Limited integration of biodiversity within climate policy: Evidence from the Alliance of Small Island States

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A B S T R A C T

Climate change and biodiversity loss are deeply intertwined anthropogenic global crises, for which forests provide powerful nature-based solutions. Biodiverse forests are more resilient to climate change than monocultures, thereby enhancing long-term carbon storage and ecosystem-based adaptation. Awareness of these interdependencies is slowly growing, but we know little about how countries are considering biodiversity within climate policies. Island and low-lying coastal states are particularly vulnerable to climate change and biodiversity loss. Here we assessed if and how the members of the Alliance of Small Island States (AOSIS) are integrating biodiversity into their national climate action plans through forest-based climate solutions. Our analysis shows that these solutions are a missed opportunity for tackling the twin crises together. Only five of the 39 countries explore co-benefits and synergies between forest-based climate solutions and biodiversity conservation measures. An additional nine mention them separately. Among these 14 countries, only a narrow range of interventions were proposed. While 28 AOSIS members prioritised forests for combating climate change, mostly for mitigation, only three prioritised their unique and globally important biodiversity. This omission is potentially risky, since mitigation measures, such as planting rapidly growing non-native trees, can have negative outcomes for biodiversity. Climate action plans must place a greater emphasis on concrete and measurable targets that create synergies with biodiversity conservation, including through the protection of old-growth forests and forest restoration. Our results highlight that forums such as the United Nations Climate Change Conferences need to continue pushing for a stronger integration of biodiversity into climate policies.

Keywords: Biodiversity co-benefits; Content analysis; Nationally Determined Contributions; Nature-based solutions; Paris Agreement; Tropical forest

1. Introduction

The climate and biodiversity crises are among the most pressing issues of our time (Ceballos et al., 2015; Ripple et al., 2020). Average rates of global warming may reach 1.5 ◦C above pre-industrial levels as early as 2030 and one in eight species are at risk of extinction (IPBES, 2019; IPCC, 2018). Solving these crises requires us to understand that climate change and biodiversity loss are mutually interdependent (CBD, 2019; Marquet et al., 2019). Some species are going extinct as a result of rising temperatures, as they are unable to shift their geographical distribution (Nunez et al., 2019; Taylor and Kumar, 2016). Lower levels of biodiversity, in turn, limit the ability of some ecosystems to combat climate change (Mori et al., 2021; Seddon et al., 2019). The causes of both crises are also often shared, driven by issues such as intensive agriculture and loss of native forest (IPBES, 2019; IPCC, 2018). As a result, scientists and politicians have increasingly been calling for a joint approach to tackling the crises (CBD, 2019; Turney et al., 2020).

International policy processes have struggled to address climate change and biodiversity loss together (Seddon et al., 2019; Turney et al., 2020). For example, the Convention on Biological Diversity (CBD) primarily deals with the conservation of biodiversity under the United Nations Environment Programme (UNEP), but although its secretariat has created an agenda item on “climate change and biodiversity”, parties still hesitate to implement activities under this heading (Secretariat of the Convention on Biological Diversity, 2017). In contrast, the United Nations Framework Convention on Climate Change (UNFCCC) aims to atmospheric greenhouse gas concentrations but has largely failed to mainstream biodiversity, despite the United Nations (UN) being officially obliged to do so across all its environmental policies (Díaz et al., 2009; Kupika and Nhamo, 2016). These challenges reflect the constraints upon the CBD and UNFCCC to achieve direct cooperation as they have different mandates, members, and negotiators. Nonetheless, climate-biodiversity collaborations are slowly developing among these international governing bodies, as well as among scientific committees (Intergovernmental Panel on Climate Change, IPCC, and Intergovernmental Platform on Biodiversity and Ecosystem Services, IPBES). IPCC and IPBES held their first joint workshop in December 2020, which led to the release of a report (P¨ortner et al., 2021). However, a coordinated policy approach that provides a balanced integration of climate change and biodiversity loss is still lacking (Deprez et al., 2019; Turney et al., 2020).

Meanwhile, there has been growing interest in biodiversity under the international climate change policy framework (Gardner et al., 2020; Veríssimo et al., 2014). On a national level, the clearest opportunity for creating synergies is hence to ensure that biodiversity conservation is fully integrated within the mitigation and adaptation components of the Nationally Determined Contributions (NDCs) to the Paris Agreement (UNFCCC, 2015).

The international community has repeatedly stressed the importance for NDCs to include nature-based solutions (NBS; Griscom et al., 2017, 2020; Seddon et al., 2020b), which are defined as interventions that "are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience" (European Union, 2020). This umbrella term spans other well-established concepts, including ecosystem-based adaptation/mitigation, natural climate solutions, and green infrastructure (Seddon et al., 2020a). NBS may contribute by more than one third to the climate change mitigation needed for reaching the Paris temperature goal (Griscom et al., 2017), as well as substantially contributing to adaptation (Chausson et al., 2020; Seddon et al., 2020b). Yet, uncertainties remain with regard to estimates and cost efficiency of these solutions, which in practice often focus on mitigation (Griscom et al., 2017; Seddon et al., 2020a).

Forests offer some of the most important NBS for both climate change mitigation and adaptation (Barber et al., 2020; Seddon et al., 2020b). We use the term forest-based climate solutions to differentiate from NBS in the climate change discourse provided by other ecosystems, such as grasslands, river catchments, or agricultural fields (Seddon et al., 2020b). As carbon sinks, forests actively capture and store atmospheric CO_2 (Pan et al., 2011), simultaneously aiding adaptation, by preventing soil erosion, supporting hydrological flows, and protecting coastal areas against storms (Pramova et al., 2012). Since forests are among the most important habitat types for terrestrial species (Watson et al., 2018), forest-based climate solutions may offer co-benefits for and synergies with biodiversity conservation (Chausson et al., 2020; Morita and Matsumoto, 2018). Biodiversity co-benefits are additional positive outcomes resulting from policy measures aimed at combating climate change (cf. Grafakos et al., 2019). Synergies occur when the effect of implementing climate and biodiversity policy measures together is greater than their separate implementation (cf. Klein et al., 2007). Despite their potentially high impact, these synergistic relationships are often undervalued

(Mori, 2020; Seddon et al., 2019). Biodiversity may be an active player in the solution, not only a conservation target (Mori, 2020): Biodiverse biomes are more productive in terms of biomass, thus better mitigating climate change (Mori et al., 2021; Poorter et al., 2015), and facilitate ecosystem-based adaptation to climate change (CBD, 2019; Seddon et al., 2019).

Island and coastal states hold unique and particularly vulnerable biodiversity (Friess et al., 2019; Kier et al., 2009), and are also expected to suffer disproportionately high impacts from climate change (Halstead, 2016). The Alliance of Small Island States (AOSIS) was formed in 1990 as a joint political voice for this vulnerable group of countries, which is recognised as a key player in the UN climate negotiations (Ourbak and Magnan, 2018). The NDCs represent an important opportunity to protect and enhance biodiversity in these countries. Here, we examine the extent to which the connections between climate change, forest-based climate solutions, and biodiversity conservation have been integrated in NDCs of AOSIS members. Specifically, we use NDCs to assess: (i) How many countries prioritise forests and/or biodiversity for climate change mitigation and adaptation; (ii) The range of forest-based climate solutions and biodiversity conservation measures being proposed; (iii) To what extent forest-based climate solutions consider co-benefits and synergies with biodiversity conservation measures. Finally, we provide some recommendations to ensure NDCs promote forest-based biodiversity co-benefits and synergies. This is especially relevant to overcome the climate-biodiversity gaps discussed at the 26th Conference of the Parties (COP 26) to the UNFCCC, which took place in Glasgow, UK, in November 2021.

2. Methods

2.1. Rationale

Island and low-lying coastal states, where the impacts from climate change and biodiversity loss are particularly prominent, represent an interesting case among UNFCCC parties. The focus and potential role of their NDCs is distinct from that of other country groups including industrialised and emerging nations. With rising sea levels and extreme weather events posing severe threats to their survival (Halstead, 2016), AOSIS members are known to emphasise adaptation in the NDC context (Mbeva and Pauw, 2016). At the same time, their high levels of endemic and extinction-prone species are of global significance (Fordham and Brook, 2010; Kier et al., 2009). Any positive or negative change in AOSIS' biodiversity can have far-reaching implications for conservation and their NDCs have the potential to promote either direction. Furthermore, the role of biodiversity conservation for climate change adaptation is more widely accepted than its impact on mitigation (Hisano et al., 2018; Seddon et al., 2019). It is therefore more likely that references to biodiversity will be found in the NDCs of the adaptation-oriented AOSIS members, compared to other groups. In addition, AOSIS have proven highly influential in climate negotiations and may thus be promising pioneers for such new approaches.

NDCs were chosen as study objects since the National Biodiversity Strategies and Action Plans (NBSAPs), as the counterpart under CBD framework, are internationally less recognised. Historically, climate negotiations are more advanced than the biodiversity ones, which can partially be explained by the existence of the clear ambitions covered in the Paris Agreement's long-term temperature goal (Legagneux et al., 2018; Mace et al., 2018). They also receive much greater attention in science and media (Legagneux et al., 2018; Veríssimo et al., 2014). It is thus wise to make use of the growing awareness of climate issues, which remain high on the policy agenda, and create synergies for biodiversity conservation under UNFCCC framework (Gardner et al., 2020; Veríssimo et al., 2014). Besides, if a country chooses to mention biodiversity in the NDC context, where there is no official requirement to do so, this effectively demonstrates its heightened interest in conservation. Another advantage of NDCs is their structural division into mitigation and adaptation action, which enables a detailed study of biodiversity integration under both components. Equally pivotal is that the UNFCCC allows for a clear split between biodiversity and forests, e.g. treating each as a separate priority for adaptation (UNFCCC, 2021a).

The inclusion of the forest sector in UNFCCC processes has a long-standing history, committing parties to land use, land-use change and forestry (LULUCF) activities, with stronger obligations for developed countries (UNFCCC, 2021b). For greenhouse gas accounting in NDCs, more and more parties are listing LULUCF as one of their categories of anthropogenic emissions and removals (UNFCCC, 2021a). Almost in parallel to LULUCF, the UN programme on reducing emissions from deforestation and forest degradation (REDD; later extended with the role of conservation, sustainable management of forests and enhancement of forest carbon stocks – REDD+) evolved. It shares the same goal, considering forest carbon sinks and sources for greenhouse gas mitigation, but uses an entirely different approach (Pistorius et al., 2017). As an incentive-based mechanism, it builds on voluntary agreements between donors (developed countries) and receivers (developing countries). Consequently, not all parties mention REDD+, or elaborate on LULUCF as such, in their NDCs (Grassi et al., 2017; Hein et al., 2018). This is also true for AOSIS countries, that lack a joint vision for both institutions, despite the awareness that forests are becoming an increasingly important negotiation topic. For instance, individual country submissions on LULUCF to the UNFCCC have been more common in the past than joint statements by AOSIS (Betzold et al., 2012). Moreover, only 10 AOSIS members are partners of REDD+ currently (UN-REDD Programme Collaborative Online Workspace, 2021), likely due to weak interest and support of donors for REDD+ initiation in relatively small forests on islands.

The idea of incorporating biodiversity concerns into forest-based climate actions already emerged within REDD+ in the form of environmental safeguards, which, in contrast, have never been discussed under LULUCF (Pistorius et al., 2017). Yet, REDD+ only allows for limited biodiversity ambitions, namely co-benefits, as the focus for funding is mitigation (Gardner et al., 2012). NBS, which started to gain relevance in the mid-2010s, cover more: As a term originating from climate change adaptation in urban areas, it can refer not only to mitigation but also adaptation, and is often rooted in biodiversity conservation (Eggermont et al., 2015; Pauleit et al., 2017), setting the ground for synergistic approaches. This combination makes NBS attractive as NDC commitments for the adaptation-focused AOSIS members. Since many of them are rich in forests, NBS from forests may be of particular interest for their climate targets. The exploration of NBS in NDCs is thus the best option to study how AOSIS countries consider synergies between forest-based climate solutions and biodiversity.

2.2. Study area

The AOSIS consists of 44 tropical countries and territories. Guinea- Bissau, Belize, Guyana, and Suriname are low-lying coastal states, while the remaining are small island states (AOSIS, 2019). For this study, we only considered the 39 countries that are full members of the UN or participate within the UN (Fig. 1). The five observer states of

American Samoa, Guam, Netherlands Antilles, Puerto Rico, and United States Virgin Islands were excluded since they are not required to submit their own NDCs.

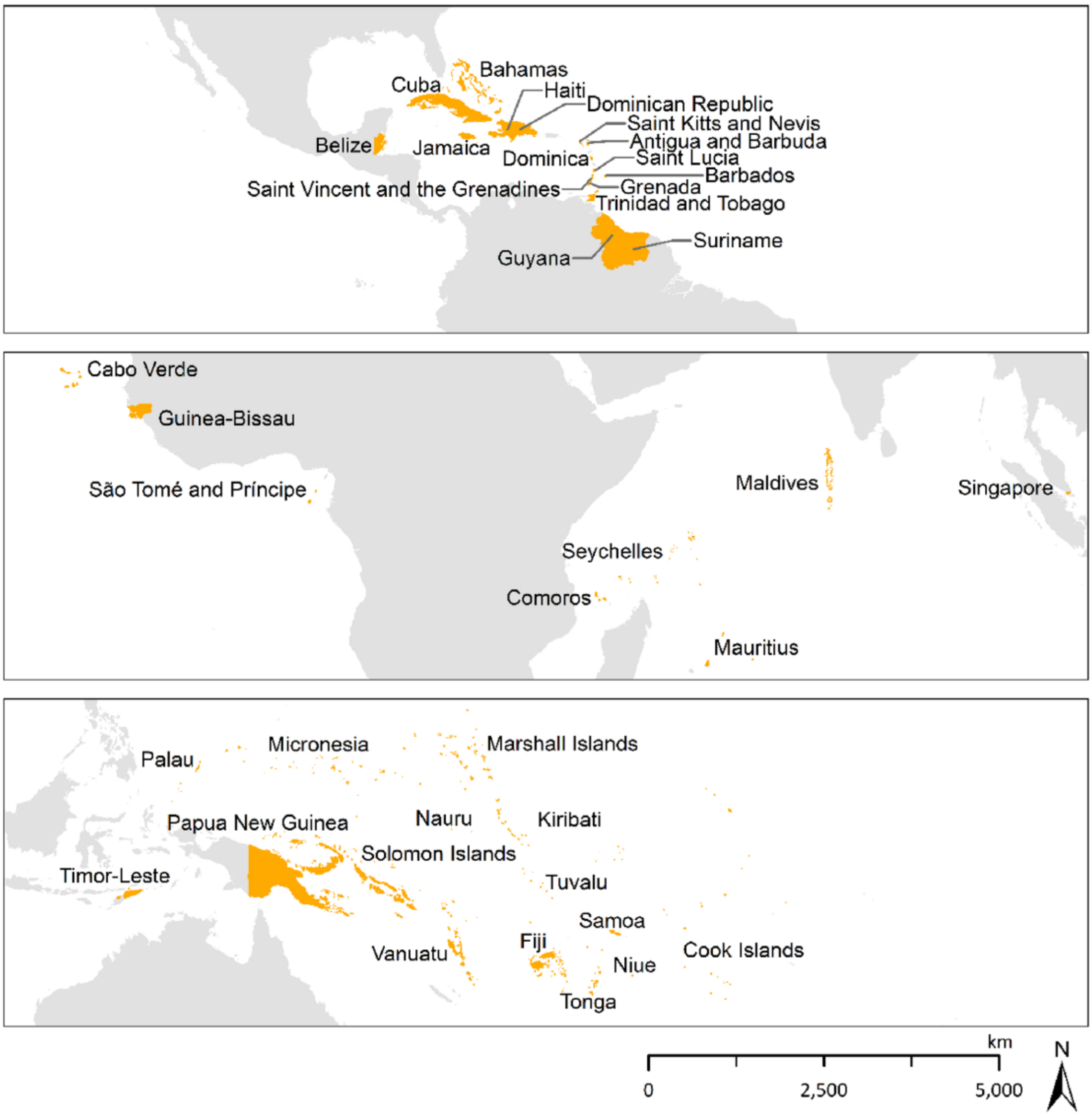

Fig. 1. Location of the 39 Alliance of Small Island States (AOSIS) countries that are full members of the United Nations or participate within the United Nations (in orange), in the Caribbean (top), the African, Indian and South China Seas (middle), and the Pacific Ocean (bottom). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

2.3. Data collection and analysis

NDCs were downloaded from the NDC registry website (UNFCCC, 2020) on 28 August 2020. The resulting set of 39 documents consisted mostly of first NDCs, but also updated first NDCs for Singapore and Jamaica and second NDCs for Suriname and Marshall Islands. The documents were in English, except for the NDCs of Comoros and Haiti, which were in French, and the NDC of Cuba, which was in Spanish. Apart from the NDC by the Dominican Republic, that provides an unofficial translation from Spanish into English, all documents were analysed in their original language.

To analyse NDCs, we conducted an iterative content analysis (Krippendorff, 2018), a commonly used method for qualitative data analysis, known for its transparency, reliability, and simplicity (Kuckartz, 2019). At its core stands the identification of categories – groups of similarly coded data (Kuckartz, 2019), which we determined through provisional and structural coding, followed by axial coding. Given that NDCs are policy documents and should be formulated in a clear, unambiguous manner, our analyses did not consider underlying, interpretive meanings (Bengtsson, 2016; Berg et al., 2004).

2.3.1. Preparatory work

Provisional coding allows data to be broken down according to broadly predefined codes. These are used to explore documents and identify key text segments (Saldaña, 2009). Thus, a list of provisional codes was first compiled concerning the main themes of this study, forests and biodiversity, which we translated into French and Spanish (SI 1). This deductive approach helped to strengthen the focus of our investigation (Saldaña, 2009). The provisional codes were derived from REDD+ key activities, namely reducing emissions from deforestation, reducing emissions from forest degradation, conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks, and their biodiversity safeguards (Gardner et al., 2012). For each activity, a range of synonyms was chosen to serve as provisional codes, in line with the literature. For instance, “forest conservation” was represented by “forests”, “trees”, “mangroves”, “conservation”, “preservation”, and “protection” (Crumpler et al., 2019; Donato et al., 2011). Considering the focus of the study, only terrestrial biodiversity was included, and particular attention was paid to “endemism”, as well as “co-benefits”, “synergies”, and “trade-offs”. The codes were used one after another, applying automatic text search to NDCs in NVivo 12 Plus software (QSR International Pty Ltd, 2018). Subsequently, relevant text passages (words, quasi-sentences, full sentences, and whole paragraphs) were highlighted by hand. These were the smallest meaning units that contained the predefined codes (Bengtsson, 2016).

2.3.2. Further coding and analysis

Next, we employed structural coding to classify data based on our research questions (Saldaña, 2009). For this purpose, we elaborated a coding frame directly linked to these questions by comparing units of text and labelling them with new codes (Bengtsson, 2016; Saldaña, 2009), as described below. In addition, we applied axial coding for the second research question. This is a method which creates linkages between codes to reorganise them in categories (Strauss and Corbin, 1990).

2.3.2.1. Prioritisation of forests and biodiversity. We started by checking which countries considered forests as a priority for climate change. Since NDCs usually have separate sections for climate change mitigation and adaptation, we used the codes "forestry as a mitigation priority sector" and "forestry as an adaptation priority sector" to differentiate between relevant text segments of these sections, and forests were considered a priority if words such as "priority", "major", "main", or "focus" were contained. If countries did not apply this terminology but listed a concise number of target sectors instead, these were regarded as the country's priority sectors. Similarly, the codes "biodiversity as a mitigation priority" and "biodiversity as an adaptation priority" were created to assess if biodiversity was prioritised in NDCs.

2.3.2.2. Forest-based climate solutions and biodiversity conservation measures. To distinguish types of forest-based climate solutions within countries, the following codes were used: "reducing deforestation and forest conservation", "reducing degradation and sustainable forest management", and "afforestation/reforestation" (Crumpler et al., 2019). This list was complemented by other forest-based climate solutions found in the NDCs and labelled as "other". The code "biodiversity" was used to identify any kind of biodiversity conservation measures. To ensure replicability, the assignment of codes to text passages was iterated until results became stable (Guba and Lincoln, 1982).

Axial coding carried out by forming categories that merged deductive and inductive codes (Table 1; Graebner et al., 2012) resulted in eight categories of forest-based climate solutions and three categories of biodiversity conservation measures linked to climate change. The category "other sectors" was only indirectly linked to forests, while "forest assessment and monitoring" was regarded as a precursor for forest-based climate solutions.

Table 1 Categories and corresponding descriptions formed to distinguish different types of forest-based climate solutions and biodiversity conservation measures, respectively, which are proposed in the Nationally Determined Contributions (NDCs) of the 39 Alliance of Small Island States (AOSIS) members.

Category	Description
Forest-based climate solutions	
Forest protection	Includes forest conservation in general as well as the preservation, management, and expansion of protected areas, such as forest reserves.
Forest (re-)growth	Includes afforestation, reforestation, forest restoration and rehabilitation. Covers related terms such as forest (re-)growth, plantation, increased tree cover, enhancement of forests or forest carbon stocks, and promotion of particular species, such as indigenous or climate-resilient species.
Reduction of deforestation and forest degradation	Covers actions to decrease levels of deforestation and forest degradation, and the control of forest fires.
Sustainable forest management	Includes activities covered by the United Nations, (2008) definition of "a dynamic and evolving concept, […] intended to maintain and enhance the economic, social and environmental value of all types of forests, for the benefit of present and future generations". This definition excludes general actions to reduce deforestation and degradation as these do not necessarily imply that the level of reduction is sustainable.
Forest management	Any type of management that did not fit into the aforementioned categories as well as forest management not specified in detail was placed into this category.
Forest governance	Includes governance, in the sense of rules, regulations, laws, strategies, policies, and programmes (Fischer et al., 2020; Lemos and Agrawal, 2006), actions not covered above, as well as market-based mechanisms such as REDD+ and certification schemes (e.g. FSC; compare Nunan, 2019).
Forest assessment and monitoring	Includes forest inventories, assessment, and monitoring.
Other sectors	Covers any reference made to other sectors that were targeted to reduce pressure on forest resources such as energy, mining, agroforestry, and arboriculture sectors.
Biodiversity conservation measures	
Biodiversity protection	Includes conservation, management, and sustainable use of biodiversity, as well as the management and expansion of protected areas for biodiversity conservation.
Biodiversity governance	Includes integrative governance and management approaches, as well as consideration of the Convention on Biological Diversity (CBD) and other biodiversity-related instruments.
Biodiversity resilience	Covers management options that aim to improve biodiversity resilience.

Then we analysed which categories of forest-based climate solutions and biodiversity conservation measures were covered by each country. This was expressed in a joint heatmap, based on the presence-absence data for each country and category, using the function "heatmap.2" from the "gplots" R package (R Core Team, 2019; Warnes et al., 2020). Since measurable targets are vital to evaluate progress towards climate action (Seddon et al., 2020c), we used subcodes to evaluate which countries were proposing these for each of the forest-based climate solutions and biodiversity conservation measures.

2.3.2.3. Links between forest-based climate solutions and biodiversity conservation measures. We built a contingency table identifying which countries mentioned forest-based climate solutions and biodiversity conservation measures simultaneously in the NDCs, and carried out a Fisher's exact test to assess the strength of the correlation between the two variables (Bower, 2003). Afterwards, we identified which categories were more frequently mentioned together and which countries made direct links between forest-based climate solutions and biodiversity conservation measures.

3. Results

3.1. Prioritisation of forests and biodiversity

Twenty-eight out of the 39 AOSIS members (71.8%) included forests as a priority sector: 24 (61.5%) for climate change mitigation and 14 (35.9%) for adaptation. The mitigation goal of the Government of Jamaica, (2020), for instance, comprised "the energy sector (supply and end-use) and land-use change and forestry" (p. 4), while Belize's adaptation action stated that "[t]he sectors of focus are agriculture, forestry, fisheries and aquaculture, coastal and marine resources, water resources, land use and human settlements, human health, energy, tourism and transportation" (Government of Belize, 2016, p. 11).

The prioritisation of forests contrasted with the lack of biodiversity prioritising. Only Mauritius, Singapore, and Timor-Leste (7.7% of AOSIS members) declared biodiversity a priority, and they did so exclusively for adaptation. The Government of Mauritius, (2016) considered biodiversity resilience in its priority adaptation actions, aiming for "[i] mprovement of the management of marine and terrestrial protected areas and expansion of protected area network including rehabilitation of wetlands, sea-grass, mangrove plantation, increase in tree coverage areas and coral reef rehabilitation/farming" (p. 4). No AOSIS state mentioned endemism as a factor to value its biodiversity in a global perspective of conservation.

3.2. Forest-based climate solutions and biodiversity conservation measures

Only Guinea-Bissau and Timor-Leste mentioned all eight categories of forest-based climate solutions (Fig. 2). Forest protection and forest (re-)growth were the most frequently cited categories (20 countries each). Twenty-five AOSIS members (64.1%) claimed to have forest-based climate solutions planned or in place. The Government of Guyana, (2016), for instance, "will utilize a combination of conservation and sustainable management of its forests in the fight against climate change" (p. 6), which fits the categories of forest protection and sustainable forest management. Forest (re-)growth and reduction of deforestation and forest degradation were identified by the Government of Saint Vincent and the Grenadines, (2016), that "intends to develop its GHG sinks though reforestation, afforestation, reduced deforestation and reduced forest degradation" (p. 4).

Eight countries quantified forest-based climate solutions (SI 2), but only São Tomé and Príncipe and Singapore quantified forest-based adaptation targets. Six out of the 24 countries claiming that forests are a priority for mitigation and three out of 14 claiming them as a priority for adaptation did not suggest forest-based climate solutions. In contrast, Niue, the Seychelles, and Saint Lucia expressed forest-based climate solutions without prioritising forests in the fight against climate change. The latter claimed that "[s]ignificant work is currently being conducted to improve forest inventory data, develop policies for forest management and protection and to identify reforestation projects" (Government of Saint Lucia, 2016, p. 4).

No country covered all categories of biodiversity conservation measures and only 15 (20.5%) proposed at least one (Fig. 2). Biodiversity protection and biodiversity governance were the most mentioned categories (eight and seven times, respectively). To improve biodiversity resilience, the Government of Timor-Leste, (2017) envisioned to "[m] aintain mangrove plantations and promote awareness raising to protect coastal ecosystems from impacts of sea level rise" (p. 19).

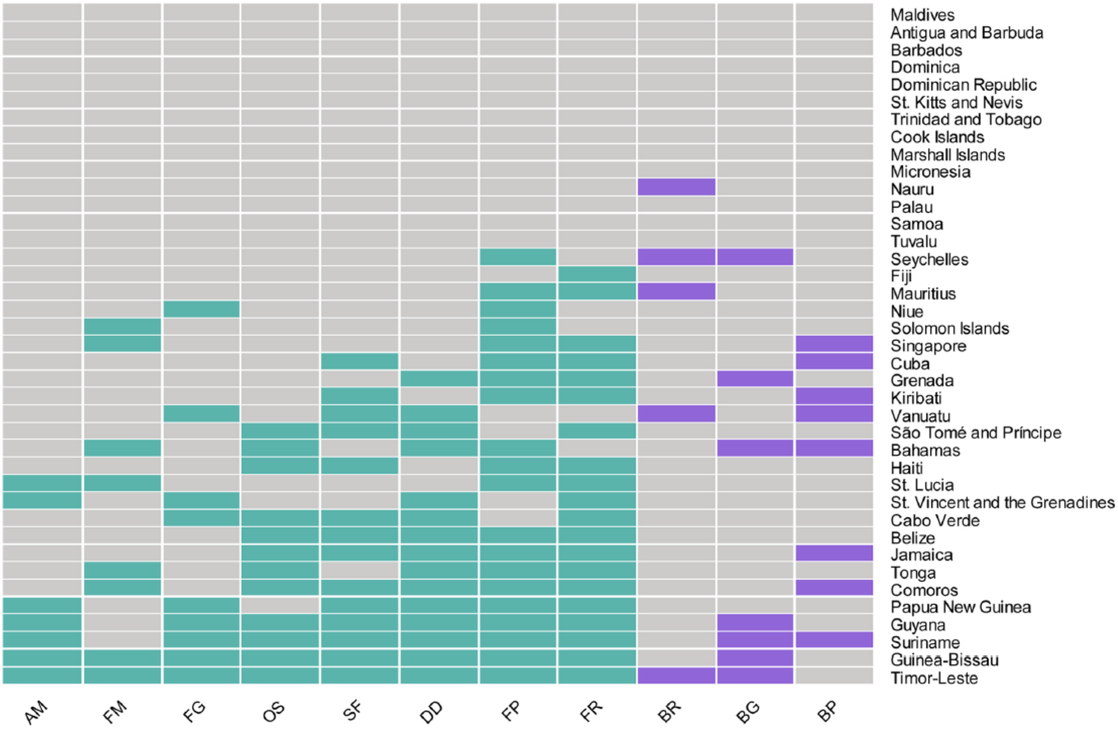

Fig. 2. Heatmap of forest-based climate solutions (green) and biodiversity conservation measures (purple) suggested in the Nationally Determined Contributions (NDCs) of the 39 Alliance of Small Island States (AOSIS) members. AM: forest assessment and monitoring, FM: forest management, FG: forest governance, OS: other sectors, SF: sustainable forest management, DD: reduction of deforestation and forest degradation, FP: forest protection, FR: forest (re-)growth, BR: biodiversity resilience, BG: biodiversity governance, BP: biodiversity protection. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

All three countries that considered biodiversity a priority for adaptation suggested biodiversity conservation measures (Table 2). Twelve countries proposed biodiversity conservation measures without making biodiversity a priority for combating climate change. Only two countries expressed quantified conservation measures in relation to biodiversity. The Government of Singapore, (2020) aimed to implement “recovery plans for over 70 more animals [sic] and plant species” (p. 24). “100% representation of all ecosystems and biological species” was strived for by the (Government of Suriname, 2019, p. 12).

Table 2 Categorised biodiversity conservation measures found in the Nationally Determined Contributions (NDCs) of Alliance of Small Island States (AOSIS) members. Whenever direct in-text links are present between forest-based climate solutions and biodiversity conservation measures, corresponding words are highlighted in bold in the quote.

Country	Category	Quote
Bahamas	Biodiversity protection	▪ "These protected areas will conserve and protect habitats for Grouper and Bonefish spawning aggregations, coral reefs, sea grass meadows, mangrove nurseries and important migratory bird areas."
	Biodiversity governance	▪ "The Bahamas acts not only under the UNFCCC but also the United Nations Conventions on Biological Diversity (CBD), and Convention to Combat Desertification (UNCCD) and other relevant multilateral and regional environmental agreements (MEAs) and initiatives."
Comoros	Biodiversity protection	▪ "Le gouvernement Comoriens a planifie de renforcer ses actions pour la conservation de la biodiversité marine et terrestre. Ainsi, il est projeté de passer à un total de 50 000 ha environ de terre sous couvert végétale, principalement les forêts, d'aires protégées à l'horizon 2030." [Translation: The Comorian government plans to reinforce its actions for the conservation of marine and terrestrial **biodiversity**. Hence, it is projected that protected areas will increase to a total of 50 000 ha of land under plant cover, mainly **forests**, by 2030.]
Cuba	Biodiversity protection	▪ Main actions: "Enfatizar la conservación y uso racional de recursos naturales como los suelos, el agua, las playas, la atmósfera, los bosques y la biodiversidad, así como el fomento de la educación ambiental". [Translation: Emphasise the conservation and the rational use of natural resources such as soils, water, beaches, the atmosphere, forests, and biodiversity, as well as the promotion of environmental education.]
Grenada	Biodiversity governance	▪ "Grenada has shown its commitment to the reduction of its greenhouse gas emissions over the years by signing on to several international and regional initiatives and expressing commitment to a number of United Nations processes relative to Climate Change, Small Island Developing States, Biological Diversity, and the Millenium Development Goals [sic]. […] Grenada has a National obligation to protect 17% of its terrestrial area as part of the Aichi Target under the convention on Biological diversity [sic]."
Guinea-Bissau	Biodiversity governance	▪ "[The initiatives taken in the context of climate change] must be part of a consistent perspective of integration into a broader policy framework, developing strategic and programmatic approaches that integrate climate policy development, planning policy and action at national, regional and local levels, involving all sectors of the national economy and integrating all other dimensions of environmental management and natural resources, including biodiversity conservation, the

		sustainable management of land and water.”
Guyana	Biodiversity governance	▪ Emissions Reductions Programme measures: “the conservation of an additional 2 million hectares through Guyana’s National Protected Area System and other effective area-based conservation measures as per Guyana’s commitment under the UNCBD, including the protection of conservancies and reservoirs and their watersheds and the watersheds upstream of new hydro-power sites”.
Jamaica	Biodiversity protection	▪ “For example, the Integrated Management of the Yallahs and Hope River Watershed Management Areas (Yallahs-Hope) Project, [sic] aims to improve the conservation and management of **biodiversity** and the provision of ecosystem services within the region […]. This will be done by implementing sustainable agriculture (including renewable power generation), **forestry**, land management and livelihood practices within targeted communities.”
Kiribati	Biodiversity protection	▪ Kiribati Development Plan (KDP) 2012–2015: “The key objective of [key policy area] 4 is to facilitate sustainable development by mitigating the effects of climate change through approaches that protect biodiversity and support the reduction of environmental degradation by the year 2015.”
Mauritius	Biodiversity resilience	▪ Priority adaptation actions: “Improve Marine and Terrestrial **Biodiversity** Resilience: Improvement of the management of marine and terrestrial protected areas and expansion of protected area network including rehabilitation of wetlands, sea-grass, **mangrove** plantation, increase in **tree** coverage areas and coral reef rehabilitation/farming”.
Nauru	Biodiversity resilience	▪ “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; energy; land management and rehabilitation; infrastructure and coastal protection; biodiversity and environment; community development and social inclusion; and education and human capacity development.”
Seychelles	Biodiversity governance	▪ “[Seychelles National Climate Change Strategy and Seychelles Sustainable Development Strategy] called for the mainstreaming of climate change adaptation into all sectoral plans and this has progressed in several sectors including tourism, health, finance, agriculture, biodiversity, fisheries, disaster management, and land-use planning. […] A new Biodiversity law is currently being drafted which will update the existing laws related to the protection of biodiversity and strengthening of the capacity of those charged with their protection. There is a need to balance protected areas and room for development whilst developing a strong capacity for biosecurity.

	Biodiversity resilience	■ "Also recently, the Seychelles Biodiversity Strategy and Action Plan (2015-2020) has been launched, and includes many cross-sectoral projects with climate change adaptation implications. Projects address issues such as sustainable tourism, watershed management, sustainable agriculture and fisheries, disaster planning, research and a shift toward ecosystem-based adaptation approaches to biodiversity conservation."
Singapore	Biodiversity protection	■ "Singapore will conserve more **native plants and animals** by carrying out recovery plans for over 70 more animals [sic] and plant species, enhancing 30 hectares of **forest**, marine and coastal habitats, and restoring ecological habitats in at least half of its gardens, parks and streetscapes by 2030."
Suriname	Biodiversity protection	■ "The 2017 – 2021 Policy Development Plan aim for the forest sector is to increase its contribution to the economy and the welfare of this and future generations, including through biodiversity preservation. […] The protection and management of protected areas is the highest priority for **biodiversity** preservation in the [Policy Development Plan] 2017-2021. It states **mangrove forests** that protect the Atlantic coastline will be protected within a scheme coupled with improved land zoning and enforcement capacities. […] Stakeholders note the large impact mining has on forests and biodiversity. The PDP speaks about the need to balance the need for development and the protection of the environment. Several projects have been initiated in the sector and the government expects to include the sector in the 2025 NDC update."
	Biodiversity governance	■ "In accordance with the 2015 NDC unconditional contribution, Suriname has established 14% of its total land area under a national protection system and will continue to pursue the expansion of this system by increasing the percentage of forests and wetlands under protection to at least 17% of the terrestrial area by 2030, in line [sic] the UN CBD Aichi target. […] This will lead to the expansion of the national network of legally protected areas to accomplish 100% representation of all ecosystems and biological species, according to the National Biodiversity Action Plan (Ministry of Labour, Technological Development and Environment, 2013), the National Forest Policy (2005) and the Suriname National REDD+ Strategy (2018)."
Timor-Leste	Biodiversity resilience	■ "Priority adaptation areas are identified in relation to food security, water resources, health, natural disasters, forestry, biodiversity and coastal ecosystem resilience, livestock production and physical infrastructure." Adaptation measures: "Forests, Biodiversity and Coastal Ecosystems Resilience:

		– Maintain mangrove plantations and promote awareness raising to protect coastal ecosystems from impacts of sea level rise. – 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. – Mangrove plantation and protection to enhance coastal resilience."
	Biodiversity governance	▪ "The Ministry of Commerce, Industry and Environment, in cooperation with the National University of Timor Lorosa'e (UNTL), has established a Center for Climate Change and Biodiversity (CCCB) with the aim to undertake climate related research, providing effective data to the Government of Timor-Leste, which is targeted to develop relevant policy and to undertake data-informed decision making. […] Proposed Biodiversity Decree Law, which specifically targets biodiversity conservation concerns such as the protection of habitats and ecosystems, threat and management of invasive alien species, trade in species and the penalties, and other provisions."
Vanuatu	Biodiversity protection	▪ "Vanuatu's INDCs is well aligned with the Government's Priority Action Agenda Policy Objective 4.5 which is most relevant to Climate Change and states, "to ensure the protection and conservation of Vanuatu's natural resources and biodiversity, taking climate change issues in consideration.""
	Biodiversity resilience	▪ "The [National Adaptation Programme of Action] further recognised that the following core issues were relevant to all priorities and should be an integral part of any proposed activities; […] Consideration of marine and terrestrial Biodiversity [sic] issues".

3.3. Links between forest-based climate solutions and biodiversity conservation measures

There was a significant association between whether NDCs mentioned forest-based climate solutions and biodiversity conservation measures (Fisher's exact test, p-value: 0.005): 14 countries (35.9%) considered both, 13 (33.3%) incorporated none, 11 (28.2%) incorporated only forest-based climate solutions, whilst Nauru (2.6%) solely mentioned biodiversity conservation measures. Regarding the most frequently cited categories, "forest protection" or "forest (re-)growth" and "biodiversity protection" or "biodiversity governance" had the strongest link. Overall, Timor-Leste covered most categories, followed by the low-lying coastal states Suriname, Guinea-Bissau, and Guyana. However, only five countries established direct in-text links between forest-based climate solutions and biodiversity conservation measures (Table 2): Mauritius and Singapore mentioned forest (re-)growth to enhance biodiversity resilience and protection respectively, Comoros and Suriname connected biodiversity protection with forest protection, and Jamaica claimed that biodiversity protection should be promoted through forestry, but did not specify through which type of forest-based climate solution.

4. Discussion

Nature-based solutions provided by forests offer great synergistic potential for combating both climate change and biodiversity loss. However, thus far there has been limited exploration of the extent to which this potential has been translated into policy documents. Here we show AOSIS members do tend to prioritise forests for climate change mitigation and to a lesser degree adaptation but hardly any prioritise biodiversity for climate action. This represents a missed opportunity for AOSIS countries to tackle both challenges simultaneously, and risks unintended consequences for biodiversity conservation whilst solely focussing on meeting climate change mitigation obligations.

4.1. Mitigation- and adaptation-oriented prioritisation of forests and biodiversity Most AOSIS members prioritise forests in their NDCs (cf. GIZ, 2021; Pauw et al., 2016). In general, AOSIS members concentrate on climate change adaptation (Mbeva and Pauw, 2016), perhaps because their own climate footprint is insignificant when compared to the world's largest CO_2 emitting countries. What is more, they are among the countries that pay the highest price in terms of loss and damage from climate change (Halstead, 2016; Thomas and Benjamin, 2018). However, in our study, forests were predominantly used as a mitigation-oriented strategy, although their combined absolute forest area is small, which limits their potential contribution to the global CO_2 balance (Saatchi et al., 2011; Wilkie et al., 2004). Forest-based climate solutions may simply be among the most achievable mitigation solutions for these countries as many of them are rich in forests.

Biodiversity is a neglected topic in the NDCs, and rarely seen as a priority. This pattern is not surprising since the role of biodiversity for climate change mitigation is even less prominent than for adaptation (Hisano et al., 2018; Seddon et al., 2019). The three countries prioritising biodiversity in their adaptation action did not distinguish between biodiversity as a conservation target and biodiversity as a contributor to adaptation.

Recognising that biodiversity can be part of the solution for both climate change mitigation and adaptation, and that further loss could indeed aggravate the climate crisis, would be crucial for promoting synergies between forest-based climate solutions and biodiversity conservation measures (Mori, 2020). Moreover, it is striking that we could not find any references regarding the high level of endemism in most AOSIS countries despite the global importance of conserving this endemism (Kier et al., 2009; Wilkie et al., 2004). Climate change will affect terrestrial endemic species 10 times more than terrestrial introduced species in terms of abundance, diversity, spatial distribution, habitat change, and physiology. In addition, climate change puts endemics from islands at a much greater extinction risk than those from mainland regions (Manes et al., 2021).

4.2. Country-level variation in forest-based climate solutions and biodiversity conservation measures

Nearly two-thirds of AOSIS members proposed forest-based climate solutions in their NDCs, which is broadly in line with global analyses. For instance, 77% of all NDCs include forest landscape restoration within their NDCs (IUCN, 2017) and two-thirds of signatories to the Paris Agreement propose NBS that include forests (Seddon et al., 2020b). Furthermore, an emphasis on forest (re-)growth and forest protection among NBS appears to be common in NDCs (IUCN, 2017; Laurans et al., 2016; Seddon et al., 2020c), which supports our findings. However, there is substantial variation among countries in their specific approach.

Interestingly, not all AOSIS members that mention forests as a priority for combating climate change also proposed forest-based climate solutions. In other words, prioritisation does not always translate into action. This raises the question if some countries are in favour of forest-based climate solutions but face constraints that prevent them from stating concrete commitments. In our analyses, the larger countries Timor-Leste, Guinea-Bissau, Suriname, Guyana, and Papua New Guinea were among those nations proposing the highest numbers of forest-based climate solutions. Analytical and financial capabilities may be key here (Griscom et al., 2020; Röser et al., 2020). In fact, many AOSIS countries make their targets conditional on external support (Rossi and Miola, 2017), which may not be equally accessible to all members. Allocation of international funds can be highly unbalanced, and often related to population size and low GDP, rather than need (Robinson and Dornan, 2017).

As high forest cover and low deforestation (HFLD) developing countries, Suriname and Guyana may generally be highly motivated to present a wide range of forest-based climate solutions in their NDCs. They explicitly referred to their HFLD status in their NDCs, with Suriname saying that it intends to sustain its 93% forest cover. The international community has increasingly recognised the importance of HFLD nations for the delivery of forest-based climate solutions. This is a process partially driven by the Krutu Declaration in 2019, which aims to support cooperation among HFLD nations and mobilise international climate finance for their needs. Other, smaller AOSIS members, namely the Bahamas, São Tomé and Príncipe, the Seychelles, and Samoa, also support the declaration but the lack of international finance might explain their comparatively low to non-existing range of suggested forest-based climate solutions. Contrastingly, a few AOSIS countries hardly have any forest area, such as Nauru or the Maldives, and therefore may refrain from setting forest-based targets.

Those AOSIS members that did propose biodiversity conservation measures in their NDCs only presented vague targets, mirroring insufficient links between NDCs and the Aichi biodiversity targets in 100 countries, and perhaps related to the lack of encouragement within the NDC process to include biodiversity-related measures (Watts et al., 2018). Furthermore, the connection of biodiversity conservation measures to climate change action was not always straightforward. This was exemplified by the Government of Comoros. They planned to step up their efforts for biodiversity conservation by expanding protected areas. This intention was described as a mitigation action but how it exactly contributed to reducing CO_2 emissions was not explained.

4.3. Co-benefits, synergies, and governance of forest-based climate solutions and biodiversity conservation measures

Ensuring that there are co-benefits and synergies between forest-based climate solutions and biodiversity conservation is a relatively new concept (Gardner et al., 2020; Mori, 2020). This is despite the fact that NBS, including forest-derived ones, predominantly have positive effects on biodiversity (Chausson et al., 2020). Indeed, here we show that the few AOSIS members referring to biodiversity conservation measures typically did not indicate whether forests play a central role for their successful implementation. The Government of Suriname, (2019) did acknowledge that their “primary old-growth tropical forests are of global importance, not only in terms of forest carbon, but also because of the interconnectedness of biodiversity, forest conservation and climate change" (p. 11).

If the opportunities presented by natural climate solutions through forests can also be of benefit to biodiversity conservation, then it is important to begin to understand what mechanisms might enable this to happen most rapidly. Given that forest protection and forest (re-)growth were most frequently mentioned in AOSIS members' NDCs, these mechanisms could be one way forward. If this is to be the case, NDCs should stress the importance of forest protection for biodiversity conservation, such as through protected areas, and provide quantitative targets. Native tropical forests host large numbers of rare and threatened species that are at the risk of being lost irreversibly. Special attention should hence be given to the preservation of these ecosystems (Barber et al., 2020). Another asset is that intact old-growth forests are generally more resilient to environmental change than human-modified ecosystems (Thompson et al., 2009), as well as offering carbon storage levels above those of other forest types (Watson et al., 2018).

Forest (re-)growth can be beneficial for biodiversity conservation if implemented appropriately, such as by avoiding monoculture plantations of non-native species (Seddon et al., 2019), or by connecting remaining habitat patches (Newmark et al., 2017; Pawson et al., 2013). A mix of species, including native and climate-resilient species, should be the preferred option for plantations to ensure long-term climate change mitigation and adaptation as well as biodiversity protection (Mori, 2020; Seddon et al., 2020c, 2019). If forests are cultivated, they should be managed sustainably and degradation as well as deforestation should be avoided as much as possible to preserve biodiversity. In particular, retention forestry is a useful practice in this regard, where key elements of the stand structure, such as dead wood or old trees, are kept in the harvesting process (Lindenmayer et al., 2012; Mori and Kitagawa, 2014). Compared to reforestation, forest restoration and rehabilitation are terms that are more inclusive of biodiversity conservation. Their usage in NDCs should thus be encouraged.

Another important aspect is forest and biodiversity governance, upon which any decision-making on a management level depends. For instance, our analyses indicates that biodiversity-related instruments such as the CBD or Aichi targets are currently not routinely noted in the NDCs, something that should change if the opportunities to exploit synergies between the international treaties are to be maximised. Governments must commit to more integrative approaches in their NDCs to link biodiversity governance and climate-oriented forest governance better. In theory, REDD+ policies provide opportunities for co-benefits as the so-called Cancun safeguards take biodiversity into account (Bodin et al., 2015) but the more relevant synergies are not actively sought. These policies must also be designed to avoid leakage that leads to biodiversity loss elsewhere (de Lima et al., 2013). In addition, REDD+ primarily focusses on climate change mitigation and not adaptation. Additional options would be to mention inclusive approaches for biodiversity conservation measures and forest-based climate solutions existing within forestry acts or policies, National Adaptation Programmes of Action (NAPAs), or National Biodiversity Strategies and Action Plans (NBSAPs) for instance.

It must also not be forgotten that the uptake of forest- and biodiversity-based approaches may negatively affect local people. Some states mentioned livelihood strategies when relating to sustainable forest management or REDD+, e.g.: "Guyana is prepared to continue to sustainably manage, conserve, and protect [its forest carbon stocks] for the benefit of ourselves and all humanity. In return, we must obtain benefits to improve the wellbeing and quality of life of Guyanese" (Government of Guyana, 2016, p. 3). It seems, however, that most AOSIS countries revealed a substantial backlog with regard to combining mitigation and livelihood strategies in the context of forests. More references were found for forest-based adaptation enabling a climate resilient development. "Maintain and restore healthy forest ecosystems by sustainable forest management, increasing afforestation and reforestation in order to increase the resilience of human communities" is what the (Government of Belize, 2016, p. 13) claimed as an adaptation priority goal, for example. Often it remained unclear, however, how forests shall be used in particular to achieve human resilience.

Although NDC commitments of AOSIS countries may have a limited influence on mitigation on a global scale, they are still crucial for adaptation in these countries. At the same time, AOSIS countries are disproportionately important for biodiversity conservation, compared to other UNFCCC parties. AOSIS members could therefore deliberately use their NDCs as an opportunity to protect their unique and threatened biodiversity by aiming for synergistic effects. In contrast, if forests are intended for mitigation purposes only, as was the case in most NDCs, approaches that are harmful for biodiversity, such as monocultures, may be supported. Further attention thus needs to be drawn to the endemic biodiversity of island states in climate negotiations. International financial support will be needed to realise synergies between biodiversity and climate protection.

5. Conclusions

Here we examine the extent to which biodiversity conservation is integrated into NDCs, using the example of AOSIS members. Although NDCs predominantly show what countries intend to do and not what they actually do, these documents allow us to draw relevant conclusions. Thus far, NDCs are a missed opportunity for tackling the inseparable climate and biodiversity dilemmas together. Especially in AOSIS countries, where biodiversity loss and climate change are severe issues, more inclusive approaches are necessary. Although it may seem an initial burden, exploring co-benefits and synergies, in particular between biodiversity conservation and forest-based adaptation, is highly relevant for the sustainable future of these and many other states. Creating climate-resilient ecosystems goes hand in hand with biodiversity protection and, in addition, ensures carbon sequestration in the long term (Osuri et al., 2020). Key to combating climate change is promoting diversity at all ecological scales and connectivity between ecosystems so that forests can resist to or recover from environmental change (Oliver et al., 2015; Pawson et al., 2013). More awareness of the essential role that biodiversity plays both for climate change adaptation and mitigation needs to be raised. As such, its protection and enhancement can be regarded as the foundation of forest-based climate solutions.

Using forest-based climate solutions as a vehicle, clear and meaningful targets must be set to achieve co-benefits and synergies with biodiversity conservation measures. This not only allows progress with individual NDCs to be quantified, but also allows comparisons to be made between countries, so that best practice and lessons learnt can be shared. In line with the finalisation of the Paris Rulebook, changes in the structure of NDCs are underway. As a result of the Covid-19 pandemic, some countries still need to submit their updated or second NDCs. However, the next round of NDCs was originally due before the COP 26, which has been postponed by one year, taken place in November 2021 instead. Overall, this delay may have provided a window of opportunity to rethink the climate-biodiversity gap within NDCs and beyond.

Authorship contribution statement

Lena Strauß: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization. Timothy R. Baker: Conceptualization, Methodology, Writing – review & editing, Supervision. Ricardo F. de Lima: Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition. Stavros Afionis: Conceptualization, Methodology, Writing – review & editing. Martin Dallimer: Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2021.11.019.

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