climat-biodiversité-océan, sur la base d'outils d'évaluation et de gestion qui cherchent à améliorer l'efficacité des actions⁶⁰ ?

Q2 : Dans quelle mesure ces outils sont-ils pertinents pour les PEIDP ?

Pour répondre à ces questions de recherche, la thèse explore quatre aspects portant sur :

- (i) la formulation des SFN côtières dans les politiques publiques des PEIDP, en termes de types d'actions, de précision et d'intégration (chapitre 1) ;
- (ii) la normalisation des SFN côtières dans les CDN des PEIDP (chapitre 2) ;
- (iii) l'évaluation des services écosystémiques côtiers dans les PEIDP (chapitre 3) ;
- (iv) la participation des acteurs locaux dans la gestion des écosystèmes côtiers pour un cas d'étude à Fidji (chapitre 4).

⁶⁰ Par exemple, les normes, les évaluations ES, les bonnes pratiques liées à l'intégration des politiques publiques et à l'engagement des parties prenantes.

Résumé du chapitre 1

Les solutions basées sur l’océan dans les contributions nationales déterminées des Petits États insulaires en développement du Pacifique : une vue d’ensemble de leurs typologie, précision et intégration

Introduction

En raison du rôle crucial de l’océan dans l’atténuation du changement climatique et l’adaptation à ses effets (GIEC, 2019), les Actions basées sur l’océan pour le climat (OBCA, pour « ocean-based climate actions » en anglais) sont de plus en plus reconnues comme des contributions clés pour l’atteinte des objectifs de l’Accord de Paris sur le climat (Hoegh-Guldberg et al., 2019 ; Gattuso et al., 2018 ; Herr & Landis, 2016). Les OBCA sont définies comme des objectifs ou des actions océaniques visant à réduire ou à éviter les émissions de gaz à effet de serre et à soutenir l’adaptation et la résilience des populations et des écosystèmes aux impacts climatiques (définition basée sur Khan et al., 2022). Les OBCA pourraient réduire le « déficit d’émissions » (c’est-à-dire la différence entre les émissions attendues si les tendances se poursuivent et les émissions compatibles avec la limitation de l’augmentation de la température mondiale) de 21 % d’ici à 2050 sur une trajectoire de 1,5 °C, et d’environ 25 % sur une trajectoire de 2 °C (Hoegh-Guldberg et al., 2019). Les OBCA se réfèrent à la fois aux solutions fondées sur les écosystèmes naturels (SFN côtières, comme la restauration de mangroves) et aux actions non basées sur les écosystèmes naturels (comme le déploiement d’énergies marines renouvelables) pour lutter contre les causes et les conséquences du changement climatique (Pörtner & Peck., 2010).

Si l’incorporation des OBCA dans les politiques publiques permet en théorie d’accroître l’ambition océan-climat-biodiversité pour répondre aux enjeux environnementaux (Pörtner et al., 2021 ; Gattuso et al., 2018 ; Herr & Landis, 2016), les résultats des OBCA ne sont pas toujours à la hauteur des attentes. Pour augmenter la probabilité que les actions incluses dans les politiques publiques produisent des résultats positifs en termes à la fois sociétaux et écologiques, les actions doivent être suffisamment décrites pour informer sur leur portée et leurs moyens de mise en œuvre (Accord de Paris, articles 4 et 13). Il est important que les potentiels bénéfiques des OBCA pour la biodiversité, le climat et d’autres défis sociétaux majeurs soient à la fois mieux compris et mieux pris en compte par les décideurs au travers d’approches de gestion intégrées (Khan et al., 2022).

Ce chapitre examine la manière dont les OBCA, et en particulier les SFN côtières, sont incluses dans les plans climat des PEIDP, en termes de précision (niveau de détail) et d’intégration (niveau de cohérence entre différents secteurs ou politiques). Cette étude se concentre en particulier sur les Contributions nationales déterminées (CDN) élaborées dans le cadre de l’Accord de Paris et analyse l’inclusion des OBCA dans les CDN, à la fois explicitement (c’est-à-dire directement dans les CDN) et

implicitement (c'est-à-dire dans les politiques mentionnées dans les CDN). En effet, il est courant que les pays mentionnent certaines politiques publiques dans leurs CDN sans incorporer explicitement dans ces CDN les actions qui découlent de ces politiques publiques (Crumpler & Bernoux, 2020).

Les objectifs de ce premier chapitre sont :

- (i) de comprendre quels types d'OBCA sont promus par les PEIDP dans leurs CDN ;
- (ii) d'évaluer les niveaux de précision et d'intégration des OBCA, deux aspects considérés comme essentiels pour mettre en œuvre des politiques robustes et ambitieuses plus susceptibles de produire des résultats positifs (Khan et al., 2022).

Tout d'abord, il est nécessaire d'inclure des actions dans les CDN de manière précise, en fournissant une description des résultats attendus, mais également de la manière dont elles seront réalisées et contrôlées. Dans le cadre de l'Accord de Paris, « chaque État-partie fournit une description de sa CDN par rapport à laquelle les progrès seront suivis » (articles 4 et 13 de l'Accord de Paris). En 2018, le Programme de travail de l'Accord de Paris énumère les éléments nécessaires à la clarté, à la transparence et à la compréhension des CDN actualisées, afin de permettre la comptabilisation du carbone, la prévision des tendances climatiques futures et la préparation aux risques (Northrop et al., 2020 ; CCNUCC, CMA, 2018). Il s'agit des éléments suivants : (i) les objectifs des actions, (ii) les années ou périodes cibles, (iii) les points de référence, (iv) les calendriers de mise en œuvre et (v) le champ d'application (en termes de secteurs, catégories, activités, sources et puits, gaz concernés) (CCNUCC, CMA, 2018). Ces informations doivent permettre de suivre les progrès collectifs dans le cadre du Bilan mondial, le mécanisme développé dans le cadre de l'Accord de Paris pour faire le point sur les progrès de l'action climatique à l'échelle mondiale et éclairer le contenu des futures CDN (figure FR-1).

Deuxièmement, il est nécessaire de mieux intégrer les politiques publiques et les actions relatives au climat, à la biodiversité, aux océans et au développement (Khan et al., 2022). La résolution des crises complexes liées à la biodiversité, au climat et au développement, dont les causes profondes sont liées aux modes de vie humains non soutenables, nécessite un niveau élevé de coordination, de cohérence et d'intégration des politiques publiques (Domorenok et al., 2021 ; Pettorelli et al., 2021 ; Pörtner et al., 2021). Ces notions, très proches et dont les définitions sont contestées, sont souvent utilisées de manière interchangeable pour décrire des actions politiques qui se renforcent mutuellement au sein des différents ministères et secteurs économiques, créant des synergies en vue d'atteindre les objectifs définis (Cejudo & Michel, 2017 ; Nations unies, 2015).

Dans cette étude, nous utilisons le terme « intégration » pour désigner le processus qui contribue à l'amélioration de la cohérence des politiques par l'articulation de plusieurs instruments ou objectifs politiques afin d'atteindre des buts politiques complexes qui englobent les objectifs respectifs de chaque instrument politique. Pour Dencer-Brown et al. (2022), l'inclusion des OBCA (et en particulier des SFN côtières) dans les CDN pourrait contribuer à réduire le fossé d'intégration observé entre les politiques

relatives à la biodiversité, les politiques socio-économiques et les politiques climatiques, favorisant ainsi l'élaboration de politiques environnementales plus cohérentes. Cette démarche permettrait de réduire les conflits entre les différentes parties prenantes, ainsi que les coûts économiques, sociaux et écologiques sur le long terme (Pettorelli et al., 2021 ; Pörtner et al., 2021 ; Seddon et al., 2021 ; Martin et al., 2020 ; Northrop et al., 2020 ; Herr & Landis, 2016).

Matériel et méthode

Les étapes suivies pour répondre aux objectifs de recherche sont les suivantes :

- **Étape 1 : l'identification des politiques pertinentes pour l'analyse, c'est-à-dire les CDN et les politiques mentionnées dans les CDN.** Nous avons examiné toute les CDN des PEIDP soumises au secrétariat de la CNUCCC avant le 31 octobre 2021, date butoir pour soumettre les CDN révisées en amont de la COP26 à Glasgow. Les politiques mentionnées dans les CDN sont également examinées afin de compléter les informations contenues dans les CDN et d'explorer dans quelle mesure les CDN reflètent l'ambition nationale en matière d'OBCA. Ces politiques publiques mentionnées dans les CDN incluent une variété d'instruments, tels que des plans, des stratégies, des communications nationales, mais aussi des sources juridiques comme des lois ou des actes. Comme les CDN, elles portent sur le niveau national dans la très grande majorité des cas et sont disponibles sous la forme de documents en ligne, en langue anglaise.
- **Étape 2 : l'identification et la catégorisation des OBCA en 10 catégories d'actions,** sur la base d'une typologie des OBCA adaptée de Gattuso et al. (2018, affinée en 2022).
- **Étape 3 : la catégorisation des politiques publiques en différents secteurs principaux (climat, développement, environnement) et sous-secteurs.** Par exemple, le secteur « environnement » est divisé en plusieurs sous-secteurs pour permettre d'identifier les documents qui portent sur un thème précis, comme l'océan, la biodiversité, l'agriculture ou la forêt.
- **Étape 4 : la caractérisation des OBCA, en termes de précision et d'intégration.** Des indicateurs d'absence/de présence sont utilisés pour comprendre dans quelle mesure les OBCA sont précises et intégrées. Les cinq indicateurs de précision sont les suivants : présence/absence (i) d'action(s) ciblée(s), (ii) d'objectif(s) quantifié(s), (iii) de coûts associés, (iv) de date liée à l'objectif ou à un calendrier de mise en œuvre et (v) d'action(s) de soutien. Les trois indicateurs d'intégration sont les suivants : présence/absence (vi) d'au moins deux buts distincts associés à l'action (terme « multi-aspect »), (vii) d'au moins deux politiques publiques d'un même secteur contenant une OBCA similaire(voir paragraphe suivant pour la définition d'un secteur), (viii) d'au moins deux politiques publiques de différents secteurs contenant une OBCA similaire.

Résultats principaux et discussion

Tout d'abord, 80 % des PEIDP ont inclus au moins une OBCA directement dans leur CDN. Si l'on prend également en compte les politiques référencées dans les CDN, 100 % des PEIDP ont inclus au moins une OBCA dans leurs politiques publiques nationales, témoignant d'un intérêt pour la mise en œuvre d'OBCA pour lutter contre le changement climatique. La façon dont les OBCA sont incluses dans les politiques nationales des PEIDP varie considérablement d'un pays à l'autre, ce qui n'est pas surprenant étant donné les différences de contextes socio-écologiques entre les pays (tels que la présence de certains écosystèmes, les priorités politiques en matière d'énergie et de développement de manière générale, ou la géomorphologie des îles).

Nos résultats mettent en évidence une forte reconnaissance du rôle des écosystèmes côtiers dans l'adaptation au changement climatique et l'atténuation de ses effets, puisque les trois catégories d'OBCA les plus fréquemment retrouvées dans les CDN actuelles des PEIDP sont basées sur les écosystèmes côtiers. Ces trois catégories correspondent à (i) la protection contre les risques côtiers basée sur la conservation ou la restauration des écosystèmes côtiers (47 % des CDN actuelles des PEIDP), (ii) la gestion écosystémique des pêches pour l'adaptation au changement climatique (40 %) et (iii) la conservation ou restauration des mangroves et herbiers pour l'atténuation (les co-bénéfices pour l'adaptation étant souvent reconnus) (40%). Les catégories d'OBCA les moins fréquemment retrouvées concernent le déploiement des énergies marines renouvelables (13 % des CDN actuelles des PEIDP), la relocalisation et la diversification des activités économiques marines et côtières (13 %), la réduction de la pollution pour préserver les écosystèmes côtiers (20 %) et la relocalisation des populations dans des lieux plus sûrs (sur les hauteurs des îles, voire sur d'autres îles ou pays) (20 %). Toutefois, le développement des énergies marines renouvelables et la relocalisation des populations dans des lieux plus sûrs sont de plus en plus considérés comme des options envisageables, avec une inclusion explicite dans 25 % et 50 % des CDN révisées respectivement pour ces deux catégories d'OBCA.

Au fil du temps, les PEIDP ont de plus en plus incorporé des OBCA dans leurs CDN et, plus généralement, dans leurs cadres politiques (c'est-à-dire dans l'ensemble de leurs politiques publiques), en particulier en ce qui concerne (i) le transport maritime, (ii) la relocalisation des populations et (iii) les quatre catégories de SFN côtières. Un résultat marquant a été le passage, au fil du temps, d'une protection côtière basée sur les infrastructures à une protection côtière basée sur les écosystèmes afin de réduire les impacts climatiques sur les zones côtières.

En outre, les OBCA figurant dans les CDN des PEIDP sont de plus en plus précises dans le temps, en particulier concernant la présence d'objectifs quantifiés, notamment vis-à-vis des SFN côtières (par exemple, des cibles en termes de pourcentage d'aires marines protégées dans la zone économique exclusive). Avec le temps, les OBCA des PEIDP sont également davantage intégrées, que ce soit entre les différentes catégories d'OBCA ou entre les multiples politiques publiques de différents secteurs. Plus

précisément, les catégories d'OBCA sont davantage intégrées dans diverses politiques de différents secteurs ou sous-secteurs au fil du temps. Les co-bénéfices entre les catégories d'OBCA sont de plus en plus fréquemment mis en évidence, notamment (i) entre les actions fondées sur la nature et celles qui ne le sont pas, (ii) entre le développement, le climat et les défis environnementaux de manière générale, et (iii) entre les composantes d'atténuation et d'adaptation climatique.

Cependant, les informations fournies dans les CDN manquent en général encore d'indications importantes sur le moment, le lieu et la manière dont les OBCA seront concrètement mises en œuvre et suivies pour s'assurer qu'elles produisent les résultats attendus. En particulier, les coûts nécessaires à la mise en œuvre et au suivi de l'efficacité des SFN côtières ainsi que leurs calendriers de mise en œuvre sont rarement mentionnés dans les CDN des PEIDP.

L'importance d'examiner non seulement les CDN mais aussi les politiques publiques qu'elles mentionnent a été particulièrement utile pour mieux comprendre comment les PEIDP intègrent plus largement les OBCA dans leurs cadres politiques. Cette démarche a permis de mettre en évidence un déficit d'informations liées aux SFN côtières pour l'atténuation. En effet, sur cette thématique, nous avons trouvé des informations pertinentes dans d'autres politiques mentionnées dans les CDN révisées qui n'ont pas été explicitement incluses dans ces dernières. Ce résultat révèle que les CDN n'expriment pas systématiquement le niveau réel d'ambition des PEIDP en termes d'OBCA, notamment en ce qui concerne (i) les activités liées au carbone bleu et (ii) l'adaptation basée sur les infrastructures. Ces actions et objectifs implicitement inclus dans les CDN pourraient être explicitement inclus afin de rendre les actions climatiques et les besoins des PEIDP plus transparents et visibles sur la scène internationale, comme le recommande l'Accord de Paris. Cette pratique permettrait également d'améliorer l'intégration des politiques climatiques et la cohérence entre les politiques et les secteurs, comme le recommandent l'Organisation de coopération et de développement économiques, le Dialogue sur les océans et le changement climatique de la Convention Climat, et la littérature scientifique (voir par exemple Dencer-Brown et al., 2022 ; Dobush et al., 2022 ; Strauß et al., 2022 ; Coscieme et al., 2021).

Conclusion

Bien que les CDN reflètent ce que les pays ont l'intention de mettre en œuvre et non ce qu'ils font réellement, l'analyse de ces documents climatiques a permis de mettre en évidence un intérêt croissant des PEIDP pour l'inclusion des OBCA – et en particulier de celles basées sur les écosystèmes côtiers – dans leurs CDN. En tant que tel, ce travail constitue une première vue d'ensemble des OBCA incluses dans les CDN des PEIDP et n'a pas vocation à évaluer l'efficacité des mesures. Il se concentre plutôt sur la façon dont les CDN incluent les OBCA à la fois directement et indirectement, révélant les liens entre les CDN et les politiques publiques nationales qui y sont associées, afin d'informer le prochain cycle de mise à jour des CDN en 2025 et le bilan climatique mondial en 2023. Comprendre comment

les PEIDP envisagent concrètement la mise en œuvre des SFN côtières et plus largement des OBCA identifiées dans leurs CDN (par exemple, via des enquêtes auprès des gouvernements des PEIDP) constitue une piste de recherche future clé pour renforcer l'adaptation des PEIDP aux impacts environnementaux en cours et à venir.

Résumé du chapitre 2

L'utilisation de standards pour les solutions fondées sur les écosystèmes côtiers dans les plans climatiques : application du Standard mondial de l'UICN au cas des Petits États insulaires en développement du Pacifique

Introduction

Les normes se réfèrent à un niveau spécifié de qualité ou de réalisation déterminé par la recherche scientifique et par la société de manière générale. Selon l'Union internationale pour la conservation de la nature (UICN), la normalisation des SFN pourrait contribuer à l'élaboration de SFN robustes, en clarifiant le concept de SFN et les besoins nécessaires pour déployer des SFN efficaces et équitables (c'est-à-dire des SFN qui produisent les résultats écologiques et sociétaux attendus) (UICN, 2020). Cette normalisation est particulièrement pertinente dans un contexte où les SFN sont de plus en plus incluses dans les politiques publiques et mises en œuvre dans le monde entier (UICN, 2020). À cette fin, l'UICN a élaboré et publié en 2020 le Standard mondial pour les SFN (UICN, 2020).

Nous avons dans un premier temps étudié la manière dont les SFN côtières sont actuellement incluses dans les CDN des PEIDP, en utilisant une approche semi-quantitative pour évaluer leur alignement avec le Standard mondial de l'UICN. Une motivation à cette étude, outre la nécessité de soutenir le déploiement d'actions environnementales équitables et efficaces écologiquement, est qu'il n'existe actuellement aucune définition unique des activités liées au carbone bleu dans le cadre de la CNUCCC, ni d'orientation claire sur la façon d'inclure les éléments (par exemple, les SFN) dans les CDN (Herr & Landis, 2016). Par conséquent, il existe une grande variété de formats et de contenus de CDN parmi les pays. Cette grande diversité rend difficile l'agrégation, la comparaison et le suivi des engagements, et compromet le succès du Bilan mondial mandaté par l'Accord de Paris (prévu pour 2023, voir figure FR-1) pour faire le point sur les progrès accomplis en matière d'atténuation et d'adaptation.

Nous discutons ensuite de deux domaines dans lesquels une description normalisée des SFN dans les CDN pourrait soutenir l'action : la mobilisation de financements et le suivi des progrès. Il s'agit de deux des principaux défis identifiés par Seddon et al. (2020a) pour accroître le potentiel des SFN. Enfin, nous discutons de l'applicabilité du Standard mondial de l'UICN et de la pertinence de la normalisation de manière plus générale pour les SFN dans les plans climat des PEIDP.

Matériel et méthode

La méthodologie se compose de trois étapes, représentées sur la figure FR-3 et détaillées ci-après :

- **Étape 1 : l'identification de SFN côtières dans les CDN des PEIDP**, basée sur une typologie d'actions océan-climat développée par Gattuso et al. (2018, affinée en 2022). Quatre catégories sont retenues pour notre étude, dont le focus est la zone côtière : (A) la restauration, conservation et gestion durable de la végétation côtière pour l'atténuation, (B) la conservation des écosystèmes côtiers pour l'adaptation, (C) la restauration des écosystèmes côtiers pour l'adaptation, et (D) la gestion communautaire durable de la pêche côtière pour l'adaptation.
- **Étape 2 : le développement d'une évaluation semi-quantitative de l'alignement des SFN avec les 28 indicateurs et les 8 critères du Standard mondial de l'UICN**. Quatre niveaux composent l'échelle permettant l'évaluation de l'alignement, auxquels nous avons attribué un score de 1 à 4 en fonction de l'adéquation de l'alignement (4 si alignement fort, 3 si adéquat, 2 si partiel, et 1 si insuffisant) (figure FR-3).
- **Étape 3 : l'obtention d'un score total d'alignement**, en faisant la moyenne des scores de chaque critère, pour chaque SFN.

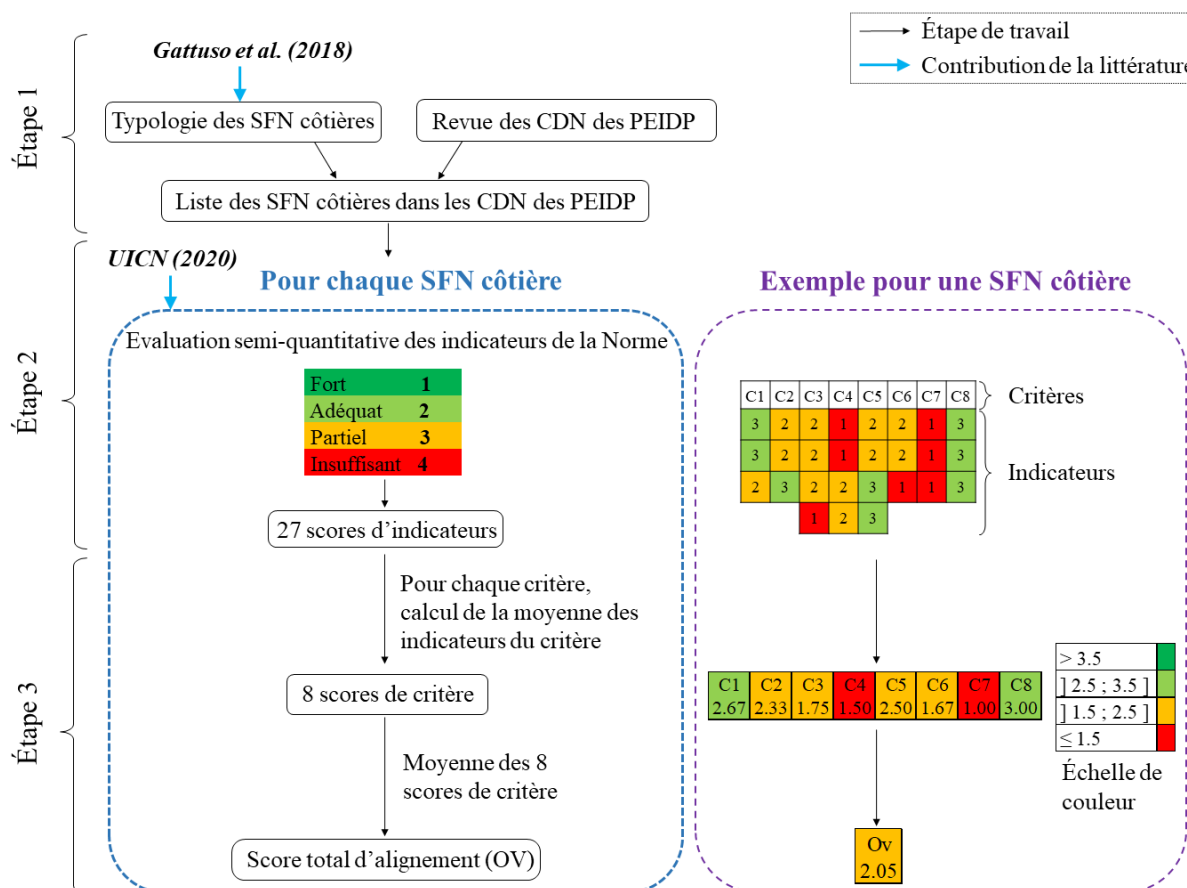


Figure FR-3 : Vue générale des étapes méthodologiques du chapitre 2.

Résultats principaux

Plus de deux tiers (n=17) des 24 CDN communiquées par les PEIDP en amont du 31 octobre 2021 incluait des SFN côtières. Au total, 22 SFN côtières ont été identifiées dans les 24 CDN. La majorité (n=16) se référait à des fins d'adaptation (catégories B, C et D), et 6 à des fins d'atténuation (catégorie A). Seule une SFN côtière sur 22 (« Gestion communautaire des ressources marines » dans la CDN originale de Vanuatu) peut être considérée comme alignée sur le Standard mondial de l'UICN.

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

Figure FR-4 : Scores des critères (C1 à C8) et score total (OV) pour chaque SFN côtière incluse dans les CDN des Petits États insulaires en développement du Pacifique. Niveau d'alignement : vert clair : adéquat ; orange : partiel ; rouge : insuffisant. C1 : défis sociétaux ; C2 : élaboration à l'échelle ; C3 : gain net de biodiversité ; C4 : faisabilité économique ; C5 : gouvernance inclusive ; C6 : équilibre des compromis ; C7 : gestion adaptative ; C8 : intégration et durabilité. BC : Carbone bleu. FSM : États fédérés de Micronésie. LMMA : Aire marine gérée localement. MPA : Aire marine protégée. PNG : Papouasie-Nouvelle-Guinée. RMI : République des Iles Marshall. SMA : Aire marine spéciale.

Les SFN côtières incluses dans les CDN révisées des PEIDP sont en moyenne davantage alignées avec le Standard mondial de l'UICN que celles incluses dans les CDN initiales, en particulier concernant les critères C1 sur les défis sociétaux, C2 sur l'élaboration à l'échelle et C3 sur le gain net de biodiversité.

En moyenne, pour les 22 SFN côtières, cinq critères ont été évalués comme partiellement alignés avec la Norme de l'UICN (critères C1, C2, C3, C5 et C8) et trois étaient insuffisants (C4, C6 et C7). Ces derniers correspondent à la faisabilité économique de la SFN (C4), l'équilibre des compromis (C6) et la gestion adaptative (C7) (figure FR-4). Les liens entre les SFN et les défis sociétaux (critère C1) et entre les SFN et leur conception à l'échelle (critère C2) ont fait l'objet d'attentions particulières. Toutes les SFN côtières ont identifié l'atténuation du changement climatique ou l'adaptation à celui-ci comme un défi prioritaire. En ce qui concerne le critère C3 sur le « gain net de biodiversité », seul l'indicateur relatif à l'état actuel de l'écosystème et aux facteurs de dégradation a été partiellement atteint, tandis que d'autres, tels que la définition d'objectifs clairs en matière de biodiversité, se sont avérés insuffisamment alignés. Par exemple, plusieurs PEIDP, dont les Iles Cook, la Papouasie-Nouvelle-Guinée et Tonga, ont identifié des aires marines protégées comme mesures d'adaptation dans leurs CDN ; cependant, la manière dont ces aires marines protégées soutiendront réellement la biodiversité n'est pas détaillée.

Discussion

La standardisation pour faciliter l'accès au financement des SFN

Dans leur CDN, les PEIDP ont fréquemment souligné la nécessité d'un financement externe (c'est-à-dire non domestique) pour développer, mettre en œuvre et suivre avec succès les SFN côtières, mais ont rarement fourni des estimations de coûts à l'échelle des SFN (critère C4). Pour pouvoir attirer des financements SFN, il est nécessaire d'avoir une idée claire des coûts impliqués, de fixer des objectifs mesurables et d'être en mesure de suivre les progrès réalisés (Swann et al., 2021). En analysant les financements du Fonds pour l'environnement mondial (FEM), un des deux principaux fonds de la Convention Climat, nous avons constaté que les financements pour les projets transversaux biodiversité-climat dans les PEIDP ont progressivement augmenté dans le temps, passant de 0 US\$ au cours de la période 1994-2006 à 368 millions US\$ entre 2018 et 2022 (alors qu'en parallèle, les financements pour les projets pour le climat seul ou la biodiversité seule ont significativement diminué). Pour une SFN donnée, le fait de renseigner les critères C1 sur les défis sociétaux et C3 sur le gain net de biodiversité pourrait ainsi faciliter l'accès des PEIDP à certains fonds, comme le FEM. Cette pratique pourrait aussi permettre de faciliter l'accès aux fonds prévus par l'UICN pour lesquels une sélection de projets est évaluée par rapport au Standard mondial de l'UICN (par exemple, c'est le cas du Mécanisme de financement du capital naturel bleu lancé en 2018). Cependant, bien qu'il semble que l'accès au financement puisse être amélioré par un meilleur alignement des SFN sur le Standard mondial de l'UICN, il incombe à la communauté internationale d'accroître sa volonté de soutenir efficacement et durablement les pays qui sont les plus dépendants de l'aide financière internationale. Ce soutien doit être

renforcé de toute urgence pour répondre à l'ampleur des impacts climatiques et aux besoins de développement, afin d'éviter que les déplacements de population ne deviennent l'ultime option pour les communautés insulaires les plus vulnérables (UNEP, 2022 ; Mcleod et al., 2011).

La standardisation pour faciliter le suivi des progrès des SFN

La description normalisée des SFN dans les CDN avec un niveau de détail plus élevé permettrait de mieux respecter l'exigence de l'Accord de Paris de « fournir les informations nécessaires à la clarté, à la transparence et à la compréhension » dans la communication des CDN (Accord de Paris, article 4). Le Bilan mondial est un processus itératif quinquennal mandaté par l'Accord de Paris pour suivre les progrès accomplis dans la réalisation de ses objectifs de long terme d'atténuation, d'adaptation et de financement. Le premier Bilan mondial doit être conduit en 2023 (figure FR-1). La première phase de ce Bilan mondial se focalise sur l'agrégation des objectifs contenus dans les CDN, en faisant l'hypothèse que les CDN seront entièrement mises en œuvre. Nos résultats – basés sur l'évaluation de l'alignement des descriptions des SFN côtières avec le Standard mondial de l'UICN – suggèrent qu'il pourrait être difficile d'informer cette étape en ce qui concerne les SFN dans les PEIDP, car l'indicateur 3.2 sur les objectifs clairs en termes de biodiversité est évalué « insuffisant » en moyenne. D'autre part, notre analyse des CDN des PEIDP a révélé que les descriptions des SFN vis-à-vis de la gouvernance inclusive (C5) et de l'intégration des politiques publiques (C8, indicateur 8.1) étaient en général « inadéquatement alignées ». De même, les informations financières liées aux SFN (C4) sont de manière générale insuffisamment incluses dans les CDN des PEIDP, ce qui suggère que la collecte de données sur les flux et les besoins en matière de financement climatique pour informer le Bilan mondial risque également d'être difficile. Une normalisation comprenant des indicateurs sur les besoins et les coûts de financement, tel que le Standard mondial de l'UICN, pourrait par ailleurs permettre aux PEIDP de rendre leurs besoins financiers visibles dans le cadre du Bilan mondial.

Pertinence du Standard mondial de l'UICN pour les PEIDP

Tout d'abord, nous devons reconnaître que la description des SFN dans les CDN peut ne pas refléter la manière dont les SFN sont véritablement conçues, mises en œuvre et suivies dans la réalité. Par exemple, il est possible que des PEIDP considèrent d'autres plans, tels que les Programmes d'action nationaux d'adaptation (PANA), comme étant davantage appropriés pour inclure et détailler les SFN à des fins d'adaptation, comme l'illustre l'inclusion croissante des SFN dans les PANA des PEIDP (Pramova et al., 2012). Par ailleurs, nos résultats pourraient suggérer que les exigences du Standard mondial de l'UICN sont trop élevées ou inappropriées pour les PEIDP, en particulier concernant les indicateurs liés à la faisabilité économique, l'équilibre des compromis et la gestion adaptative. Dans ces pays dont la capacité institutionnelle est limitée (Campbell & Barnett, 2010), la collecte des données nécessaires pour renseigner de manière adéquate les 28 indicateurs de la Norme pour toutes leurs SFN côtières peut s'avérer fastidieuse, voire impraticable. Au-delà de la question de la pertinence du Standard mondial de

l'UICN dans les PEIDP, la normalisation des SFN en général soulève des questions sur la flexibilité des PEIDP à personnaliser les approches de conception de leurs SFN. Il est probable que les pays ayant des contraintes financières, humaines et technologiques aient surtout besoin d'aide pour développer des SFN bien adaptées à leur contexte local et que la question de la normalisation soit secondaire.

Conclusion

Nous avons identifié les possibilités offertes par une description normalisée des SFN dans les CDN, notamment en ce qui concerne la mobilisation de financements adéquats pour les SFN et le suivi des progrès des SFN. En tant que telle, notre recherche permet de donner un aperçu du potentiel d'utilisation du Standard mondial de l'UICN comme base de description des SFN dans les CDN, dans un contexte où les modalités de suivi de la mise en œuvre des CDN sont en cours de discussion par les organes techniques de la CNUCCC. Nos résultats soulèvent également la question de savoir si les exigences du Standard mondial de l'UICN sont trop élevées ou inappropriées pour les PEIDP. La question de savoir s'il existe un compromis entre plus de normalisation et moins de flexibilité pour les pays afin de personnaliser les approches de gestion environnementale reste ouverte et nécessite des données pour mieux comprendre les besoins des PEIDP. Une recherche complémentaire à notre étude pourrait consister en des études de cas pour recueillir les points de vue des représentants des gouvernements des PEIDP sur les avantages et les obstacles qu'ils identifient concernant l'utilisation du Standard mondial de l'UICN pour les SFN dans le cadre de l'élaboration, de la mise en œuvre et du suivi des CDN. Cela permettrait de mieux comprendre les conditions d'applicabilité du Standard mondial de l'UICN dans les PEIDP et de déterminer les options les plus appropriées pour élaborer, mettre en œuvre et suivre des SFN qui produisent des résultats désirés.

Résumé du chapitre 3

Revue systématique des services écosystémiques côtiers dans les Petits États insulaires en développement du Pacifique

Introduction

Les mangroves, herbiers marins et récifs coralliens procurent de multiples avantages directs et indirects aux populations humaines, via notamment la sécurité alimentaire, la régulation du climat et des cycles biogéochimiques, la protection des côtes, les loisirs et les activités économiques et traditionnelles (Börger et al., 2014 ; Barbier et al., 2011). C'est particulièrement le cas dans les PEIDP, qui dépendent fortement des écosystèmes côtiers pour leurs moyens de subsistance, leurs revenus et leur culture (Selig et al., 2019 ; Cullen-Unsworth et Unsworth, 2018 ; Hilmi et al., 2014 ; Hills et al., 2013). Ces bénéfices que l'homme retire des écosystèmes sont appelés « services écosystémiques » (SE).

Cependant, les écosystèmes côtiers sont en déclin dans les PEIDP (Devlin et al., 2021 ; Brodie et al., 2020 ; Lovelock et al., 2015), en raison des effets combinés du changement climatique et d'autres facteurs de stress anthropique tels que la surpêche, la pollution et le défrichage des mangroves (Devlin et al., 2021 ; Pendleton et al., 2016a). Ce déclin réduit la capacité de ces écosystèmes à faire face aux changements climatiques et démographiques, et à maintenir les services écosystémiques (IPBES, 2018 ; Pendleton et al., 2016). Dans ce contexte, la préservation des écosystèmes côtiers dans les PEIDP devrait être un objectif prioritaire pour réduire la vulnérabilité des populations côtières (Hilmi et al., 2014).

Les évaluations de services écosystémiques permettent de mettre en lumière les services écosystémiques et sont reconnues comme un outil précieux pour soutenir la protection et la gestion durable des écosystèmes (Börger et al., 2014). Elles peuvent par exemple mettre en évidence des services écosystémiques culturels qui auraient pu être omis si seuls les revenus et les coûts commerciaux avaient été pris en compte dans la gestion environnementale, et ainsi améliorer la compréhension des compromis entre plusieurs options de gestion (Börger et al., 2014). Bien que les types de services fournis par les écosystèmes côtiers soient bien connus (Barbier et al., 2011), les contributions de ces écosystèmes aux populations restent mal comprises localement, y compris dans les PEIDP (Blythe et al., 2020). Par ailleurs, les évaluations de services écosystémiques sont rarement associées à des recommandations politiques dans la littérature et ne répondent pas nécessairement aux besoins et aux préoccupations politiques et sociales (Bitoun et al., 2022).

Dans ce contexte, nous avons tenté :

- (i) de fournir une vue d'ensemble de l'état actuel de la littérature sur les services écosystémiques côtiers dans les PEIDP ;

(ii) de rendre compte des méthodologies utilisées dans la littérature pour évaluer les services écosystémiques ;

(iii) de comprendre le contexte dans lequel les évaluations de services écosystémiques côtiers ont été réalisées ;

(iv) d'approfondir la compréhension des services écosystémiques culturels dans les PEIDP. Les services écosystémiques culturels correspondent aux services récréatifs, esthétiques, scientifiques ou d'identité culturelle (Costanza et al., 2011). Ils sont généralement difficiles à évaluer monétairement, car ils ne sont pour la plupart pas commercialisés, et leur valeur est très subjective et relève parfois du sacré (par exemple, la fonction culturelle des récifs est sacrée pour les populations du Pacifique) (Lau et al., 2019 ; Díaz et al., 2018 ; Hilmi et al., 2014).

Matériel et méthode

Trois critères d'inclusion sont utilisés pour identifier les services écosystémiques dans la littérature.

- **Critère n° 1** : il concerne le type d'écosystème. Nous n'avons retenu que les études comportant des évaluations des services rendus par les mangroves, les récifs coralliens, les herbiers marins ou une combinaison de ces écosystèmes.

- **Critère n° 2** : il se réfère au champ géographique de l'étude. Nous n'avons considéré que les études portant sur les quinze PEIDP (voir la section sur l'Introduction générale de thèse pour le détail des pays), que ce soit à l'échelle de la région entière, d'un pays, d'une province ou d'un village.

- **Critère n° 3** : il concerne la définition du service écosystémique. Dans cette étude, un service écosystémique est considéré comme tel s'il remplit les trois conditions suivantes :

(i) il s'agit d'une contribution, directe (ex. : bois de la mangrove pour cuisiner) ou indirecte (ex. : régulation climatique), d'un écosystème côtier au bien-être humain ;

(ii) cette contribution est reliée à un écosystème identifiable faisant partie de notre champ d'étude (voir critère n° 1) ;

(iii) cette contribution est géographiquement localisable et délimitée.

Nous avons tenté d'identifier tous les services écosystémiques côtiers des PEIDP à la fois dans la littérature scientifique évaluée par les pairs et dans la littérature grise, jusqu'en avril 2021 maximum, sur la base d'équations de recherche avec mots-clés dans les bases de données Google Scholar, Scopus et le Pacific Hub Database (figure FR-5). Cette recherche a abouti à l'identification de 57 études (26 études scientifiques évaluées par les pairs et 31 rapports) contenant des services écosystémiques côtiers comme définis par nos trois critères d'inclusion.

Nous avons classé les données d'intérêt selon la classification de « L'économie des écosystèmes et de la biodiversité » (TEEB, 2010), qui s'appuie sur le « Millennium Ecosystem Assessment » (MEA, 2005), système de référence pour l'évaluation des services écosystémiques (bien que critiqué, notamment pour ses difficultés à collecter les différents points de vue sur les valeurs des SE, en particulier des populations autochtones) (Díaz et al., 2018). Ce système divise les services écosystémiques en trois catégories (provision, maintenance et régulation, culture) et 23 types (incluant par exemple la provision de nourriture, la régulation des cycles biogéochimiques et le tourisme). Nous avons classé les biens (contributions matérielles) dans la catégorie culturelle lorsqu'ils faisaient explicitement référence à des pratiques traditionnelles, un choix soutenu par Fish et al. (2016). C'est le cas des types « matières premières » (faisant toujours référence au bois de mangrove) et « ressources médicinales » provenant de la mangrove, car ils étaient systématiquement liés à des pratiques traditionnelles dans les études examinées.

Nous avons comparé nos données avec celles de la base de données « Évaluation des services écosystémiques » (ESVD, 2020) (qui s'appuie sur celle du TEEB, 2010) afin de nous assurer qu'aucune donnée monétaire n'a été omise ou mal déclarée (ESVD ne contient que des données monétaires). Toutes les valeurs monétaires étaient exprimées en dollars américains dans les études. Nous les avons converties en prix de 2022 à l'aide d'un calculateur d'inflation. Puis, pour comprendre comment les auteurs ont saisi l'importance des services écosystémiques côtiers au-delà des termes économiques, nous avons proposé de classer les services écosystémiques selon qu'ils étaient (i) monétairement, (ii) quantitativement mais non monétairement, ou (iii) qualitativement évalués.

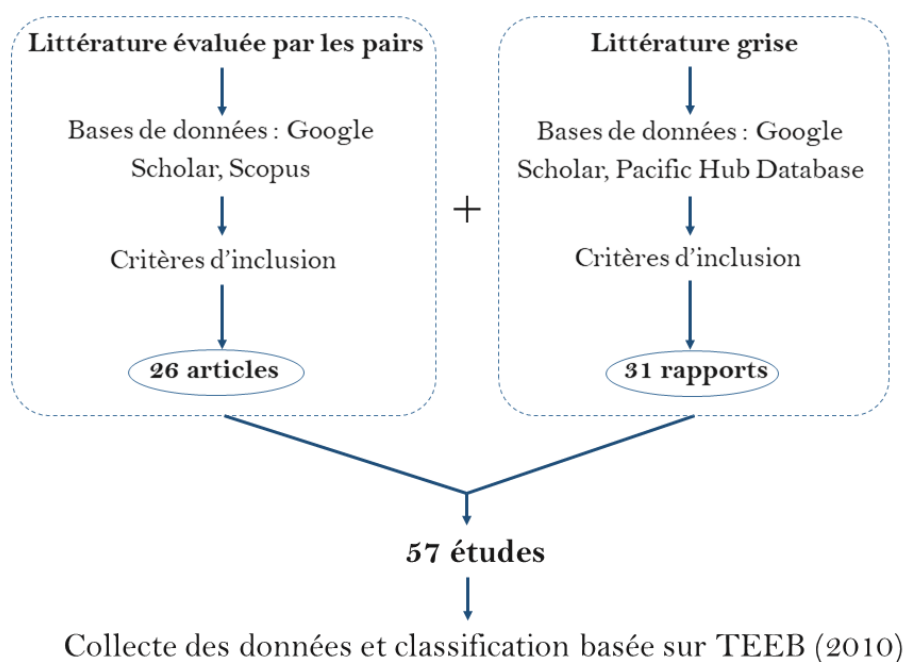


Figure FR-5 : Étapes suivies pour l'identification des services écosystémiques côtiers dans la littérature.

Résultats et Discussion

Nous avons identifié 292 services écosystémiques côtiers dans les 57 études. La Mélanésie est la région comportant le plus d'études contenant des évaluations de services écosystémiques côtiers (44 études), la Micronésie en comptant huit et la Polynésie, six. De même, le nombre de services écosystémiques évalués est plus élevé en Mélanésie (201) qu'en Polynésie (56) et en Micronésie (28). Les récifs coralliens sont le type d'écosystème le plus étudié, avec 146 évaluations. La distribution des récifs coralliens, des mangroves et des herbiers marins dans la région du Pacifique, qui diminue d'ouest en est (c'est-à-dire de la Mélanésie à la Polynésie) (McKenzie et al., 2021 ; Bhattarai & Giri, 2011 ; Chin, 2010), peut expliquer en partie pourquoi la littérature est plus abondante en Mélanésie qu'en Polynésie et en Micronésie. De même, le fait que les récifs coralliens soient plus abondants dans les PEIDP que les mangroves et les herbiers marins peut expliquer en partie pourquoi les récifs coralliens ont été plus fréquemment évalués. Les herbiers marins ont été de plus en plus évalués au fil du temps, ce qui pourrait encourager la conservation des herbiers marins dans les PEIDP où la conservation marine s'est traditionnellement concentrée sur les récifs coralliens (McKenzie et al., 2021b).

En comparant nos résultats pour les PEIDP à ceux obtenus pour l'échelle mondiale par Liqueste et al. (2013), nous constatons que l'approvisionnement en nourriture, en particulier la pêche, est le service écosystémique côtier le plus fréquemment évalué à la fois à l'échelle mondiale et à l'échelle des PEIDP. Contrairement à nos attentes, les services écosystémiques culturels ne sont pas évalués plus fréquemment (en proportion des autres catégories de services écosystémiques) dans les PEIDP que dans le reste du monde, malgré la forte dépendance des PEIDP à l'égard du tourisme côtier (SPREP, 2020) et l'importance spirituelle des écosystèmes côtiers dans les PEIDP (Movono et al., 2018). Nos résultats suggèrent un manque de connaissances en termes de services écosystémiques coralliens en Papouasie-Nouvelle-Guinée (où seulement quatre évaluations ont été conduites d'après notre revue systématique), alors que le pays est l'un des plus dépendants de la santé des récifs coralliens à l'échelle mondiale (Pendleton et al., 2016).

De manière générale, nos résultats mettent en évidence une grande variété de services écosystémiques côtiers et de méthodes d'évaluation. Cependant, seuls trois types de services écosystémiques (approvisionnement alimentaire, possibilités de loisirs et de tourisme, matières premières) (figure FR-6) et trois méthodes d'évaluation (prix du marché, transfert de bénéfices et évaluation contingente) représentent la moitié de l'ensemble des évaluations de services écosystémiques. Pourtant, afin de réduire les incertitudes sur les évaluations de services écosystémiques, il est important (i) de prendre en compte dans les évaluations de services écosystémiques l'ensemble des services fournis (Gallagher et al., 2022) (ce qui n'est pas le cas dans les études examinées ici) et (ii) de mener des évaluations qui reflètent la manière dont les écosystèmes contribuent réellement aux diverses activités et au bien-être humain localement (Himes-Cornell et al., 2018b). Ce deuxième point non plus n'est pas adéquatement

adressé dans la grande majorité des études examinées, puisque peu de méthodes participatives sont mobilisées par les auteurs des 57 études et qu'un tiers des évaluations de services écosystémiques sont basées sur la méthode des transferts de bénéfices, méthode impliquant potentiellement d'importants biais. En effet, les valeurs de services écosystémiques (qu'elles soient monétaires ou non) ne sont pas aisément transposables d'un endroit à l'autre, chaque endroit ayant ses propres réalités écologiques (ex. : état de la mangrove), sociales et économiques (Himes-Cornell et al., 2018).

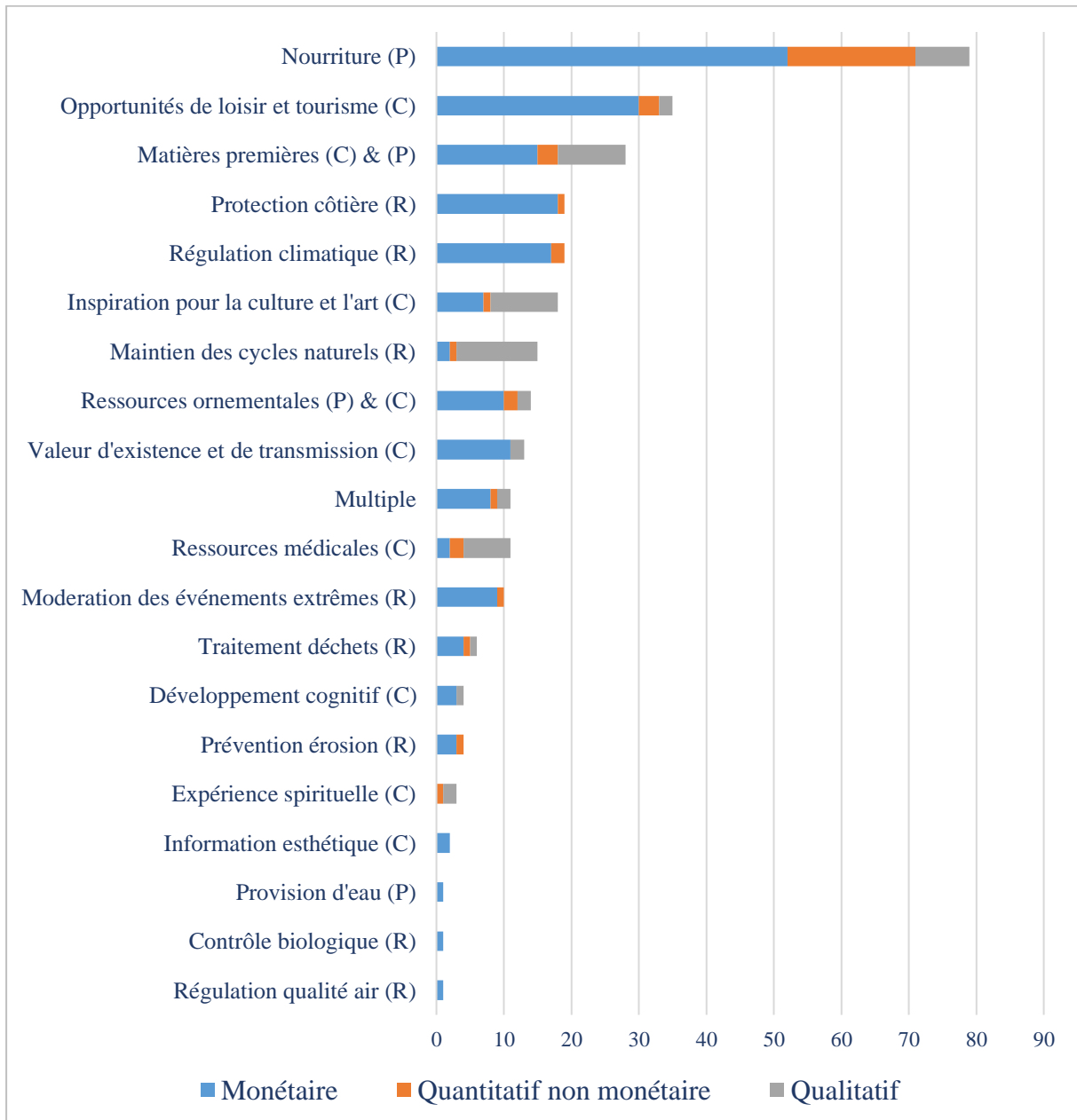


Figure FR-6 : Nombre de services évalués monétairement (bleu), quantitativement non monétairement (orange) et qualitativement (gris), par type de services comme définis par le TEEB (2010). (P) : service d’approvisionnement ; (R) : service de régulation et maintenance ; (C) : service culturel.

Ainsi, nos résultats soulignent l'importance du choix de la méthode d'évaluation. Par exemple, les services écosystémiques culturels étaient systématiquement (sauf dans un cas) évalués comme étant moins importants que les services d'approvisionnement et de régulation lorsque des méthodes monétaires étaient utilisées ; cependant, ils étaient plus fréquemment jugés plus importants que les services d'approvisionnement et de régulation lorsque des méthodes non monétaires (par exemple, impliquant un classement en termes d'importance) et des méthodes participatives étaient utilisées. Nous avons constaté que dans le cas de la littérature examinée, les méthodes de transfert de bénéfices ont généralement tendance à sous-estimer les services écosystémiques côtiers dans les PEIDP. Ces constatations soulignent la nécessité exprimée dans la littérature (voir par exemple Armatas et al., 2018 et De Groot et al., 2012) de développer et d'utiliser davantage d'indicateurs non monétaires pour évaluer les services écosystémiques côtiers afin de mieux prendre en compte les multiples perspectives des populations locales sur l'importance des services écosystémiques côtiers, en particulier les services écosystémiques culturels liés aux pratiques traditionnelles et aux valeurs de non-usage. De plus, les informations basées sur des indicateurs non monétaires sont utiles dans les processus décisionnaires et de gestion : les décideurs politiques ont tendance à préférer utiliser une variété de mesures dans les valeurs des services écosystémiques ainsi que des informations tangibles, telles que le nombre de ménages à risque ou la proportion de personnes qui dépendent d'un écosystème donné pour leur subsistance (Ruckelshaus et al., 2015).

De plus, la prise en compte d'indicateurs non monétaires permettrait de passer d'une vision encore trop utilitariste de la nature à l'échelle mondiale (c'est-à-dire que la nature est valorisée pour les services qu'elle rend à l'homme) à une reconnaissance du droit de la nature à prospérer indépendamment des besoins humains, comme le recommande fortement l'IPBES (2022).

Notre analyse a révélé que plus de la moitié des études (35 sur 57) incluaient des recommandations visant à gérer les écosystèmes côtiers de manière plus durable ou équitable, suggérant que les auteurs des 35 études ont la volonté d'informer les politiques sur les actions prioritaires à mettre en œuvre. Cependant, aucune de ces recommandations ne s'adressait à un gouvernement ou à une organisation hors des PEIDP. Ce résultat est intéressant car les écosystèmes des PEIDP sont également affectés par des facteurs de stress provenant d'autres parties du monde, tels que les émissions de gaz à effet de serre des pays du Nord qui contribuent au blanchissement corallien par le réchauffement et l'acidification des océans (Hughes et al., 2003). Cette constatation soulève la question de la responsabilité de la gestion des écosystèmes côtiers des PEIDP, sachant que (i) ces écosystèmes rendent à la fois des services au niveau local (par exemple, via la protection des côtes) et au niveau mondial (par exemple, en contribuant à l'équilibre de la biodiversité mondiale et à l'atténuation du changement climatique) et que (ii) les décisions locales peuvent affecter la fourniture de services écosystémiques éloignés (Seppelt et al., 2011).

Conclusion

Sur la base de nos résultats de recherche, nous recommandons que des recherches futures portent sur des évaluations supplémentaires de services écosystémiques (notamment en Papouasie-Nouvelle-Guinée). L'évaluation d'un plus grand nombre de types de services écosystémiques, en particulier les services de purification de l'eau, qui sont le deuxième service de régulation côtière le plus fréquemment évalué au niveau mondial (Liquete et al., 2013), serait également utile pour mieux rendre compte de la diversité des services écosystémiques dans les PEIDP et ainsi mieux conseiller les décideurs. Des évaluations monétaires supplémentaires seraient également nécessaires pour fournir des comparaisons significatives.

Nous recommandons également que les évaluations qualitatives et quantitatives non monétaires des services écosystémiques côtiers soient prises en compte non seulement dans les évaluations de services écosystémiques, mais également dans les revues de littérature. Cette pratique est susceptible de mieux rendre compte de la diversité des services écosystémiques côtiers et de l'importance des services de régulation et des services culturels, à la fois pour les chercheurs qui effectuent des analyses bibliographiques et pour les décideurs, les gestionnaires et les communautés impliquées dans la gestion côtière. Enfin, nos résultats soulignent l'importance de considérer la littérature grise dans les revues de littérature sur les services écosystémiques. La littérature grise, d'une part, fournit des informations précieuses pour mieux comprendre l'importance des services écosystémiques côtiers dans les PEIDP et, d'autre part, contient la majorité des recommandations politiques identifiées.

Ce travail enrichit les bases de données existantes sur les services écosystémiques, telles que la base de données mondiale ESVD, en compilant des données provenant d'études évaluées par des pairs, mais aussi de rapports, qui sont actuellement absents de cette base de données. Cette étude ouvre la voie à de futures revues systématiques qui refléteront de manière plus exhaustive les connaissances sur les services écosystémiques côtiers, grâce à la prise en compte d'évaluations non monétaires et de résultats issus de la littérature grise. La catégorisation des méthodes d'évaluation en trois types (monétaires, quantitatives non monétaires et qualitatives) établit un cadre d'analyse qui peut faciliter les futures analyses de services écosystémiques dans d'autres régions du monde et pour d'autres types d'écosystèmes.

Résumé du chapitre 4

L'engagement des parties prenantes dans la gestion des écosystèmes de mangrove : cas d'étude dans une communauté côtière fidjienne

Introduction

La participation des parties prenantes locales dans les processus de gestion, y compris les communautés locales et les populations autochtones, est essentielle pour parvenir à une gestion durable et équitable des écosystèmes qui contribue à renforcer l'adaptation des populations aux changements environnementaux (IPBES, 2022 ; IPBES, 2019 ; Lau et al., 2019 ; Romanelli et al., 2015). Les approches de gestion axées sur la gestion communautaire sont de plus en plus reconnues comme des outils pertinents pour gérer durablement et équitablement les ressources côtières (Johnson et al., 2020 ; Remling & Veitayaki, 2016). Il a été démontré que ces approches permettent de maintenir l'engagement des parties prenantes sur le long terme (Johnson et al., 2020b), via la reconnaissance des besoins, des droits, des connaissances et des aspirations des populations locales, ce qui favorise l'acceptation sociale, la collaboration, la cohérence des politiques et la diffusion des connaissances (IPBES, 2022 ; GIEC, 2022 ; Romanelli et al., 2015). En outre, les communautés locales sont en première ligne pour identifier les impacts sur les écosystèmes, mettre en œuvre des actions locales et suivre les progrès des actions. C'est notamment le cas dans les pays où les services gouvernementaux disposent de capacités limitées pour effectuer un suivi régulier des actions menées, comme dans les PEIDP (Johnson et al., 2020).

Ce chapitre explore la perception de l'implication des acteurs locaux dans la gestion des écosystèmes côtiers (en particulier les mangroves) dans un contexte de système de gouvernance complexe, aux Fidji, afin de mieux comprendre les dynamiques de gestion locale.

La gestion des écosystèmes et des ressources côtières aux Fidji est sous-tendue par un système de gouvernance double, où la gestion informelle par les utilisateurs coutumiers des ressources coexiste avec une approche centralisée formelle institutionnalisée par le gouvernement fidjien (Veitayaki et al., 2016 ; Vierros et al., 2010). Bien que le gouvernement soit responsable de la gestion des mangroves aux Fidji, les communautés fidjiennes jouissent en pratique d'une indépendance considérable quant à la manière dont elles utilisent les mangroves, en tant que propriétaires coutumiers et traditionnels (Veitayaki et al., 2017 ; Loi sur la gestion des mangroves de Fidji, 2013). La structure traditionnelle fidjienne est centrée sur le *Vanua*, qui est à la fois le plus grand groupe social auquel les membres de la communauté déclarent appartenir et un concept essentiel de la culture indigène fidjienne. Ce concept symbolise une croyance traditionnelle en un lien intrinsèque entre les humains et leur environnement (CSIRO, 2023 ; Sloan & Chand, 2016). Le respect des politiques et des réglementations gouvernementales est un défi au niveau

communautaire, car les communautés ne sont pas toujours au fait des politiques ou des réglementations gouvernementales existantes, ou lorsque de nouvelles règles sont mises en place (CSIRO, 2023).

Dans ce contexte, nous avons cherché :

- i) à évaluer comment les membres d'une communauté côtière de Fidji perçoivent leur implication dans la gestion de la mangrove ;
- ii) à comprendre les contraintes qui les empêchent de s'impliquer davantage ;
- iii) à mettre en évidence les risques et les opportunités potentiels associés aux perspectives de la communauté.

Cette étude est une composante d'un projet régional plus large entre l'Australie et les Fidji, intitulé « Blue Carbon Ecosystem Services and Livelihoods (BCELS, 2019-2022) ».

Matériel et méthode

Pour répondre aux objectifs énoncés précédemment, nous avons utilisé une méthode d'enquête et collaboré avec des membres d'une organisation non gouvernementale (ONG) locale pour élaborer et conduire les entretiens auprès des membres de la communauté de Tawake. Tawake est un village côtier fidjien situé dans la deuxième plus grande île des Fidji (Vanua Levu), dans la province de Cakaudrove. Tawake peut être considéré comme représentatif des contextes sociaux, culturels et biophysiques des Fidji. Comme beaucoup d'autres villages fidjiens, Tawake est situé dans une zone côtière rurale et isolée, avec des infrastructures limitées, notamment un manque d'approvisionnement en eau potable et des routes difficiles d'accès.

Deux enquêtes ont été conduites, la première en octobre 2020 et la seconde en juillet 2022. La réalisation d'une deuxième enquête a permis de comparer l'évolution dans le temps de la perception de l'implication de la communauté dans la gestion de la mangrove. Les deux enquêtes ont été conçues et réalisées de manière similaire, mais leur contenu présente de légères différences. J'ai préparé les questions de l'enquête, qui ont ensuite été revues par Leo Dutra (CSIRO), Ingrid van Putten (CSIRO) (pour la première enquête uniquement) et Adi Vasulevu M. Levu (directeur général de l'ONG partenaire fidjienne « Transcend Oceania »). Des réunions à distance ont été organisées entre nous pour valider les questionnaires avant de mener les entretiens. Les entretiens d'enquête ont été réalisés en face à face par des membres de l'ONG partenaire locale.

Les deux enquêtes sont structurées en quatre parties : (i) les caractéristiques des répondants telles que l'âge, le sexe, le rôle social et l'activité, (ii) la perception de leur implication, (iii) leur perception de l'implication du gouvernement, et (iv) leur perception de l'implication de leurs chefs traditionnels. La deuxième enquête a été conçue sur la base des réactions à la première enquête. Les changements apportés au questionnaire de la première enquête comprenaient des questions spécifiques sur les trois

étapes du processus décisionnel (conception, mise en œuvre, suivi), car de nombreux répondants à la première enquête ont indiqué que ces distinctions étaient trop détaillées et non pertinentes. La deuxième enquête est plus courte (16 questions au lieu de 26). Lors des différentes étapes méthodologiques (conduite d'entretiens, analyse des résultats de l'enquête), nous avons suivi les protocoles d'éthique de la recherche approuvés par le Comité d'éthique de la recherche humaine du CSIRO (Approbation de l'éthique de la recherche humaine 126-20).

Résultats et Discussion

Cinquante participants ont répondu à la première enquête et quarante-cinq à la seconde, ce qui correspond dans les deux cas à environ un quart de la taille de la communauté. La plupart des personnes interrogées étaient engagées dans des activités de subsistance ou informelles telles que la pêche et l'agriculture (86 % des personnes interrogées lors de la première enquête et 75 % lors de la seconde). En moyenne, deux tiers des répondants à la deuxième enquête étaient, au moment de la recherche, actuellement impliqués dans la gestion de la mangrove (question n° 2), ce qui est une proportion plus élevée par rapport à la première enquête (40 %). En moyenne, les répondants souhaitent s'impliquer davantage dans la gestion de la mangrove (question n° 3) et se voient impliqués dans la gestion de long terme, c'est-à-dire dans les 5 à 10 ans (question n° 4). Ces résultats sont très similaires à ceux de la première enquête.

Sans surprise, compte tenu de la hiérarchie des rôles et des responsabilités en fonction des positions familiales, du sexe et de l'âge, les participants les plus jeunes (<18 ans et 18-30 ans) se sentent les moins impliqués dans la gestion de la mangrove, alors que ceux âgés de 31 à 45 ans se sentent les plus impliqués. Par ailleurs, il y a très peu de différences dans la perception de l'implication actuelle dans la gestion entre les hommes et les femmes (les deux se sentent impliqués). Cependant, leurs aspirations futures diffèrent en ce sens que les hommes souhaitent être plus impliqués que les femmes (test de significativité *t.test* de 0,0452) et que les hommes se voient également plus impliqués à long terme que les femmes (*t.test* de 0,0173).

La principale action envisagée par les répondants en matière de gestion de la mangrove est la restauration, en replantant la mangrove. La restauration doit être planifiée et mise en œuvre avec soin afin de minimiser les risques liés aux conditions biophysiques, écologiques et socio-économiques locales. En effet, les projets de plantation de mangroves à grande échelle ont souvent échoué et les projets à petite échelle peuvent ne pas apporter les bénéfices escomptés, même s'ils sont menés par les communautés locales (Lovelock et al., 2022). Ces échecs sont principalement dus à des initiatives de court terme qui ont été développées dans des endroits inappropriés ou inadaptés, avec un soutien communautaire insuffisant (Lovelock & Brown, 2019).

Il existe de nombreuses façons de restaurer les mangroves, compte tenu de la diversité et de la complexité des facteurs qui influencent le succès de la restauration des mangroves (Lovelock et al., 2022). Le défi consiste à déterminer où, quoi et comment restaurer, compte tenu des caractéristiques socio-économiques et environnementales locales (par exemple, les espèces historiquement présentes, l'hydrologie, le type de terrain). La littérature scientifique fournit des lignes directrices pour soutenir les projets de restauration des mangroves menés par les communautés. Par exemple, Lovelock et al. (2022) conseillent de regrouper les petits projets de restauration au niveau communautaire en créant des réseaux de collaboration. Ce regroupement pourrait faciliter le partage des connaissances entre les communautés locales ainsi que l'attrait pour les donateurs, tout en réduisant les coûts d'entretien des infrastructures clés (par exemple, les pépinières de mangroves et les coûts de vérification pour les projets basés sur le carbone) grâce à des économies d'échelle (Lovelock et al., 2022). En outre, les initiatives menées à Tawake peuvent s'inspirer de celles menées ailleurs dans le Pacifique Sud, où, comme aux Fidji, les mangroves sont essentiellement indigènes (Gilman & Ellison, 2007).

Pour les autres écosystèmes côtiers, tels que les récifs coralliens et les herbiers marins, d'autres stratégies de gestion sont privilégiées, davantage axées autour de la conservation. Malgré ces différences, la moitié des personnes interrogées a souligné que les écosystèmes côtiers devraient être gérés comme un tout, car « ils sont connectés ». Cette vision holistique de la vie marine semble faire référence au concept de *Vanua*.

Nos résultats mettent en évidence des risques et les défis potentiels ainsi que des opportunités de gestion durable de la mangrove à Tawake. D'une part, les principaux obstacles à l'implication des membres de la communauté dans la gestion de la mangrove sont liés à un manque perçu de connaissances et à une mauvaise communication avec leurs dirigeants politiques. L'âge (la jeunesse) et le genre (féminin) sont les deux autres principaux obstacles à cette participation, qui pourraient être surmontés en incluant davantage de jeunes et de femmes dans les processus de prise de décision.

D'autre part, nos résultats mettent en évidence certains points forts et certaines opportunités pour une gestion juste et efficace des mangroves à Tawake. Ceux-ci sont principalement liés à la forte volonté des membres de la communauté de participer à la gestion des mangroves, à leur conscience de l'importance des mangroves pour leurs moyens de subsistance et à leur volonté de collaborer avec d'autres parties prenantes (dirigeants politiques et organisations locales) afin d'améliorer la diffusion et l'appropriation des connaissances et d'accéder aux ressources humaines et financières.

Conclusion

Cette étude, basée sur des enquêtes de terrain, révèle les perceptions des membres d'une communauté côtière fidjienne vis-à-vis de la gestion actuelle et future des mangroves. Elle révèle notamment une forte volonté des personnes interrogées de préserver et d'améliorer la santé des écosystèmes de mangrove locaux et les services écosystémiques associés, en collaboration avec les responsables politiques et les organisations locales.

À la lumière des contraintes d'implication révélées dans cette étude, il serait utile d'acquérir des données supplémentaires pour mieux comprendre comment ces contraintes pourraient être atténuées et dans quelle mesure les opportunités proposées par les personnes interrogées sont concrètement réalisables. Il sera pour cela nécessaire de collecter des informations par le biais d'entretiens complémentaires avec les acteurs locaux, sur les opinions des décideurs concernant les options de protection ou de restauration et les possibilités de financement. La mise en perspective de ces résultats avec ceux d'autres activités menées dans le cadre du projet BCE SL, telles que la cartographie de la gouvernance et les préférences en matière de services écosystémiques, contribuera à combler ce manque de connaissances. Une enquête ciblant le gouvernement sur sa propre perception des rôles des différents acteurs (communauté, gouvernement, chefs traditionnels, ONG), des options de gestion et des contraintes actuelles permettrait de comparer les points de vue de la communauté et du gouvernement. Outre la collecte de ces informations, l'étape suivante consistera à présenter les résultats de nos enquêtes à la communauté et aux dirigeants politiques. Il serait également utile d'avoir un retour sur la façon dont ont été menées les enquêtes et sur la pertinence de leur contenu. Ces perspectives aideront à co-construire avec la communauté et les autres parties prenantes les voies d'avenir souhaitables pour Tawake.

Résumé de la Conclusion générale de thèse

Nous avons utilisé des approches interdisciplinaires et collaboratives pour traiter les questions de recherche de la thèse, qui étaient les suivantes :

Q1 : Comment les PEIDP intègrent-ils les SFN côtières dans leurs politiques publiques pour traiter les questions climat-biodiversité-océan, sur la base d'outils d'évaluation et de gestion qui cherchent à améliorer l'efficacité des actions (par exemple, les normes, les évaluations ES, les bonnes pratiques liées à l'intégration des politiques publiques et à l'engagement des parties prenantes) ?

Q2 : Dans quelle mesure ces outils sont-ils pertinents pour les PEIDP ?

Dans un premier temps, nous répondrons aux deux questions de recherche, puis nous discuterons des limitations de la thèse ainsi que des perspectives de recherche offertes par ce travail de thèse.

Comment les PEIDP intègrent-ils les SFN côtières dans leurs politiques publiques pour traiter les questions climat-biodiversité-océan, sur la base d'outils d'évaluation et de gestion qui cherchent à améliorer l'efficacité des actions ?

Tout d'abord, l'importance de protéger et de restaurer les écosystèmes côtiers est reflétée dans les documents politiques climatiques des PEIDP (chapitres 1 et 2) et dans les évaluations des services écosystémiques côtiers (chapitre 3). La prise en compte des co-bénéfices pour l'adaptation et l'atténuation, ainsi que pour la nature et les populations humaines, est plus fréquente dans les CDN révisées (2018-2021) que dans les CDN initiales (2015-2017), ce qui suggère que les PEIDP sont davantage enclins à préserver le large éventail de services écosystémiques (en particulier climatiques) que les mangroves, les récifs coralliens et les herbiers marins fournissent (Brodie et al., 2020 ; Selig et al., 2019). Les OBCA (qui comprennent à la fois les SFN côtières et les OBCA non basées sur la nature) incluses dans les CDN des PEIDP ciblent principalement l'adaptation au changement climatique, par opposition à l'atténuation. Ce résultat est cohérent avec les conclusions de Williamson et Gattuso (2022) selon lesquelles la protection et la restauration des écosystèmes à carbone bleu sont très bénéfiques pour l'adaptation au climat, y compris la protection côtière, l'approvisionnement alimentaire et la conservation de la biodiversité, alors que l'inclusion des SFN côtières pour l'atténuation pose davantage de questions (liées aux incertitudes dans les calculs de flux de carbone, notamment). Ce résultat est également intéressant car la composante « adaptation » des CDN n'est pas obligatoire ; d'autres politiques nationales élaborées dans le cadre de la CNUCCC, telles que les plans nationaux d'adaptation, sont spécifiquement consacrées à l'adaptation (Hammil et al., 2017). Cependant, l'inclusion d'actions basées sur l'océan pour l'atténuation du changement climatique (en particulier la décarbonisation du transport maritime) a fortement augmenté ces dernières années dans les CDN des PEIDP.

Nous avons mis en évidence l'existence de signaux positifs pour une mise en œuvre efficace des SFN côtières, à travers l'analyse de la précision et de l'intégration des politiques publiques des PEIDP. Grâce à des analyses basées sur des indicateurs d'absence/présence et semi-quantitatifs, les résultats des chapitres 1 et 2 ont tout d'abord montré qu'en plus d'être de plus en plus fréquemment incluses dans les politiques des PEIDP, les SFN côtières ont été décrites de manière de plus en plus détaillée, avec des informations utiles pour comprendre leur portée et mesurer leur efficacité (par exemple, par le biais d'objectifs mesurables). Ce niveau de détail accru améliore la clarté et la transparence dans la planification de l'action climatique, comme l'exige l'Accord de Paris et comme le recommande la littérature scientifique pour mener des actions efficaces sur le long terme (par exemple, dans Coscieme et al., 2021 ; Northrop et al., 2020).

De plus, le chapitre 1 a montré que les SFN côtières ont été de plus en plus intégrées (i) dans différentes catégories d'OBCA (c'est-à-dire qu'une SFN donnée est décrite comme répondant à plusieurs objectifs, comme l'atténuation du climat et la protection côtière) ainsi que (ii) dans de multiples politiques axées sur différents secteurs (environnement, climat et développement). Par ailleurs, le chapitre 2 montre que les descriptions des SFN côtières dans les CDN des PEIDP ont été de plus en plus alignées sur les critères du Standard mondial de l'UICN pour les SFN au fil du temps, ce qui est cohérent avec les résultats du chapitre 1 précédemment mentionnés. Par rapport au chapitre 1, le chapitre 2 fournit des détails supplémentaires sur les dimensions de précision et d'intégration des SFN côtières incluses dans les politiques publiques nationales des PEIDP, notamment concernant les défis sociétaux que les SFN cherchent à relever, le gain net de biodiversité, la faisabilité économique et la gestion adaptative. Étant donné que toutes ces dimensions sont considérées comme essentielles pour assurer une gestion environnementale efficace (IPBES, 2022, Coscieme et al., 2021 ; Northrop et al., 2020), les conclusions du chapitre 2 suggèrent que les SFN côtières sont de plus en plus conçues pour aider efficacement les PEIDP à relever les défis de la perte et de la dégradation de la nature, du changement climatique et, plus généralement, du développement durable.

Cependant, malgré une précision et une intégration croissantes des SFN côtières dans les politiques publiques nationales des PEIDP, la réussite de la mise en œuvre de ces actions n'est pas garantie. Des défis d'accès à l'information ainsi que des défis d'ordre financier et de suivi des progrès sont mis en évidence à travers nos résultats.

En effet, d'une part, des lacunes de connaissances sur les services écosystémiques côtiers et une sous-estimation générale des valeurs de ces services (liées à une surutilisation des transferts de bénéfices lors de l'évaluation des services écosystémiques (chapitre 3)) entravent l'accès à l'information pertinente pour les gestionnaires des PEIDP. Dans le chapitre 4, le manque de connaissances sur la mangrove et les services qu'elle fournit est reconnu comme étant l'obstacle principal à l'implication de la communauté locale dans la gestion de ses mangroves. Suivent l'âge, la communication insatisfaisante avec les dirigeants politiques et le genre (un tiers des femmes ont identifié leur genre comme la plus

grande contrainte à leur participation à la gestion des mangroves). Les réponses à l'enquête ont révélé que les membres de la communauté considèrent généralement que les connaissances proviennent non pas d'eux-mêmes mais de l'extérieur, en particulier de leur gouvernement. Le gouvernement est considéré comme responsable de fournir les informations nécessaires pour gérer efficacement les mangroves, d'après la communauté de Tawake. Ce résultat est intéressant car les membres de la communauté ont des connaissances tacites, pratiques et traditionnelles sur les écosystèmes côtiers, basées sur leur expérience directe avec leur environnement (par exemple, à travers la pêche) et l'observation des changements au fil du temps (Vince et al., 2017). Par conséquent, ils ont certainement des informations et des connaissances précieuses à partager au sein de la communauté et avec leurs dirigeants et d'autres parties prenantes. Ce manque perçu de connaissances locales et cette perception d'une communication insatisfaisante avec leurs dirigeants peuvent être problématiques, car ces aspects peuvent affecter la confiance de la communauté envers ses dirigeants et réduire le partage de connaissances. En fin de compte, ces obstacles peuvent entraver la volonté des membres de la communauté de participer activement à la gestion de la mangrove d'une manière collaborative et efficace.

D'autre part, les politiques nationales des PEIDP n'indiquent pas clairement quand ni avec quelles ressources les SFN côtières incluses dans les CDN seront mises en œuvre et comment leur efficacité sera contrôlée (chapitres 1 et 2). Cela peut être problématique dans la mesure où les PEIDP ont explicitement fait de leur besoin de soutien financier, technique ou de renforcement des capacités une condition préalable à la réalisation des objectifs de leur CDN (Crumpler & Bernoux, 2020). En outre, pour être en mesure d'attirer des donateurs pour le financement des SFN, il est nécessaire de bien comprendre les coûts impliqués, de fixer des objectifs clairs et mesurables et de mettre en place un système de suivi efficace de la mise en œuvre (Swann et al., 2021 ; UICN, 2020). Cependant, les SFN côtières dans les CDN des PEIDP ne sont généralement pas alignées sur le Standard mondial de l'UICN en ce qui concerne ces dimensions clés (chapitre 2, section 3.1). Ce manque d'informations est susceptible d'entraver le bon déroulement du Bilan mondial mandaté par l'Accord de Paris pour évaluer les progrès de l'action climatique mondiale en 2023. Le chapitre 2 complète donc les conclusions du chapitre 1 en montrant que, malgré des signaux positifs pour la mise en œuvre réussie des SFN côtières des PEIDP, les informations fournies ne seront probablement pas suffisantes pour suivre efficacement les progrès de l'action climatique, tant au niveau local (à l'échelle de la SFN) qu'aux niveaux national et mondial.

Pistes pour réduire les difficultés liées à la conception, au financement et au suivi des progrès des SFN côtières dans les PEIDP

Tout d'abord, cette thèse met en évidence des pistes pour rehausser l'ambition des CDN à rendre les besoins et les actions climatiques des PEIDP plus cohérents et plus visibles sur la scène internationale. Nous avons montré que les CDN des PEIDP ne reflètent pas toujours l'ambition climatique nationale des pays en termes de SFN côtières (chapitre 1, 4.3). En d'autres termes, les politiques référencées dans les CDN contiennent parfois soit des SFN côtières supplémentaires, soit des SFN mises à jour (c'est-à-dire avec les objectifs associés les plus élevés) par rapport aux SFN incluses directement dans les CDN. C'est particulièrement le cas pour les deux catégories d'OBCA suivantes : (i) la protection/restauration des écosystèmes de carbone bleu pour l'atténuation du changement climatique et (ii) les actions basées sur les infrastructures pour protéger les côtes des impacts climatiques. Inclure les OBCA dans les CDN de manière plus explicite pourrait aider les PEIDP à rendre l'action climatique plus visible et à accroître l'intégration des politiques, dans un contexte où la majorité des CDN des PEIDP promeuvent l'intégration et la cohérence des politiques (Crumpler & Bernoux, 2020).

Ensuite, nous mettons en lumière des pistes pour augmenter les opportunités de financement des SFN côtières, à travers leur standardisation dans les CDN sur la base du Standard mondial de l'UICN. En particulier, il apparaît important de fournir davantage d'informations sur la faisabilité économique et sur la manière dont les défis sociétaux tels que le changement climatique et les gains nets de biodiversité seront concrètement abordés par les SFN.

Les pratiques d'évaluation des services écosystémiques suivantes pourraient également contribuer à améliorer l'accès à des informations plus précises et actualisées pour la gestion côtière, en favorisant une meilleure compréhension des services écosystémiques côtiers locaux :

- la prise en compte d'un plus grand nombre d'indicateurs, y compris des indicateurs non monétaires, à la fois lors de la réalisation d'évaluations de services écosystémiques et d'analyses documentaires sur les évaluations des SE. Cette pratique rendra très probablement les services écosystémiques culturels plus visibles pour les chercheurs qui effectuent des analyses bibliographiques et, en fin de compte, pour les décideurs politiques. Elle contribuera à répondre à la nécessité, soulignée par l'IPBES (2022), de reconnaître la diversité des liens entre l'homme et la nature, qui ne sont pas uniquement fondés sur la rationalité économique (qui présume que les écosystèmes naturels n'ont de valeur que pour les services qu'ils rendent aux populations humaines). Ces liens sont aussi fondés sur la volonté de vivre en harmonie avec le vivant non humain et/ou sur la reconnaissance d'une valeur intrinsèque des écosystèmes et des espèces, qui ont le droit de vivre et de prospérer indépendamment des besoins humains ;

- la prise en compte de la littérature grise (rapports) lors des analyses documentaires, en parallèle des études évaluées par les pairs, car elle fournit des informations complémentaires utiles à la compréhension des services écosystémiques et des recommandations politiques.

De plus, nous avons observé une considération croissante pour l'évaluation des services écosystémiques en ce qui concerne les herbiers marins dans les PEIDP, ainsi que pour l'inclusion d'actions basées sur les herbiers marins dans les CDN des PEIDP. Cet intérêt croissant pour la conservation et la protection des herbiers est encourageant pour la gestion côtière de manière générale. En effet, Guannel et al. (2016) ont montré que la gestion conjointe des récifs coralliens, des mangroves et des herbiers marins (c'est-à-dire en tenant compte de leurs interactions) permet d'améliorer la résilience des écosystèmes côtiers, qui se protègent mutuellement, et donc de maintenir, voire d'accroître, les services qu'ils fournissent aux populations humaines (Guannel et al., 2016).

Enfin, nous avons mis en évidence des opportunités d'accroissement du suivi des progrès des SFN côtières. L'utilisation du Standard mondial de l'UICN comme base de description des SFN dans les CDN pourrait contribuer au bon déroulement du Bilan mondial prévu en 2023, en facilitant l'agrégation et la comparaison des contenus des CDN entre les pays (chapitre 2, section 4.2). En effet, cette norme contient des indicateurs qui rendent compte d'un grand nombre d'éléments qui devraient être rapportés dans les CDN pour réaliser le Bilan mondial (chapitre 2, 4.2). La participation des communautés locales est essentielle pour suivre les progrès. En effet, il est souvent difficile pour les gouvernements des PEIDP de contrôler l'efficacité des actions environnementales sur le terrain (Mangrove Management Plan of Fiji, 2013) ; la collaboration avec les acteurs locaux (par exemple, les communautés) qui expérimentent quotidiennement leur environnement naturel est donc un atout précieux pour contrôler, évaluer et analyser les changements qui se produisent dans cet environnement suite à la mise en œuvre des actions (Vince et al., 2017). Une collaboration locale-nationale réussie dans la mise en œuvre des SFN repose sur des principes de bonnes pratiques, notamment sur une communication solide pour favoriser la confiance mutuelle et le partage des connaissances, ainsi que sur la mise à disposition de ressources adéquates (humaines, techniques (techniques de suivi) et financières) (Seddon et al., 2021). Les pratiques qui favorisent une bonne communication entre les communautés locales et le gouvernement comprennent des visites régulières de la communauté et des activités de suivi. Cela permet de s'assurer que le gouvernement est consulté et tenu informé des actions menées sur le terrain et des problèmes potentiels, et qu'il peut fournir les moyens de les résoudre (Veitayaki et al., 2011). Les résultats du chapitre 4 (3.5) corroborent ces conclusions, les membres de la communauté de Tawake ayant exprimé le besoin (i) d'être davantage sensibilisés à l'importance des mangroves et (ii) de faire l'objet de visites plus régulières de la part des représentants du gouvernement pour suivre les actions menées.

Limites

Nous avons identifié des limites au travail de thèse, concernant :

(i) L'analyse des documents politiques. Les politiques publiques examinées (par exemple, les CDN et les stratégies, politiques, plans ou lois associés) dans les chapitres 1 et 2 peuvent d'une part ne pas englober toutes les SFN côtières conçues par les PEIDP. D'autre part, ces politiques publiques peuvent ne pas refléter de façon réelle comment les SFN qu'elles contiennent sont véritablement conçues. Les documents politiques ne reflètent que ce que les pays ont l'intention de faire, et non ce qu'ils font ou feront réellement. Une des limites de notre étude est qu'en analysant uniquement les informations incluses dans les CDN, il est impossible de conclure si la mise en œuvre des SFN côtières contenues dans ces politiques est ou sera réussie. Tant qu'il n'y a pas d'exigences spécifiques ou d'incitations fortes à décrire en détail comment et quand les actions contenues dans les documents politiques seront mises en œuvre, les pays restent libres de décider du contenu de leurs documents politiques et de les mettre en œuvre ou non ;

(ii) L'utilisation d'indicateurs dans les chapitres 1 et 2. L'analyse basée sur les indicateurs implique une dimension subjective, que l'on a tenté de réduire à travers différentes techniques : deux évaluations indépendantes avec des références croisées et une argumentation finale, la définition d'une échelle et d'un processus d'évaluation clairs, et un examen final pour s'assurer que chaque indicateur a été évalué de manière cohérente, à la fois dans tous les pays et dans les SFN côtières. Par ailleurs, les informations peuvent être disponibles, mais elles sont souvent dispersées dans les documents politiques et ces derniers manquent souvent de clarté quant aux actions concrètes qui seront mises en œuvre et aux résultats escomptés. Si plusieurs aspects (tels que les objectifs quantifiés et les secteurs politiques) ont été relativement faciles à identifier et à évaluer, ce n'est pas le cas des calendriers ou des coûts de mise en œuvre. Le niveau de détail des dates ou des coûts était parfois trop faible pour comprendre si les dates ou les coûts indiqués dans les documents s'appliquaient à une SFN distincte ou à un projet/programme plus large, ce qui a rendu difficile l'évaluation des indicateurs et la qualification précise des SFN côtières ;

(iii) L'interprétation des résultats, en particulier dans les chapitres 3 et 4. Ces limitations sont en partie liées au fait que je n'ai pas été à Tawake et que je n'ai donc pas pu expérimenter la culture et les problématiques locales.

À l'origine (octobre 2019), ce travail de thèse était conçu pour inclure des études de terrain. Avec mes encadrants, il était établi que je mènerais des entretiens d'enquête ciblant les représentants gouvernementaux des PEIDP afin de recueillir leurs points de vue (besoins, aspirations, préoccupations, contraintes) autour de la conception, de la mise en œuvre et du suivi des SFN côtières. Il était également prévu que je développe et teste une méthodologie pour évaluer les services écosystémiques côtiers dans des localisations spécifiques des PEIDP. Ces études sur le terrain n'ont pas été menées en raison de

contraintes de déplacement international liées à la pandémie de Covid-19. Au printemps 2020, avec mon équipe d'encadrement, nous avons procédé à des ajustements dans la planification de la thèse pour tenir compte des conditions imposées par les restrictions de voyage. Nous avons décidé que la thèse se concentrerait davantage sur la recherche documentaire basée sur la littérature existante en matière d'ES (chapitre 3) et sur les documents politiques (chapitres 1 et 2), au détriment du travail de terrain. Le chapitre 4 est un peu plus hybride car j'ai eu l'opportunité de collecter à distance (depuis la France) de nouvelles données de terrain (à Fidji) en collaborant avec une ONG locale et le CSIRO.

Perspectives de recherche

Ce travail de thèse suggère des pistes de recherche complémentaires, impliquant en priorité des études de terrain afin de mieux comprendre les points de vue des gouvernements des PEIDP sur les aspects suivants :

- Des entretiens avec les gouvernements des PEIDP pourraient être menés pour explorer plus en détail les opportunités de financement des SFN côtières. Cela permettrait notamment de mieux faire coïncider les ambitions climat-biodiversité-océan des PEIDP avec les conditions d'accès aux fonds, qu'ils soient publics ou privés.
- Des recherches plus approfondies pourraient examiner les compromis potentiels entre une plus grande normalisation et une moins grande flexibilité dans les PEIDP pour personnaliser les approches de gestion côtière, au niveau national. Cela permettrait d'éclairer la manière dont les normes pourraient être adaptées pour mieux correspondre aux contextes locaux. Des entretiens auprès des représentants gouvernementaux des PEIDP permettraient de recueillir leurs points de vue sur les avantages et les obstacles à l'utilisation de normes.
- Il semble nécessaire d'améliorer la connaissance des rôles et responsabilités des différentes parties prenantes dans la gestion côtière. Des entretiens à destination des gouvernements permettraient de pouvoir comparer les attentes d'un groupe (par exemple, la communauté côtière de Tawake) par rapport à un autre (par exemple, le gouvernement fidjien) concernant les mesures de gestion à privilégier, par qui et comment (ressources, modes de collaboration, planification de la gestion).

Les SFN n'apporteront des avantages à long terme que si les écosystèmes sont sains et peuvent s'adapter aux changements (Macreadie et al., 2019). Cela pourrait ne pas être le cas, comme l'illustre la projection du GIEC (2019) selon laquelle 20 à 90 % des zones humides côtières actuelles seront perdues d'ici 2100, avec une perte potentielle de 99 % des coraux d'eau chaude d'ici 2100. Par conséquent, comme l'ont affirmé notamment Hoegh-Guldberg et al. (2019) et Seddon et al. (2020a), la mise en œuvre croissante des SFN ne devrait pas détourner l'attention de la communauté internationale de la réduction urgente des émissions mondiales de gaz à effet de serre. La question de savoir comment la communauté internationale devrait soutenir les PEIDP est cruciale (pour fournir des ressources adéquates qui

correspondent aux valeurs et aux aspirations locales), mais elle n'a guère été mise en avant dans la littérature (chapitre 3). Les études qui contiennent des recommandations politiques visant à améliorer la gestion des écosystèmes côtiers s'adressent principalement aux gouvernements des PEIDP et, dans une moindre mesure, aux communautés locales (chapitre 3, 3.6). Aucune des recommandations ne s'adressait à des acteurs extérieurs aux PEIDP, bien que d'autres pays extérieurs aux PEIDP aient une responsabilité forte dans la dégradation des écosystèmes côtiers des PEIDP (GIEC, 2022). Une prochaine étape pourrait consister à étudier dans quelle mesure les gouvernements et les institutions des PEIDP connaissent, approuvent et prennent en compte les recommandations contenues dans la littérature analysée dans cette thèse, et si ce n'est pas le cas, pour quelles raisons.

Une autre perspective de recherche pourrait consister à évaluer les services écosystémiques associés aux SFN côtières incluses dans les CDN. Pour Gupta et al. (2021), l'évaluation des services écosystémiques dans les SFN donnerait confiance aux planificateurs de l'action climatique, aux investisseurs et aux acheteurs pour les approches marchandes et non marchandes. Cela pourrait favoriser l'intégration des SFN dans les mécanismes marchands et non marchands de l'Accord de Paris, tels que REDD+. L'évaluation des services écosystémiques associés aux SFN côtières nécessiterait la mise au point d'indicateurs tenant compte des conditions locales, du type d'écosystème et de ses actifs (Gupta et al., 2021). Le développement d'indicateurs adéquats est une préoccupation majeure dans la littérature pour évaluer l'efficacité des SFN en termes significatifs. Cette préoccupation se reflète dans les conclusions du chapitre 2, qui ont montré que les aspects de suivi et de gestion adaptative des SFN côtières pour l'adaptation au changement climatique et/ou l'atténuation n'ont été que marginalement pris en compte dans les politiques nationales des PEIDP jusqu'à présent. En outre, les résultats du chapitre 3 ont révélé une grande variété de services écosystémiques côtiers dans les PEIDP, suggérant qu'une large gamme d'indicateurs ciblant de nombreux aspects (par exemple liés à la pêche, à la séquestration du carbone, mais aussi à la spiritualité) serait nécessaire pour refléter de manière exhaustive la variété des services écosystémiques associés aux SFN côtières. Ces informations pourraient contribuer à réduire les lacunes en matière de connaissances sur les risques et les incertitudes liés aux SFN (Riisager-Simonsen et al., 2022).

Enfin, il sera important d'aller au-delà de la conception des SFN et de comprendre comment les SFN côtières incluses dans les CDN des PEIDP sont et seront concrètement mises en œuvre, et d'évaluer si elles fournissent les résultats escomptés. Là encore, des entretiens avec les décideurs et gestionnaires politiques dans les PEIDP, des ONG, des donateurs internationaux, des organisations régionales et d'autres parties prenantes pourraient permettre de mieux comprendre la mise en œuvre des SFN côtières dans les PEIDP. Pour citer le rapport du Programme des Nations unies sur l'environnement portant sur les lacunes en matière d'adaptation (2022), « le test ultime de l'adéquation et de l'efficacité de la planification de l'adaptation sera de savoir si ces plans sont mis en œuvre et, à leur tour, si cette mise en œuvre réduit les risques et la vulnérabilité et renforce la résilience et la capacité d'adaptation ». Ces

recherches supplémentaires permettraient de mieux évaluer le « déficit de mise en œuvre » des SFN côtières (c'est-à-dire l'écart observé entre les mots et l'action concrète), de fixer des objectifs ambitieux mais réalistes pour les SFN et d'étudier comment de nouvelles incitations socialement justes et écologiquement souhaitables peuvent créer des opportunités pour la conservation de la nature et pour l'amélioration de la sécurité, de la santé et du bien-être des populations humaines.

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Titre : Les solutions fondées sur les écosystèmes côtiers pour l'atténuation et l'adaptation au changement climatique dans les politiques publiques nationales des Petits États insulaires en développement du Pacifique

Mots-clés : climat, solutions fondées sur la nature, océan, politiques publiques, gouvernance, Petits États insulaires en développement du Pacifique.

Résumé : Les solutions fondées sur les écosystèmes côtiers, telles que la conservation ou la restauration des mangroves, des herbiers et des récifs coralliens, sont de plus en plus reconnues par les communautés scientifiques et politiques comme des actions pertinentes pour l'atténuation et l'adaptation au changement climatique. Cependant, leur mise en œuvre se heurte à des contraintes techniques, financières et institutionnelles dans les Petits États insulaires en développement du Pacifique (PEIDP), qui comptent parmi les pays les plus vulnérables aux changements climatiques et à la dégradation de la nature. Les objectifs de cette thèse sont (i) de comprendre comment les PEIDP incluent les solutions fondées sur les écosystèmes côtiers dans leurs politiques nationales, en particulier dans le cadre de l'Accord de Paris ; et (ii) d'examiner la pertinence pour les PEIDP d'outils proposés pour concevoir des politiques publiques efficaces. Les résultats mettent en évidence une intégration croissante des solutions fondées sur les écosystèmes côtiers dans les politiques publiques des PEIDP. Nous identifions les potentiels inconvénients et opportunités liés à leur standardisation, en termes d'accès à des financements et de suivi de la mise en œuvre. Nous étudions l'éventail des services écosystémiques côtiers dans les PEIDP et identifions des moyens d'améliorer leur évaluation. Enfin, une étude de cas dans une communauté côtière fidjienne recueille les perceptions locales et des propositions d'amélioration de la gestion côtière par le biais d'une sensibilisation et d'une coopération accrues entre les communautés, les autorités et la recherche.

Title: Coastal nature-based solutions for climate adaptation and mitigation in the national policies of Pacific Small Island Developing States

Keywords: climate, nature-based solutions, ocean, policies, governance, Pacific Small Island Developing States.

Abstract: Coastal nature-based solutions (NbS), such as the conservation or restoration of mangroves, seagrasses and coral reefs, are increasingly recognized by science and policy as valuable actions for climate adaptation and mitigation. However, their implementation faces technical, financial and institutional constraints in the Pacific Small Island Developing States (PSIDS), which are among the most vulnerable countries to climate impacts and nature loss and degradation. This thesis aims at (i) understanding how PSIDS include coastal NbS in their national policies, in particular in the Nationally Determined Contributions (NDCs) developed under the Paris Agreement; and (ii) examining the relevance for PSIDS of tools promoted at the global level to design effective policies. Results highlight an increased integration of coastal NbS over time in the policies of PSIDS. We identify potential drawbacks and opportunities for coastal management provided by the standardization of NbS in NDCs, in terms of access to funding and progress tracking. We investigate the range of coastal ecosystem services in PSIDS and identify ways to improve their assessments to inform policy-making. Finally, a case study in a Fijian coastal community collects local perceptions and proposals for improving coastal management through increased awareness and cooperation between communities, authorities, and research.