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RECEIVED 16 September 2025

REVISED 24 November 2025

ACCEPTED 04 December 2025

PUBLISHED 07 January 2026

CITATION

Brown Z, Kendall K, O'Donnell E, Tavasi L and Seddon N (2026) Nature-based solutions for climate adaptation in small island developing states: a systematic review. *Front. Environ. Sci.* 13:1706713. doi: 10.3389/fenvs.2025.1706713

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Nature-based solutions for climate adaptation in small island developing states: a systematic review

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Introduction: Small Island Developing States (SIDS) are disproportionately affected by climate change, with impacts threatening their communities, ecosystems, and economies. Nature-based solutions (NbS) offer a promising approach to address these challenges, yet their effectiveness in SIDS remains poorly understood.

Methods: We systematically reviewed 49 studies reporting 53 NbS interventions across 26 SIDS, coding intervention types, ecosystems, climate hazards, adaptation effectiveness, broader outcomes (social, ecological, economic, mitigation), and reported socio-ecological resilience mechanisms.

Results: Nearly three-quarters of cases reported positive climate outcomes, though only half provided clear evidence, and fewer employed baselines, counterfactuals, or thresholds. Evidence was skewed toward croplands and agroforestry, while coastal ecosystems were underrepresented. Broader outcomes were mostly positive, but reporting on ecological and social resilience mechanisms was limited, equity considerations were largely absent, and formal economic appraisals and direct comparisons with non-NbS alternatives were scarce. Large geographic gaps were also evident, with more than half of SIDS unrepresented in the literature.

Discussion: Overall, the evidence indicates that NbS can reduce climate risks in SIDS and deliver 'triple wins' for climate, biodiversity, and people, but decision confidence is constrained by uneven geographic coverage, agricultural bias, lack of counterfactuals and baselines, limited equity reporting, and scarce economic appraisal. Future research priorities include: (1) stronger representation of understudied SIDS contexts, (2) greater focus on coastal and ocean-related NbS, (3) evidence linked to baselines and counterfactuals, (4) holistic, long-term monitoring and evaluation, (5) national- and regional-scale synthesis of grey literature, and (6) integration of equity and knowledge pluralism in NbS design and evaluation. These steps would help governments design, finance, and account for high-integrity NbS in NDCs, NAPs, adaptation investment plans, and disaster-risk strategies.

Systematic Review Registration: <https://osf.io/wcb68>, identifier wcb68.

KEYWORDS

small island developing states, nature-based solutions, climate change, climate adaptation, ecosystem-based adaptation, resilience, socio-ecological systems

1 Introduction

Anthropogenic climate change presents a global challenge with profound social, ecological, and economic consequences. The year 2024 was the warmest on record and the first to exceed 1.5 °C above pre-industrial levels—a threshold considered critical for preventing the most severe impacts of climate change (World Meteorological Organization, 2025). Warming is expected to continue, with widespread impacts including sea level rise, increased frequency and intensity of extreme weather events, displacement, increased health risks, and biodiversity loss. The economic costs are also substantial, with climate-related damages projected to reach US\$ 54 trillion under a 1.5 °C warming scenario and US\$ 69 trillion under a 2 °C scenario, by 2100 (Eckstein et al., 2019). Consequently, governments, organizations, and communities are developing climate adaptation strategies in response to escalating climate risks (Robinson, 2017). Estimated spending on climate adaptation is projected to increase two-to threefold by 2030 and potentially four-to fivefold by 2050 (Eckstein et al., 2019). This growing focus on adaptation is also reflected in the academic literature, with climate change adaptation publications increasing at an annual average rate of 28.5% (Nalau and Verrall, 2021).

While adapting to climate change is an issue of global concern, climate impacts are disproportionately and unjustly altering the fate of Small Island Developing States (SIDS) around the world. SIDS are a distinct collection of 57 nations characterized by their limited land availability, geographic isolation, vulnerability to natural disasters, deep integration into global markets, and a strong reliance on and proximity to coastal and marine resources (Connell et al., 2020; Baptiste et al., 2020). Due to these characteristics, SIDS are often described as the ‘canaries in the coal mine’ for climate change and are particularly vulnerable to ocean- and cryosphere-related hazards, including sea-level rise, extreme weather events, marine heatwaves, ocean acidification, and climate-driven disruptions to supply chains (Baptiste et al., 2020). The intensity of these hazards is predicted to increase over time and the consequences have already become apparent in SIDS globally.

It is important to acknowledge that the umbrella term SIDS risks oversimplifying the diversity of contexts and capacities across these nations, which are heterogeneous in their ecological, political, cultural, and economic environments (Robinson, 2020). These factors shape both the extent to which climate change impacts are felt and the types of adaptation strategies that are feasible or effective. For instance, geographic differences mean that low-lying atolls and coral islands such as Tuvalu and The Bahamas face greater exposure to sea-level rise than higher-elevation islands like Fiji, or Dominica. Perceptions of climate impacts and adaptive capacity are also shaped by socio-cultural factors; the qualities that render a place habitable are grounded in culturally and historically specific understandings, local knowledge, and emotional and spiritual connections to place (Enari and Viliamu Jameson, 2021; Farbotko and Campbell, 2022). Economic and financial resources also vary widely across islands, further affecting countries’ vulnerability to climate impacts and ability to implement adaptation measures. Nevertheless, this paper employs the collective term SIDS to draw together knowledge from contexts that, while diverse, share many climate-related challenges. SIDS as a group continue to experience some of the most severe climate

impacts globally; Evidence shows that SIDS experience higher levels of climate change–attributed losses and damages than non-SIDS countries across income levels. This includes around five times more climate-related deaths from extreme weather and average annual losses equivalent to roughly 0.8% of their collective GDP (Panwar et al., 2025). It is therefore critical for these nations to develop and implement effective, context-appropriate adaptation strategies, and to strengthen knowledge sharing across regions where solutions may hold broader relevance despite local differences.

Klöß and Nunn’s (2019) systematic review of adaptation trends in SIDS found that only 55% of SIDS have peer-reviewed research on adaptation, with most studies concentrated in Pacific Island nations, with central and more populated islands receiving more focus compared to rural and outer islands. Although adaptation efforts are likely occurring across all SIDS, uneven reporting obscures where these efforts are concentrated, and which strategies are most effective. Engineering solutions such as sea wall construction are among the most commonly reported adaptation strategies in SIDS (Klöß and Nunn, 2019). However, these measures have often proven ineffective or even maladaptive, failing to provide long-term resilience against climate risks (Klöß et al., 2022; Piggott-McKellar et al., 2020). Furthermore, Robinson’s (2017) review of National Communications submitted to the UNFCCC found that climate impact observation and assessment were the most frequently reported adaptation actions, rather than direct interventions that address climate threats. While such efforts lay essential groundwork for promoting understanding of climate change and adaptation, they do not necessarily enhance the adaptive capacity of systems, institutions, or communities to cope with its impacts (Robinson, 2017).

Although both peer-reviewed adaptation literature and NCs of SIDS mention ecosystem-based or nature-based adaptation strategies, implementation of these approaches remains limited. Conservation and restoration actions constituted only 4.9% of all climate adaptation actions reported in SIDS NCs (Robinson, 2017). However, a review of peer-reviewed literature in the Western Indian Ocean region found that nature-based interventions accounted for 27% of adaptation actions, reflecting some variation across regions (Poti et al., 2022). This highlights the need for a deeper investigation into the nature-based adaptation strategies being implemented and their effectiveness in addressing climate adaptation challenges, to better scale and optimize these solutions across SIDS.

Nature-based Solutions (NbS) are defined as “actions aimed at protecting, conserving, restoring, and sustainably managing natural or modified terrestrial, freshwater, coastal, and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human wellbeing, ecosystem services, resilience and biodiversity benefits” (UNEA, 2022). This framing highlights how, when implemented effectively, NbS are uniquely positioned to provide a ‘triple win’ for climate, biodiversity, and people (Key et al., 2022). This umbrella term of NbS covers a broad range of actions from increasing biodiversity on farms to improve food and livelihood security (Clough et al., 2011), installing green-roofs and green walls in urban areas to regulate temperatures reduce surface water run-off (He et al., 2023), and restoring vegetation on slopes to reduce erosion risk (Vicarelli et al., 2021). Concepts such as Ecosystem-

based adaptation (EbA) and Ecosystem-based Disaster Risk Reduction (Eco-DRR), also fall under the NbS umbrella.

NbS can support climate adaptation by reducing people's exposure and sensitivity to climate hazards, as well as through building adaptive capacity (Seddon et al., 2020; Smith et al., 2021). Furthermore, evidence suggests that over time, NbS benefits typically outweigh the costs required to implement and maintain them, and NbS are often more cost-effective than conventional grey infrastructure alternatives (Reddy et al., 2024; Vicarelli et al., 2024). NbS are dynamic and able to adapt to changes in the environment in ways that grey infrastructure alone cannot (FIDIC and AECOM, 2023). For example, some mangrove forests have demonstrated an ability to keep pace with rising sea levels (Krauss et al., 2014). Given the limited resources of SIDS, NbS hold potential as an affordable strategy to reduce climate risk in these regions, especially those related to coastal threats and food insecurity. Furthermore, the strong dependence of SIDS' livelihoods and economies on their natural environments highlights the potential of NbS to bridge conservation and development priorities in these regions.

In prioritizing both human wellbeing and biodiversity through place-based interventions, NbS are inherently grounded in the concept of socio-ecological systems (SES) (Hilmi et al., 2025; Turner et al., 2022). SES frameworks understand ecosystems and human societies as fundamentally interconnected, characterised by feedback loops and mutual dependence (Sterk et al., 2017). Building SES resilience is central to successful climate adaptation in SIDS, as it relates to a system's ability to sustain key functions amid disturbances (in this context, climate-related disturbances), by buffering shocks and adapting or transforming in response to change (Sterk et al., 2017; Talubo et al., 2022). Numerous factors influence SES resilience, ranging from access to education and livelihood diversity to ecological factors like genetic diversity and connectivity. Understanding how NbS influence these resilience-building factors are key to ensuring the long-term adaptation success of NbS, though few studies explore this in depth (Turner et al., 2022). For the rest of this paper, these resilience-building factors will be referred to as *resilience 'mechanisms'*, following Turner et al. (2022).

1.1 Knowledge gaps

In recent years, there has been increasing support for nature-based solutions to address mitigation and adaptation and a building pool of evidence demonstrating positive outcomes for both nature and people (Debele et al., 2023; Seddon, 2022; Seddon et al., 2020). However, uncertainty remains around their long-term resilience and reliability (Hafferty et al., 2025). For example, NbS often require longer implementation times and are considered to be more effective for addressing frequent, low-intensity climate events rather than severe, urgent threats (Seddon et al., 2020). Identifying and defining these limits, as well as barriers to their implementation, and the extent to which NbS can contribute to resilience, can enhance adaptation strategies and prevent maladaptation (Filho et al., 2021).

Chausson et al. (2020) have also found that the majority of NbS research for climate adaptation has occurred in high income

countries. Even greater, there is limited research into how NbS can sustain the habitability of small islands, particularly atolls, and limited evidence of implementation in these contexts (Barnett et al., 2022). Only 10 peer-reviewed studies from SIDS were identified in a global review of NbS for climate adaptation (Chausson et al., 2020). Given the reality of climate change impacts, there is an urgent need to understand the effectiveness of different climate adaptation strategies in SIDS. Knowing "what works, in which contexts and why" is not only of critical importance to the estimated 65 million people living in SIDS, but also to the unique ecosystems of tropical islands, which could be damaged irreversibly without timely intervention (Baptiste et al., 2020; Bours et al., 2013). Identifying which climate threats and adaptation actions are being prioritized is crucial for adaptation planning and directing funds and research efforts toward islands, regions, and climate hazards that are underrepresented.

These knowledge gaps are particularly important as SIDS are increasingly incorporating NbS (and related concepts) into their National Adaptation Plans (NAPs), Nationally Determined Contributions (NDCs), and National Biodiversity Strategy and Action Plans (NBSAPs) (Wingfield et al., 2025). For instance, a 2024 review of NAPs found that seven of 12 SIDS in the sample explicitly identified ecosystem-based or environmentally sustainable approaches as guiding principles (Terton et al., 2024). Yet, how this recognition of NbS will be translated into practice and policy remains uncertain. Wingfield et al., 2025 point out that although national strategies often reference ecosystems or nature-based approaches, they rarely make explicit use of NbS terminology, and they typically lack concrete details such as implementation strategies or measurable targets. Another challenge is that national-level plans like NAPs and NDCs are often poorly communicated or understood at sub-national scales. To ensure that nationally defined NbS priorities in SIDS are effectively implemented, there is an urgent need for decisions to be grounded in scientific evidence, which this review aims to provide.

While there have been systematic reviews of climate adaptation in SIDS (Klöck and Nunn, 2019; Poti et al., 2022), to our knowledge there are currently no published systematic reviews investigating the implementation of NbS in SIDS and their effectiveness for climate adaptation and building resilience.

1.2 Aims of research

This study seeks to critically evaluate the current state of NbS implementation for climate adaptation in SIDS, identifying patterns and knowledge gaps in understanding NbS effectiveness. By systematically reviewing literature indexed in academic databases, we specifically aim to understand and assess 1) the current landscape of NbS implementation for human climate adaptation in SIDS; 2) the effectiveness of NbS to reduce the impact of climate hazards in SIDS; 3) the impact of NbS on broader social, ecological, and economic outcomes; and 4) the mechanisms through which NbS contribute to building social-ecological climate resilience. Our results and discussion sections are structured around these key research aims.

It is important to acknowledge that our review provides insight into adaptation trends documented in academic databases, the

majority of which are derived from peer-reviewed scientific journals. It is therefore not a comprehensive account of all adaptation trends in SIDS.

2 Methods

2.1 Systematic review protocol

To ensure transparency and rigour in our review process, we drew on systematic review guidelines developed specifically for environmental research (ROSES and CEE) to formulate our review protocol (Haddaway et al., 2018; Pullin et al., 2022).

We modified the search string developed by Chausson et al. (2020) in their global mapping of nature-based solutions for climate adaptation. The string was adapted to fit the geographical context of Small Island Developing States. This included both the 39 UN Member States and the 18 Non-UN Members/Associate Members, across all three SIDS geographical regions. The names of nations with double islands were separated out in search string in the case of studies which only occurred on one island (e.g., São Tomé and Príncipe were written as “São Tomé” OR “Príncipe”). Additionally, island names prefaced by ‘Saint’ were searched as both St. And Saint (e.g., “St. Lucia” OR “Saint Lucia”). Following Smith et al. (2021)’s review of NbS for climate adaptation in Bangladesh, Chausson et al.’s search string was also expanded to include urban NbS, hybrid ‘green-grey’ NbS, agriculture, fisheries and aquaculture interventions. This alteration was important given the relevance of food security, fisheries, and hybrid coastal protection mechanisms, to the context of SIDS (Baptiste et al., 2020).

Following a librarian consultation, we were advised to exclude outcomes from our review search to avoid overlooking relevant studies that report on different, but equally important, outcomes or do not report the outcomes in the abstract if they are non-significant (Tsujimoto et al., 2022). Doing so increased the outputs of our search to a much larger, but manageable pool of retrieved studies.

2.2 Search

We ran our search string in Scopus, Web of Science (Core Collection), and CAB Abstracts on 17 July 2024. The search was restricted to title content, abstract content, author keyword. No date limits were applied to any of these searches. While we recognize that many reports of NbS projects occurring in SIDS may exist exclusively in grey literature, and that grey literature can also

offer deeper insights into the planning and execution of nature-based projects at the local level (Doswald et al., 2014), grey literature was excluded from this study due to time and resource constraints.

Given the linguistic limitations of the review team, our searches were limited to the English language. While expanding the search to include other languages would make the review more comprehensive, particularly in effectively evaluating the spatial distribution of adaptation interventions, 74.4% (29/39) of UN SIDS and of 72.2% (13/18) of non-sovereign associate member states have English as one of their national languages. Therefore, we expect our review to encompass the majority of available research material, despite language restrictions. However, further research should look to expand this review to include the >30 different languages spoken across all SIDS.

2.3 Screening process

We imported the resulting citations into the systematic review software, Covidence, where the entire screening process was conducted. After removing duplicates, we screened the studies by title and abstract, then full text, to filter out papers that did not meet the inclusion and exclusion criteria (Table 1).

Studies were included if interventions met the IUCN definition of Nature-based solutions and assessed factors that directly or indirectly influence people’s risk to climate change through the implementation of the intervention. Studies that reported climate adaptation outcomes, but did not provide evidence to support those outcomes were also included. The degree of evidence provided was noted for each study. Studies were excluded if they focused on climate mitigation but not adaptation, or were hybrid infrastructure or integrated management projects where the NbS component was not explicitly clear or separated. The selection criteria were iteratively refined throughout the screening process to improve decision-making consistency (Supplementary Material). Reviews were generally not included, unless they also included primary data collection in addition to the review.

A random subset of the papers (10%) was blind screened by secondary reviewers (KK, EO, LT) to minimize the risk of human error (Pullin et al., 2022). While having second reviewers appraise all papers would reduce nearly all risk of bias, this was not within the capacity of team’s time and resource constraints. However, having a subset of studies screened by a secondary reviewer still falls within good practice guidelines (Collaboration for Environmental Evidence, 2022). In cases where the primary and secondary reviewers disagreed, the primary reviewer conducted a second

TABLE 1 Summary of the criteria used to define eligible studies for the systematic review.

Population	Intervention	Comparators	Outcomes
People, social groups, communities, and/or their livelihoods and economic sectors. Ecosystems, if explicitly linked to human societies through ecosystem services.	Interventions implemented in Small Island developing States that involve managing, restoring, or protecting biodiversity, ecosystems, or ecosystem services, or interventions involving the creation or management of artificial ecosystems,	Pre-intervention baselines, repeat measurements over time, control sites/groups without adaptation actions, modeled counterfactuals, evaluator inference of a counterfactual, reported changes attributed to NbS, even without a clear comparator	Measured, observed, or reported outcomes assessing factors that directly or indirectly* influence human risk (vulnerability, exposure, adaptive capacity) to climate change that have been impacted by the implementation of the intervention.

*This encompasses both direct outcomes of reducing climate hazards (such as erosion of beaches or soil, damage from wind, flooding, wildfires, and temperature changes) and indirect effects on areas like crop production, fisheries, water resources, livelihoods, risk exposure, and community vulnerability.

review of the papers to reach a final decision (Supplementary Material).

2.4 Coding strategy

For each included study, we documented essential bibliographic information and details of the NbS intervention, including geographic region, governance type, intervention type, and ecosystem type. Studies investigating the same NbS intervention or utilizing the same primary data were regarded as duplicates. The duplicate offering the most robust evidence was included and coded. For papers that included multiple interventions, we coded each intervention separately.

We recorded the outcomes and effectiveness of each intervention to reduce the impact of climate hazards, as well as broader climate mitigation, social, ecological, or economic outcomes reported. We also recorded the mechanisms through which the intervention builds socio-ecological resilience, using Turner et al.'s (2022) typology of social-ecological resilience mechanisms that may be influenced by nature-based solutions (NbS) (Table 2). All coding was conducted in Covidence systematic review software. The details of our coding framework can be found in the Supplementary Material).

2.5 Data analysis and synthesis

We used descriptive statistics to map the interventions based on SIDS geographic region, ecosystem type, NbS type, intervention type, and the climate hazards addressed. We assessed the reported effectiveness of NbS interventions in addressing the impacts of climate hazards, as well as the extent to which broader climate mitigation, social, ecological, and economic outcomes were reported. We also reported on the social and ecological mechanisms through which the NbS built climate resilience.

3 Results

Our search yielded 11,034 studies. After removing duplicates and screening for relevance, 49 studies representing 53 distinct

interventions remained for analysis (Supplementary Material). Only a small proportion of retrieved papers presented empirical evidence of real-world NbS implementation. Many focused instead on conceptual or theoretical discussions or were implemented in non-SIDS locations that appeared due to place name overlaps (e.g., "Jamaica Bay," United States).

3.1 The current landscape of NbS implementation for human climate adaptation in SIDS

3.1.1 Data quality

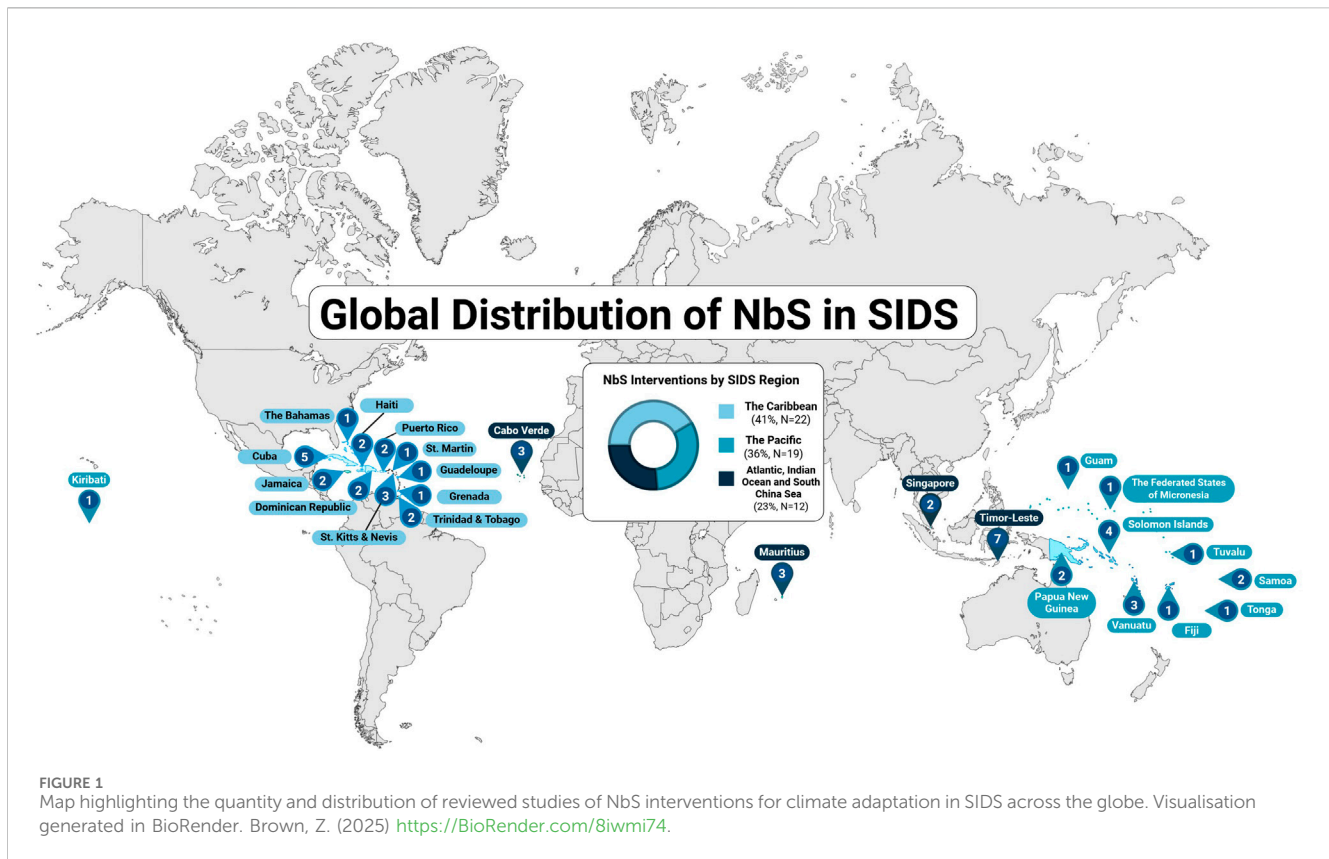
Of the 53 interventions reviewed, 75% (40) were original studies, collecting and analyzing primary data. An additional 11% (6) combined secondary data with primary research. 9% (5) relied solely on secondary data, while 4% (2) had unclear information regarding their originality, making it difficult to classify them definitively. 47% (25) relied on qualitative data and 32% (17) used quantitative data. The remaining 21% (11) employed mixed methods.

Two-thirds (35) of interventions provided some of evidence for the effectiveness of NbS in delivering climate adaptation outcomes, though, the quality of evidence varied: 53% (28) presented clear evidence, 13% (7) poor-quality evidence and 34% (18) did not provide any evidence. Furthermore, less than half (26) compared their outcomes to a baseline, counterfactual, or threshold.

Of those 26 studies, 12 (46%) used counterfactuals; These were predominantly (67%) experimental agricultural studies testing different treatments (e.g., mulching, hedgerows, organic fertilizer) against control plots. The remaining 33% were non-experimental, comparing intervention and non-intervention area. For example, Noltze et al., 2013 compared rice farms in Timor Leste adopting natural resource management technologies to non-adopting farms. Ten studies (38%) benchmarked outcomes against pre-intervention baselines, assessing how the NbS influenced indicators (such as yields, income levels, carbon storage, etc.) over time, and three (12%) used both counterfactual and baseline approaches. One study employed a mix of baseline and threshold comparisons, assessing water quality changes relative to wastewater discharge standards (Pérez et al., 2024).

TABLE 2 Adapted typology of resilience mechanisms potentially influenced by nature-based solutions (NbS), across social and ecological dimensions of socio-ecological systems (SES). Adapted from Turner et al. (2022).

Social mechanisms	Ecological mechanisms
Diversity: livelihoods, actors, knowledge and experience	Individual-level: Genetic diversity, phenotypic plasticity, sensitivity to environmental change
Social capital: Knowledge exchange, bonding/bridging capital, attachment to place	Community/ecosystem-level: Species diversity, response diversity, functional diversity, heterogeneity, keystone species or functional groups, dominant species, strength of species interactions, habitat area, control of local threats, availability of resources, intact habitat structure
Learning potential: access to information and education	
Access to assets: financial, technical	Landscape-level: network structure, heterogeneity, ecological learning and memory
Agency: empowerment, rights/ownership, social acceptance	
Equity: distributional, recognitional	



3.1.2 Geographic region

Evidence spanned 26 island nations (Figure 1), most frequently Timor-Leste (7 studies), Cuba (5), and the Solomon Islands (4). Several other countries, including St. Kitts and Nevis, Cabo Verde, Mauritius, and Vanuatu, had three studies each; the remaining nations had two or fewer. Most interventions occurred in the Caribbean (22), followed by the Pacific (19) and the Atlantic, Indian Ocean, and South China Sea (AIOOSCS) region (12).

Nearly half (45%) of studies were authored solely by Global North institutions, 31% involved collaboration between SIDS and non-SIDS countries, and only 24% were exclusively SIDS-led. Among Global North-led and collaborative studies, approximately 37% were conducted by administering or historically linked powers (e.g., U.S.-led research in Puerto Rico and French-led work in Mauritius and Guadeloupe).

3.1.3 Governance type

Governance structures were diverse, with national governments or agencies involved in 34% of projects, community-driven initiatives in 30%, and international development organizations and research institutions in 26% each. International governments (13%), environmental organizations (11%), and local NGOs (11%) participated less frequently. Local and national development organizations or government agencies featured in 4% of projects, and private sector engagement was rare (2%). Governance was often multi-scalar, involving multiple governance drivers.

Community and stakeholder participation characterized most interventions: 70% (37) demonstrated active involvement in decision-making or implementation, 4% were passive (informing

but not engaging communities), 21% unclear, and 6% reported none. However, only 26% of interventions explicitly targeted poor or disadvantaged communities.

3.1.4 Temporal and spatial scale

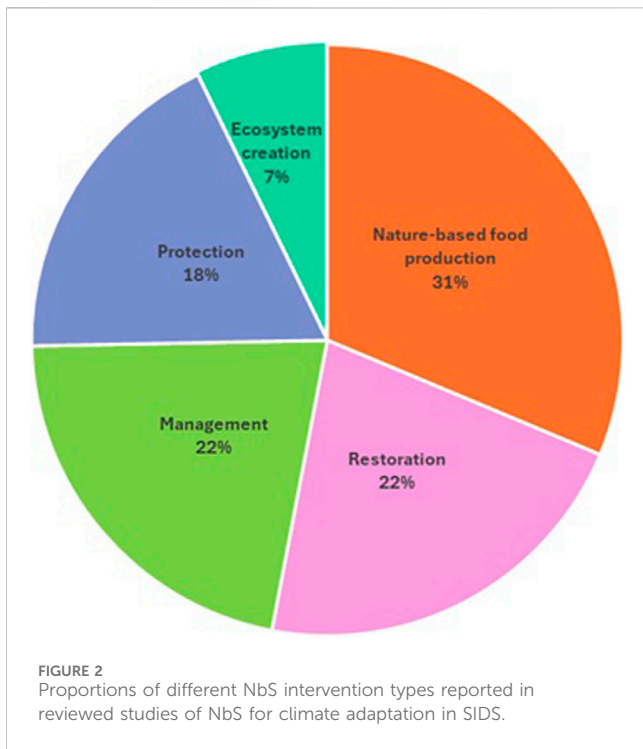
Timescales were reported in 70% (37) of interventions, ranging from 12 weeks to 28 years (mean 5.4 years). Spatial scale was reported in 62%, though units varied (e.g., “across 73 villages,” “93 management areas”). Where standardized metrics were available, intervention areas ranged from 0.7 to over 600 hectares. Less than half (43%) operated at a landscape or seascape scale.

3.1.5 NbS intervention type

NbS interventions were categorized into five main types (Figure 2). Nature-based food production was the most frequently implemented NbS (31%), followed by restoration (22%), management (22%), protection (18%), and ecosystem creation (7%). Just under half (43%) of the interventions involved multiple NbS types (e.g., management and nature-based food production).

3.1.6 Ecosystem type

Interventions were implemented across a diverse range of ecosystems (Figure 3). Croplands were targeted in 33% (17) of interventions, followed by agroforestry (27%), tropical oceans (22%), tropical or subtropical forests (20%), and coral reefs (16%). Pastures and created forests each appeared in 10% of cases. Mangroves and streams or rivers each featured in 8%,



while coastal ecosystems and created wetlands were represented in 6%. Aquaculture, oyster reefs, inland wetlands and created grasslands were the least common, each recorded once.

Different NbS intervention types tended to be implemented in particular ecosystems (Figure 4). Nature-based food production was typically applied in cropland (38%) and agroforestry (33%) contexts. Protection and management focused on oceans (both 25%) and

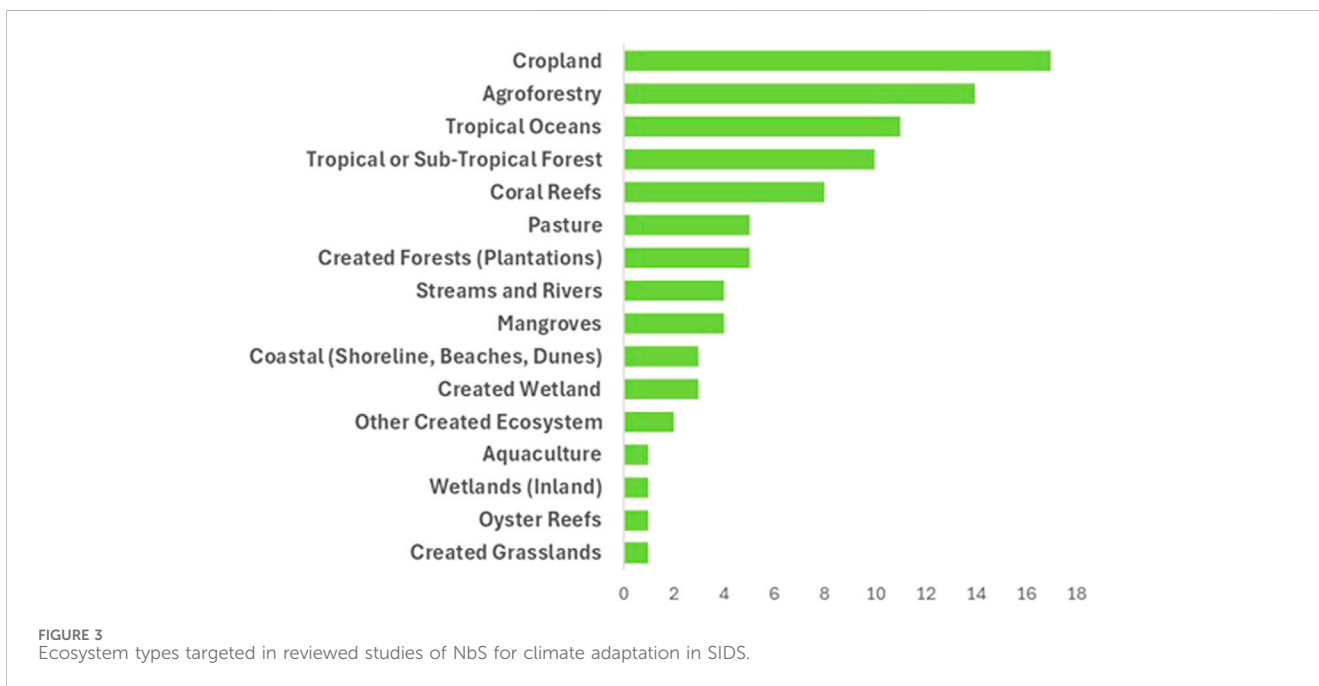
coral reefs (12%). Restoration centered on tropical forests (22%), agroforestry (19%), and mangroves (13%), while ecosystem creation targeted streams, rivers, and wetlands (each 13%).

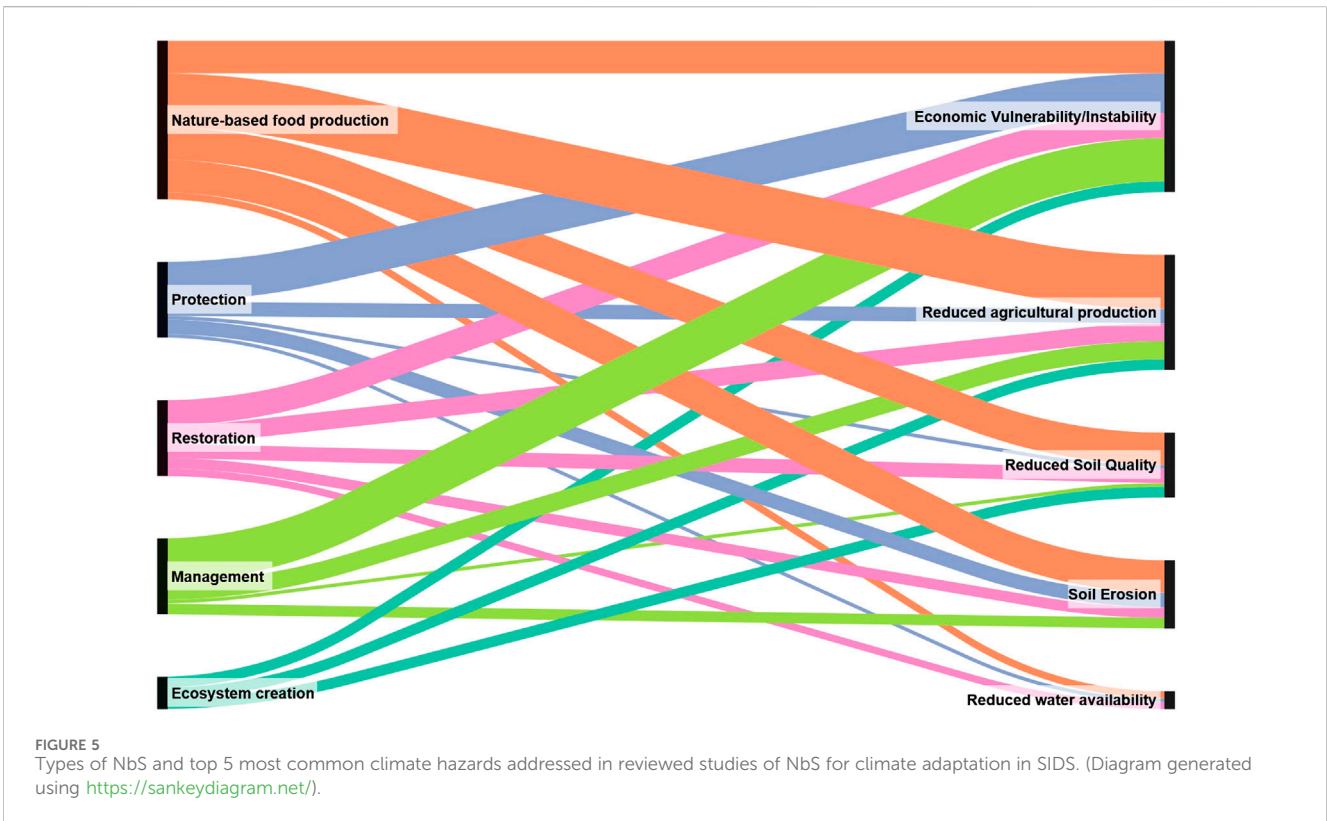
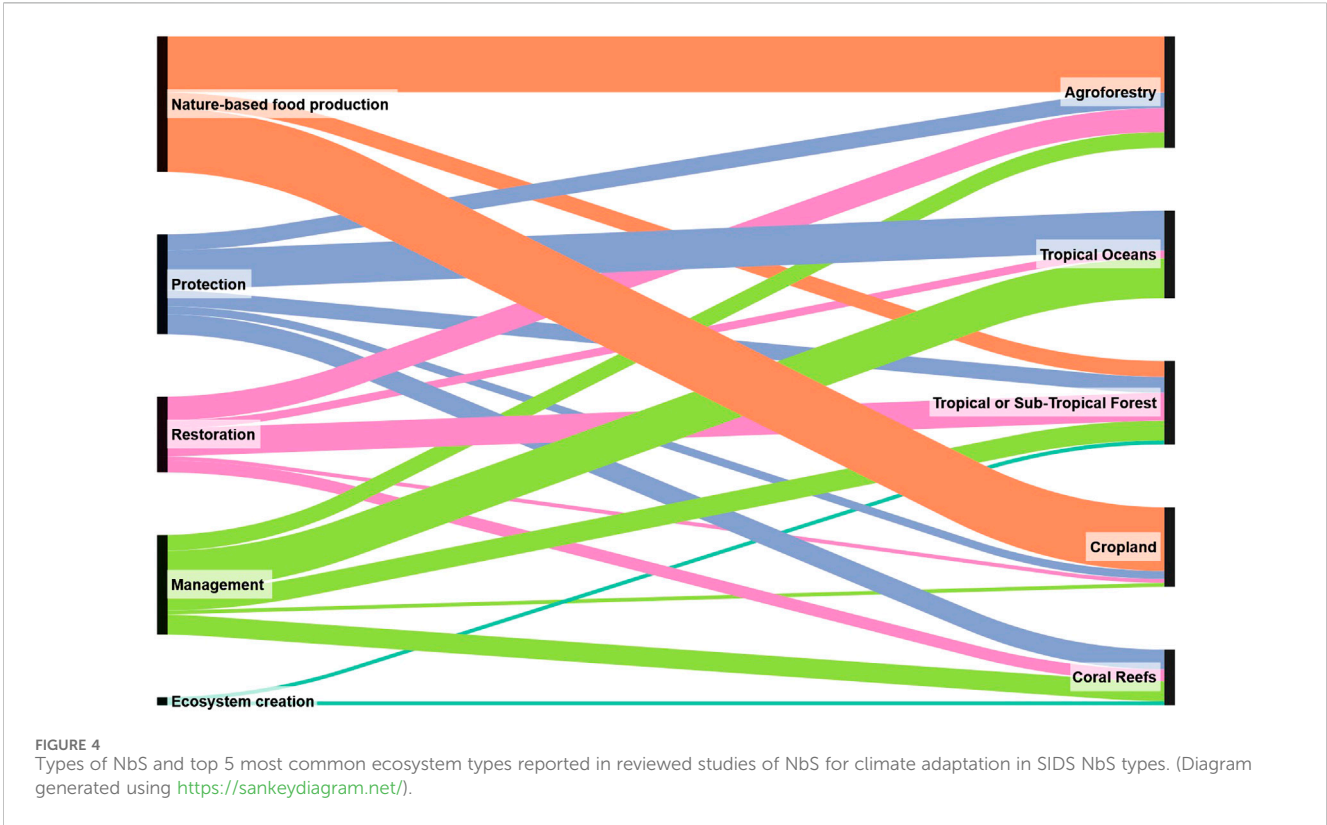
3.2 The effectiveness of NbS to reduce the impacts of climate hazards in SIDS

3.2.1 Climate hazards addressed by NbS

NbS interventions in SIDS targeted 22 different climate hazards, with each addressing between three and four distinct climate hazards. The most commonly reported were reduced agricultural production (15% of all hazards), economic vulnerability (13%), and soil erosion (12%). Water-related issues, including reduced availability (8%), declining quality (4%), and waterlogging (0.6%), were also prominent. Other frequently reported hazards included biomass cover loss (8%), reduced fishery production (8%), and soil quality decline (8%). Coastal threats such as storm surge, inundation, and erosion accounted for 8% combined, while drought (1%), wildfire (<1%), and disease (<1%) were rarely addressed.

Patterns emerged between the type of NbS and the climate hazards targeted (Figures 5, 6). Protection-based NbS focused on mitigating economic vulnerability/instability (28%), reduced fishery production (23%), and soil erosion (13%). Restoration interventions primarily address biomass cover loss (33%), economic vulnerability/instability (33%), and soil erosion (43%), with some attention towards coastal hazards like storm surge and wave-induced erosion. Management-based NbS focused on reducing economic vulnerability/instability (29%), reduced fishery production (22%), and soil erosion (15%). Ecosystem creation interventions primarily address freshwater flooding (13%), reduced water quality (13%), and soil erosion (13%).





NbS Interventions by Ecosystem and Climate Hazard Addressed

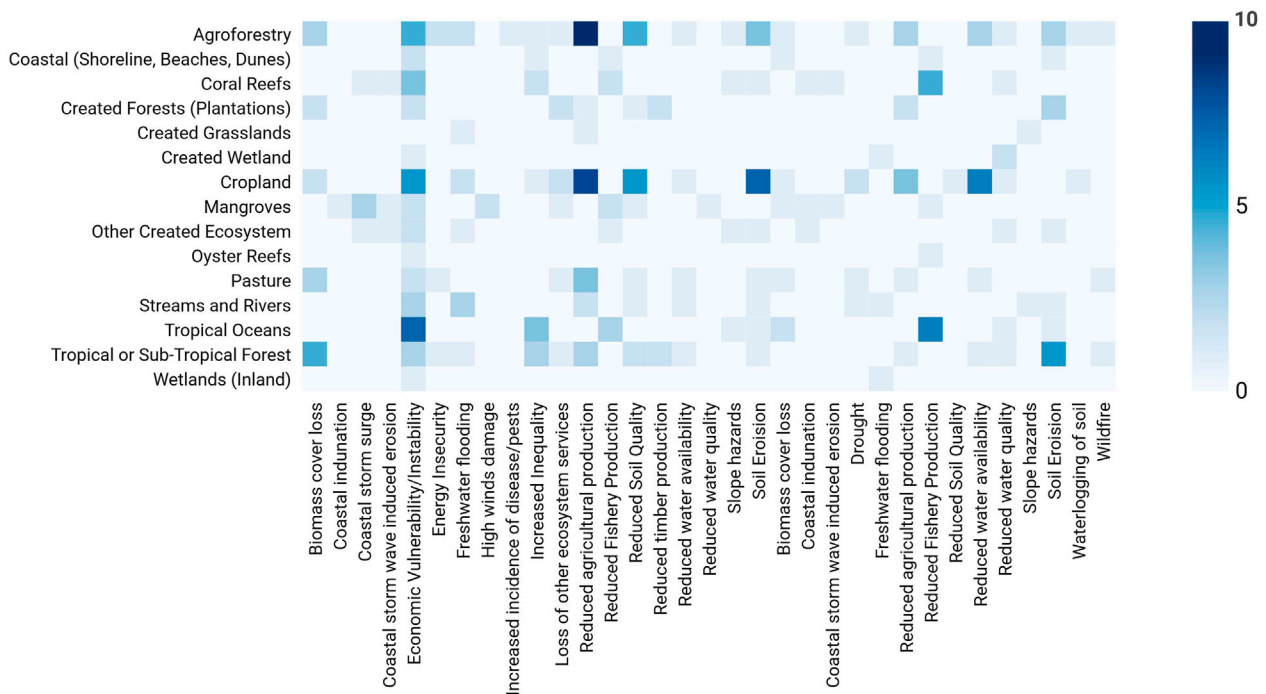


FIGURE 6

Heat map of NbS interventions by ecosystem type and climate hazard addressed in reviewed studies of NbS for climate adaptation in SIDS. Visualisation generated in BioRender.

3.2.2 Outcomes of NbS in reducing impacts of climate hazards

The reported outcomes of NbS in reducing the impacts of climate hazards were predominantly positive (72%) (Figure 7), though the extent of reported benefits varied depending on the intervention type, ecosystem, and hazard addressed (Table 3). In 21% cases, outcomes were unclear, while 4% reported no effect and 2% reported mixed results. Only one study documented a negative outcome, where the use of *Sargassum* sp. as fertilizer reduced agricultural yields (Adderley et al., 2023).

3.3 The impact of NbS on broader social, ecological, and economic outcomes

3.3.1 Social outcomes

Studies frequently reported (60%) on the social outcomes of NbS interventions. Among the studies that assessed the effects of NbS on social outcomes, the vast majority (90%) reported positive outcomes (Figure 8). One study found mixed effects, and two (6%) did not draw a clear conclusion. Of the positive studies, several were related to strengthening social ties within and between communities and stakeholder groups. For example, Andrew et al., 2018 reported that the fostered lasting connections between marginalized fishing communities, government agencies, NGOs, and donors, improving community resilience through improved service

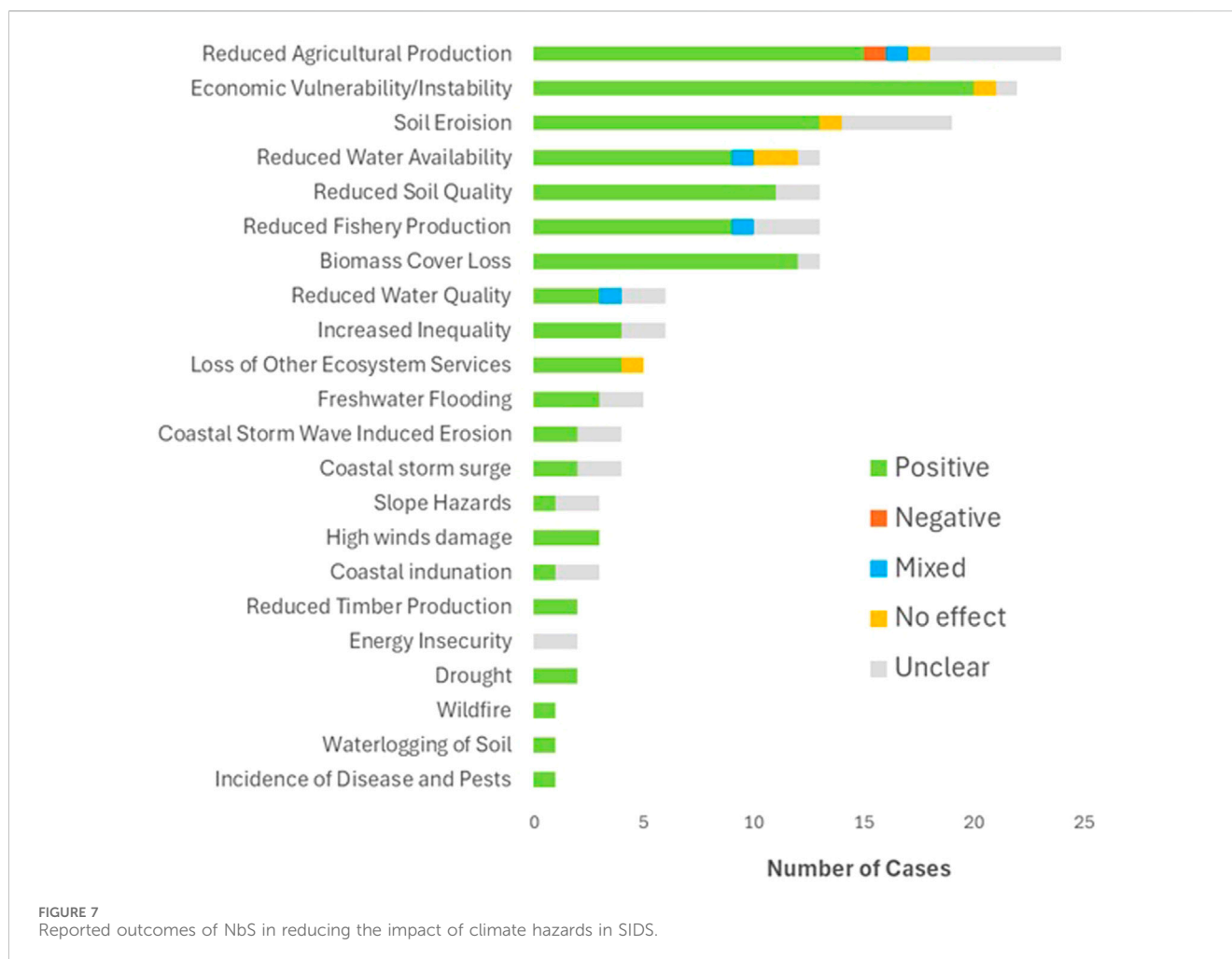
delivery, technical and financial support. Similarly, a giant clam aquaculture intervention reported strengthening relationships between coastal villages and fisheries agencies (Quimby et al., 2023).

In several studies, improved access to information and opportunities for knowledge exchange were key outcomes. Roop and St. Martin (2020) found that farmers gained business training through the NbS project, enabling them to attract further funding and pursue additional education. Four studies explicitly focused on empowering women; For instance, in Fiji, a mangrove restoration project created new livelihood opportunities for women, such as shoreline fishing at high tide, which was not possible prior to the intervention (Medina Hidalgo et al., 2021). In the Solomon Islands, women's savings clubs established through a pro-forest beekeeping initiative reported increased household resilience and funds directed toward family wellbeing (Bosma et al., 2017).

The study reporting mixed outcomes, a carbon forestry project in Timor-Leste, reported overall positive outcomes but highlighted risks of reinforcing inequalities, especially for women and low-income households (Bond et al., 2020). It raised concerns that carbon forestry may increase women's workloads, as they manage both domestic household and agricultural labor, while men retain control over income from profitable crops.

3.3.2 Ecological outcomes

More than half (53%) of interventions reported ecological outcomes, 93% of which were positive (Figure 8) and spanned a



range of ecosystems. In Singapore, river re-naturalization enhanced biodiversity, with reported increases in plant, insect, and bird diversity, and the return of previously absent otters (Lim and Xenarios, 2021). Similarly, mangrove restoration in Cuba contributed to the recovery of fish and bird populations, including the Zapata rail and Cuban crocodile (*Crocodylus acutus*), a species of conservation concern (Miller et al., 2018). In Timor-Leste, reforestation efforts led to the survival of over 150,000 trees and increased local wildlife sightings (Bond et al., 2020). In Puerto Rico, the restoration of shaded coffee agroforestry systems improved habitat quality for migratory and endemic bird species, and two endangered species—the Puerto Rican Sharp-shinned Hawk (*Accipiter striatus venator*) and the Puerto Rican Boa (*Epicrates inornatus*)—by enhancing forest connectivity (Miranda-Castro and Padrón, 2005).

3.3.3 Economic outcomes

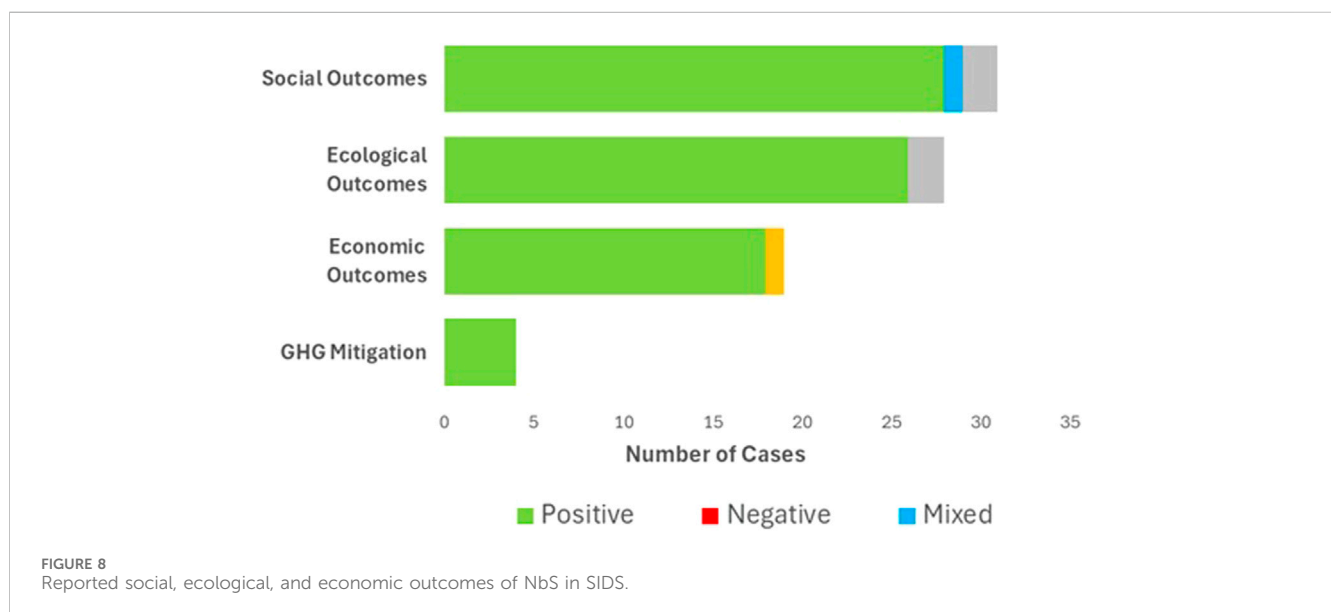
Economic outcomes were less frequently reported, appearing in 36% of studies. Of these, 95% were positive, and one reported no effect (Figure 8). In some cases, NbS interventions led to reported increases in employment opportunities and household income. A sustainable fisheries management project in Cuba created or transformed 212 jobs, including 81 specifically for women, by diversifying income streams toward sustainable alternatives such

as oyster farming (Miller et al., 2018). In Timor-Leste, tree payments from a carbon forestry project provided an average of USD 335 per household annually, around 32% of participants' total income (Though earnings varied by plantation size and density) (Bond et al., 2020). Similarly, in Vanuatu, a REDD+ project increased local income by 68% for men and 38% for women compared to pre-project levels (Carodenuto et al., 2022) (Table 3).

Few studies (13%, 7) included economic appraisals of NbS, though all found them to be cost-effective. Cost-benefit analyses were the most common method, with an Integrated Watershed Management Project in Haiti reporting benefit–cost ratios as high as 29.7 and rates of return exceeding 200% (White and Quinn, 1992). Only two studies (4%) compared the cost-effectiveness of the NbS intervention to a non-NbS alternative. For example, in Vanuatu, communities found forest conservation and agroforestry under REDD+ more economically viable than business-as-usual forest conversion to copra production (Carodenuto et al., 2022). An agroecological micro-farm in Guadeloupe reported mixed economic results, as it required higher initial investment compared to a non-NbS alternative (USD 93,000 ha⁻¹ vs. 8,600 ha⁻¹) but delivered a higher gross margin (USD 8,100 ha⁻¹ vs. 3,300 ha⁻¹), alongside unquantified benefits such as improved nutrition, diversified livelihoods, and carbon sequestration (Selbonne et al., 2023).

TABLE 3 Key examples highlighting the range of reported positive outcomes across different NbS interventions.

Study	Ecosystem type	Intervention (As specified by authors)	Climate hazard addressed	Outcome reported
Tortoló et al. (2018)	Cropland; Pasture; Agroforestry	Agroecology	Reduced agricultural production; biomass cover loss	Agroecological practices resulted in increased milk production from 3–5 kg/cow per day to 6–8 kg/cow per day, plant density increasing from 1.4 to 107.5 plants per hectare, and stored forest carbon increasing from 10 t of C/ha to 42 t of C/ha.
Lalljee et al., 2013	Cropland	Sustainable agriculture	Soil erosion	Sustainable soil management techniques led to 29%–57% reduction in soil erosion compared to control plot, and reduced surface run-off by up to 75%.
O Ha'apio et al., 2014	Mangroves; coral reefs; tropical oceans	Marine protected Area	Economic vulnerability	In the area surrounding the established marine protected area, there was a reported increase in small business entrepreneurship, such as eco-tourism.
Carodenuto et al., 2022.	Tropical or Sub-tropical forest; Agroforestry	REDD+	Economic vulnerability; reduced water availability	Following the REDD+ agroforestry intervention, Income levels in the community had increased 68% for men and 38% for women compared to pre-intervention baselines. Also, reported water shortages in the community reduced by 45%.
Pradoa et al., 2018	Cropland; created forests (plantations)	Specialized shade coffee cultivation	Reduced water availability	Soil moisture at the base of the coffee trees grown under shade trees was about 9% higher than coffee grown in full sun, without shade.
Lim and Xenarios (2021)	Streams and rivers; created wetland	Blue-Green Infrastructure	Freshwater flooding	Re-naturalization of river increased the river's carrying capacity by 40%.
Lee et al., 2022	Mangroves	Mangrove restoration	High winds damage; coastal storm damage	Restored mangroves were found to reduce wind speed by 11%–80% and reduce wave heights by 13%–68%.



3.3.4 Climate mitigation outcomes

Only 6% (3) studies reported climate mitigation outcomes, all of which were positive (Figure 8).

For instance, in Guadeloupe, a climate-smart agroecological farm reported shifted from emitting 2.4 tCO₂ eq ha⁻¹ to sequestering 1.1 tCO₂ eq ha⁻¹ after the intervention (Selbonne et al., 2023). Similarly, in Cuba, carbon sequestration increased from 10 to 42 tCO₂ eq ha⁻¹ following agroecological practices (Tortoló et al., 2018). In Vanuatu, REDD+ agroforestry projects

reported higher carbon stocks per hectare than business-as-usual farming, in some cases double or triple (Carodenuto et al., 2022).

3.4 Socio-ecological resilience mechanisms in NbS

Across all studies, 15 categories of social resilience mechanisms were identified, with each intervention reporting on average two to

Future Research Priorities

- (1) Stronger representation of under-studied SIDS contexts
- (2) Greater focus on coastal and ocean-related NbS
- (3) Evidence linked to baselines and counterfactuals
- (4) Holistic, long-term monitoring and evaluation
- (5) National- and regional-scale synthesis of grey literature
- (6) Integration of equity and knowledge pluralism in NbS design and evaluation

FIGURE 9
Suggested future research priorities to enable the scaling of nature-based solutions in small island developing states.

three. The most frequently cited mechanisms were financial assets (15% of all reported social resilience mechanisms), livelihood diversity (13%), and access to information (13%). Factors such as rights and ownership, and knowledge or experience diversity, each represented around 1% of reported mechanisms, while distributional equity was not mentioned in any study.

Ten categories of ecological resilience mechanisms were also identified, though each intervention typically reported only one or two. The most common were species diversity (33% of all ecological mechanisms), habitat area (23%), and control of local threats (17%). Mechanisms such as genetic diversity (3%), species interactions (3%), resource availability (3%), keystone functional groups (3%), and landscape heterogeneity (2%) were rarely reported. Others, such as dominant species, ecological learning, network structure, phenotypic plasticity, and response diversity, were entirely absent.

3.5 Multiple benefits of NbS

Several projects (21%) reported delivering positive ‘triple win’ outcomes through NbS. Of these, 9 (17%) demonstrated positive outcomes across climate adaptation, social, ecological, and economic dimensions, while 2 (4%) showed benefits spanning climate adaptation, social, ecological, and climate mitigation outcomes.

4 Discussion

We conducted a systematic review of literature indexed in academic databases to 1) assess the current landscape of NbS implementation for human climate adaptation in SIDS; 2) build evidence of the effectiveness of NbS for addressing the impact of climate hazards in SIDS; 3) understand the impact of NbS on broader social, ecological, and economic outcomes; and 4) understand the mechanisms through which NbS contribute to building social-ecological climate resilience. Our research demonstrates that a wide range of NbS activities targeting a variety of climate hazards are being implemented in SIDS and published in academic literature. However, the published interventions are concentrated in certain islands and to particular NbS approaches and climate threats. The reviewed literature

suggests, though with limited robust evidence, that the outcomes of NbS for climate adaptation and socio-ecological resilience in SIDS are generally positive; NbS can improve livelihoods, benefit local economies, and safeguard biodiversity, while helping small island communities adapt to pressing climate-related impacts like food-insecurity, flooding and water scarcity.

4.1 The current landscape of NbS implementation for human climate adaptation in SIDS

Similar to other studies of NbS (Alikhanova and Bull, 2023), our search returned only a small number of empirical studies detailing real-world NbS implementation. The 49 studies and 53 interventions analysed in this study represent a significant increase in available studies compared to [Chausson et al.’s \(2020\)](#) global review of NbS for climate adaptation, which only found 10 studies from SIDS. This increase in available evidence could be attributed to a growing research focus on climate adaptation in SIDS ([Robinson, 2020](#)), or the expansion of our search criteria to include urban NbS, hybrid NbS, agricultural and fisheries interventions. Despite this rise in the number of studies, our findings highlight a continued lack of comprehensive evidence reporting, which still limits the available evidence on the effectiveness of NbS in SIDS.

The amount of evidence reported in our study was comparable to that of other regions, with 66% of the studies providing some evidence of effectiveness and 53% offering strong, clear evidence. A similar review of NbS for climate adaptation in Bangladesh found that 62% of reported outcomes were based on strong evidence ([Smith et al., 2021](#)). Even among studies that reported evidence, key factors such as baseline data, counterfactuals, and clear descriptions of implementation scales were often missing. Poor-quality reporting poses barriers to scaling up NbS, as decision-makers require standardized evidence-based frameworks to guide their decisions ([Seddon et al., 2021](#)). To strengthen the evidence base for NbS in SIDS, consistent methods should be used to monitor NbS outcomes, considering confounding factors, and documenting synergies, trade-offs, and broader outcomes ([Smith et al., 2021](#)).

The distribution of interventions highlights a concentration of published research on NbS for climate adaptation in a few select countries, while many SIDS remain underrepresented. The largest proportion of NbS studies in our review were based in the Caribbean, which aligns with broader publishing trends in which the Caribbean leads across SIDS regions in both patent filings and scientific publications ([Mohan et al., 2025](#)). Only 26 countries of 57 SIDS were represented in our study. This geographic disparity is not only evidenced in nature-based approaches to climate adaptation, but climate adaptation in general; [Klöck and Nunn \(2019\)](#) revealed that only 32 SIDS have peer-reviewed research on adaptation. Some reporting disparities may stem from the exclusion of non-English publications, though limited research capacity within SIDS remains a key constraint; [Mohan et al. \(2025\)](#) highlight that SIDS contribute a disproportionately small share of global scientific output, accounting for just 0.09% of all journal articles, much of which is produced by foreign institutions with greater resources and capacity, highlighting the structural barriers to locally led research in SIDS ([Mohan et al., 2025](#)).

The authorship patterns presented in this study highlight how knowledge production on NbS in SIDS is largely shaped by institutions in the Global North. While institutional affiliation does not necessarily reflect researcher identity (i.e., researchers from SIDS can be affiliated with Global North institutions), the dominance of Global North institutions in framing and publishing NbS research has significant implications for how adaptation is conceptualized and evaluated; Ideas of effectiveness may therefore not be grounded in local values or understandings of what constitutes a successful intervention for building climate resilience, but instead reflect external priorities and epistemologies (Johnson et al., 2022). This can lead to an emphasis on economic efficiency, technical feasibility, or replicability over the social, cultural, and spiritual dimensions that underpin place-based adaptation practices (See et al., 2024). Addressing these imbalances requires not only greater inclusion of SIDS-based authorship, but also a broader decolonization of climate adaptation research, through critical reflection on the epistemic and institutional hierarchies that continue to shape how NbS knowledge are produced and mobilized globally (Johnson et al., 2022; See et al., 2024).

Although NbS governance in SIDS was reported to be highly collaborative across institutions and jurisdictions, private sector involvement remained limited. This is despite extensive research highlighting the private sector as a key enabling factor in NbS implementation. Public sector agencies, particularly in small island developing states, often face institutional, administrative, and financial constraints, which can hinder the implementation NbS (Calderón-Argelich et al., 2022). As a result, there has been increasing recognition of the private sector as a crucial actor in advancing NbS projects, with public-private partnerships seen as a promising mechanism to leverage expertise, financial resources, and the scalability of NbS initiatives (Calderón-Argelich et al., 2022). For example, one reviewed study on climate-friendly mariculture noted that strong private sector engagement contributed to the development and long-term sustainability of the intervention by ensuring that product prices reflect global market rates (Ellis et al., 2018). While the private sector can play a significant role in supplementing public efforts, some argue that its conventional focus on short-term gains and profit-seeking behavior may not align with all types of projects and development initiatives, which may explain the lack of private sector involvement in our reviewed studies (Lukas, 2021). Future NbS efforts should consider fostering public-private partnerships that align long-term climate adaptation goals with private sector incentives (particularly given that businesses can reap direct and indirect financial benefits from NbS (Chausson et al., 2024) helping to overcome institutional and financial barriers common in the public sectors of SIDS. Though, care should be taken to avoid commodification that leads to human rights and biodiversity transgressions in the name of profit (Chausson et al., 2024).

4.2 The effectiveness of NbS to reduce the impacts of climate hazards in SIDS

Overall, the reported outcomes of NbS were largely positive (72%), providing strong evidence that NbS can effectively address

climate threats in SIDS. Most interventions typically addressed multiple climate hazards and socio-ecological resilience mechanisms, and 21% of interventions reported 'triple win' outcomes—simultaneously addressing climate change, enhancing biodiversity, and societal wellbeing. The reported evidence highlights the strategic potential of high-integrity NbS to deliver cross-cutting benefits across sectors (JNCC, 2021). This is particularly important given the interconnected nature of impacts across sectors in SIDS, from tourism and infrastructure to health, food, and water security (Baptiste et al., 2020).

The focus of the literature on nature-based food-production (31% of interventions) and addressing agriculturally relevant climate hazards (such as reduced productivity, soil quality, etc.) is important given food insecurity issues islands face. All SIDS have shown an increase in the amount of imported food and over half of these nations import over 80% of their food (Fao, 2016). The added burden is that the majority of SIDS rely heavily on tourism, which adds additional food security considerations. For example, not only do Caribbean SIDS produce less than 50% of the food required to feed their 41 million collective inhabitants, but they also must bear the impact of feeding over 19 million tourists that visit the islands each year (Rahman et al., 2022). Climate change not only poses challenges to local food production in SIDS, but creates disruptions in the supply chains that these nations rely on for their import-based food systems (Daley et al., 2022; Reyer et al., 2015). Therefore, it is imperative that SIDS consider and implement sustainable food-production strategies. Our review highlights positive examples of NbS addressing food-related climate hazards, suggesting that well-designed NbS can be an avenue for sustainable food production and reduced import dependency in SIDS. However, most existing research comes from Cuba and Timor-Leste, limiting insights into how NbS function under different ecological and socio-economic conditions. Broader implementation and research is needed to determine how NbS can best support food systems across diverse island contexts.

While addressing agriculture-related climate hazards is critical for climate adaptation in SIDS, few NbS interventions in this study addressed climate risks such as coastal flooding, storm surge, and inundation, despite broader research emphasizing the urgency of these threats (Baptiste et al., 2020; Doorga et al., 2024; Storlazzi et al., 2015; Vousdoukas et al., 2023). As Baptiste et al. (2020) highlight, SIDS have extensive coastlines and concentrated coastal populations, infrastructure, and assets, making them highly vulnerable to rising sea levels, erosion, and extreme weather events. Furthermore, many SIDS have large exclusive economic zones, exposing valued marine resources to oceanic changes. The financial and social risks of these coastal threats are substantial, with annual damage from coastal flooding projected to increase nine to eleven times by mid-century, potentially amounting to 1.2%–5.1% of current SIDS GDP (Vousdoukas et al., 2023). By 2070, over one million SIDS inhabitants could be exposed to coastal flooding, a sharp increase from the current estimate of 118,000 people (Vousdoukas et al., 2023). This discrepancy between the hazards targeted in reviewed NbS interventions and documented climate risks suggests the need for further investigation. It is unclear whether marine and coastal adaptation is underrepresented in published NbS studies or if these regions rely more on engineered coastal defenses, resulting in limited implementation of coastal NbS. Evidence from

the Pacific suggests that engineered coastal solutions are widespread and often the default approach, though frequently proven ineffective and, in some cases, maladaptive (Klößel et al., 2022; Piggott-McKellar et al., 2020).

At the same time, a regional NbS assessment in the Pacific reported that coastal and marine ecosystems received the highest and third-highest shares of NbS funding, respectively (Wingfield et al., 2025). However, this study examined NbS broadly and was not limited to climate adaptation, suggesting that many ocean and coastal NbS may be designed to address other priorities, such as food security (which nonetheless intersects with adaptation). Currently, 36 of the 39 UN-recognized SIDS include at least one ocean-related measure in their NDCs (UN, 2024). Measures tied to the ocean economy that involve protecting, expanding, or restoring ecosystems were the second most common type of conservation commitment, with 101 measures mentioned across 28 SIDS. Most of these measures (75%) focused on adaptation. Considered together, these findings highlight the opportunity for NbS to strengthen connections across the ocean–climate–biodiversity nexus in SIDS. As Northrop and Belonje (2025) emphasize, strategies that create synergies across these systems are central to transformational climate action, acknowledging that the climate crisis, biodiversity loss, and ocean degradation are deeply interconnected challenges that demand integrated solutions.

4.3 Impact of NbS on broader outcomes and socio-ecological resilience mechanisms

Most NbS interventions reported positive social outcomes, particularly in strengthening local economic and informational resources. Yet, critical dimensions of social resilience, such as rights and ownership, diversity of knowledge and experience, and procedural and distributional equity, remained unaddressed, and few studies specifically targeted poor and marginalized groups. A lack of reporting on equity has been highlighted in other studies of NbS in forest and mountain ecosystems (Palomo et al., 2021; Turner et al., 2022). Failure to integrate equity considerations into NbS design and implementation can undermine their effectiveness and increase social vulnerabilities if costs and benefits are unequally distributed across social groups (Mcleod et al., 2018; Woroniecki et al., 2023). The positive social outcomes of the literature may need to be interpreted with a grain of salt, as the reported benefits may not be representative across all members of the relevant communities (Turner et al., 2022), or may reflect external notions of success rather than community-defined values.

Similarly, ecological outcomes were largely positive but focused on a narrow subset of resilience mechanisms, such as species diversity, habitat area, and control of local threats. Other crucial components of long-term ecological resilience such as genetic diversity and landscape heterogeneity were rarely reported. Similar patterns have been observed in other NbS reviews; Smith et al. (2021) showed ecological reporting in NbS studies was mainly confined to species richness reports on limited number of taxa, and Turner et al. (2022) found that key mechanisms for ecological resilience like response diversity, stand and landscape heterogeneity, genetic diversity, and landscape structure were hardly ever reported in NbS studies in forests.

These findings highlight both the strengths and limitations of current assessments of NbS interventions. While the overall positive outcomes suggest that NbS can support socio-ecological resilience needed for climate adaptation, the narrow range of mechanisms reported on make it unclear whether NbS are prioritizing short-term resilience to known threats over long-term adaptability to future uncertainties (Turner et al., 2022). Furthermore, ecological and social outcomes were only reported in slightly over half of reviewed studies. It remains unclear whether these gaps reflect a lack of NbS impact on diverse social-ecological mechanisms, a failure to evaluate NbS holistically to capture the diversity of socio-ecological mechanisms they act upon, or methodological challenges in assessing certain mechanisms, such as response diversity, which is inherently difficult to measure (Ross et al., 2023). Further research is needed to discern this. Expanding the scope of reporting to include less frequently assessed but ecologically and socially significant factors, as well as embedding equity into project planning from the outset, could provide a more comprehensive understanding of NbS effectiveness in supporting long-term socio-ecological resilience.

Economic vulnerability was the second most frequently addressed climate hazard in our review, with generally positive reported outcomes. Yet, only 39% of studies provided evidence of local economic impacts. For example, a study on agroforestry and restoration in Yap reported improved household income and economic viability through diversification with valuable tree species, but lacked quantifiable data, such as the specific increases in household income that occurred through the intervention (Krishnapillai, 2017). Although the broader literature supports the economic potential of such interventions (Blaise and Allred, 2021; Middendorp et al., 2018; Waldron et al., 2017), few studies in our review conducted formal economic appraisals (13%) or cost comparisons with non-NbS alternatives (4%). As a result, it remains unclear whether NbS interventions are economically viable when compared to conventional approaches. This aligns with previous research indicating that while there is evidence that NbS can contribute to economic growth across multiple sectors, this conclusion is based on a limited number of studies, with a notable gap in systematic data collection on NbS implementation (Chausson et al., 2024). The lack of economic assessment hinders decision-making processes for stakeholders considering NbS options, as decision-makers involved in fiscal policy often prioritize economic factors like job generation and fiscal multipliers when evaluating interventions (Chausson et al., 2024).

Some reviewed studies provided strong evidence of the economic viability of NbS in SIDS. For example, a study in Pohnpei Island, Federated States of Micronesia, found that introducing sponge, coral, and clam farming as alternative livelihoods to kava farming (which caused upland erosion and siltation of reefs) resulted in average hourly earnings exceeding the Pohnpei State minimum wage and, depending on the cultivated item, incomes were either comparable to or greater than those from kava farming without the environmental impacts (Ellis et al., 2018). This is consistent with findings from Chausson et al. (2024) that NbS often yield comparable or better economic outcomes than conventional alternatives while also providing additional social, environmental, and climate adaptation benefits. Another study of over eighty NbS interventions in the Alps estimated that NbS had an

average economic value of 424,662 Euros per hectare, with a three to one return on investment (González-García et al., 2023).

However, it is important to note that even when economic measures are included in evaluations of NbS, conventional economic appraisal methods often do not capture the full scope of benefits and risks provided by NbS, leading to their misvaluation—particularly in the long-term. For example, Selbonne et al., 2023's comparison of an agroecological micro-farm NbS to a non-NbS alternative reported mixed economic results, but did not include broader, but less quantifiable benefits, such as improved nutritional content of crops, greater livelihood diversification, and carbon sequestration, in the economic valuation. Similarly, in the aforementioned kava farming example (Ellis et al., 2018), evaluating NbS solely through economic metrics overlooks the cultural and social significance of kava in Pacific communities (Aporosa, 2019); The economic advantages of the presented alternative livelihoods may therefore come with trade-offs that affect community identity and practices. The absence of such considerations highlights how narrow NbS valuation approaches can cause important benefits and risks to be overlooked in favor of immediate financial returns, whether through traditional grey infrastructure or through NbS that neglect the social, cultural, and ecological values of place (Buckwell et al., 2020; Seddon et al., 2020). Therefore, scaling up NbS and enhancing NbS credibility among decision-makers could benefit from holistic evaluations that incorporate broader benefits and risk into valuations, in addition to more consistent economic assessment and reporting, and comparisons of economic outcomes with pre-intervention baselines or non-NbS alternatives.

The lack of GHG mitigation reporting (6% or 3 cases) was interesting given the potential of NbS to draw down atmospheric carbon emissions, addressing climate adaptation and mitigation simultaneously (Key et al., 2022; Rosenzweig and Tubiello, 2007; Seddon, 2022). Notably, none of the reviewed interventions on the restoration of mangrove ecosystems reported on GHG mitigation outcomes, despite extensive evidence of mangroves sequestering up to five times more carbon than tropical forests of equivalent area (Chatting et al., 2022). Strengthening assessment of mitigation benefits alongside adaptation outcomes could help to bolster NbS' position as multi-benefit climate strategies. Integrated approaches can be leveraged to unlock diverse climate finance pathways and reinforce the inclusion of NbS within national adaptation and mitigation plans. Integration may also enhance local uptake of mitigation projects, as combining adaptation measures can increase community acceptance by addressing immediate local needs, in addition to the longer-term global benefits of mitigation (CIFOR, 2014).

5 Limitations of study

To our knowledge, this is the first systematic review to assess the effectiveness of NbS in addressing the impacts of climate hazards in SIDS. Our research has shown that systematic literature reviews can be a valuable tool for synthesizing existing knowledge on NbS in SIDS, identifying gaps in the evidence on their climate adaptation and socio-ecological outcomes, and understanding how their effectiveness is assessed. However, this research also has its limitations.

Our review relied on literature retrieved from academic databases, primarily peer-reviewed and scholarly publications. This approach excluded many NbS projects in SIDS that are not formally published or archived in academic databases. For instance, the authors are aware of a large-scale mangrove restoration effort in The Bahamas not captured in our pool of studies (Bonefish and Tarpon Trust, n.d.). Similarly, a recent inventory of NbS in Fiji lists numerous interventions that were not apparent in our dataset (International Institute for Sustainable Development et al., 2024). We also acknowledge that the peer-reviewed focus inevitably left out Traditional Ecological Knowledge, Indigenous wisdom, and local practices (e.g., Pacific ridge-to-reef systems) (Fache and Pauwels, 2022). Although these knowledge systems play a critical role in shaping nature-based adaptation in SIDS, they were not captured within the scope of this review as peer-reviewed journals remain disproportionately dominated by research from the Global North, meaning that locally grounded perspectives and Indigenous knowledge from SIDS are underrepresented (Nelson and Reed, 2025). This structural limitation constrains how fully the review can capture the diversity of NbS practices and knowledge across SIDS. Though, expanding the scope of future reviews to include grey literature, project reports, non-academic and local perspectives could provide a more holistic understanding of NbS implementation. Regional or country-specific reviews focused on grey literature and local perspectives would be a valuable next step toward building a fuller picture of NbS implementation and contextualizing the patterns identified in this study.

Our review also focused on studies that framed NbS in terms of human climate adaptation. This led to the exclusion of projects that only assessed ecological or biophysical outcomes of NbS. For example, several excluded coral reef restoration studies measured coral growth and fish diversity but did not explore how these efforts influence wave attenuation or support fisheries of local economic importance. In addition, by including only English-language publications, our findings may underrepresent NbS in non-English-speaking SIDS, which make up roughly a quarter of all SIDS. While this decision reflects the time and resource constraints of our research team, it highlights the need for the incorporation of more languages in future research to ensure a more inclusive and representative synthesis of NbS in SIDS. The limited reporting of negative outcomes in our study may reflect publication bias, as positive results are more likely to be published—a known issue that can introduce bias into systematic reviews and meta-analyses (Mlinarić et al., 2017). This can obscure important trade-offs and unintended consequences of NbS interventions that could provide valuable lessons for future implementation (Taylor et al., 2025). We also acknowledge that the small size and heterogeneity of our dataset limited the feasibility of conducting a robust meta-analysis, which might have yielded more quantifiable findings.

Despite these limitations, the evidence available from our study remains valuable in recognizing the potential of well-designed nature-based solutions for climate adaptation. Future reviews should work to fill geographic gaps in NbS research, including island- and community-level contexts that remain largely absent from the peer-reviewed literature. Strengthening the evidence base will also require broadening the sources of knowledge included in NbS reviews, such as grey literature, non-English publications, and locally produced documents. Diversifying the evidence synthesized

may allow for more inclusive representation of Indigenous and local perspectives on NbS outcomes and potentially highlight NbS addressing distinct climate risks that are currently underrepresented in academic literature (e.g., disease, wildfire). Further research is also needed to identify the underlying factors that enable or constrain the success of NbS documented in SIDS. Together, these efforts can help to build a more comprehensive understanding of NbS effectiveness in SIDS.

6 Conclusion

Given the urgency of climate threats facing SIDS, scaling up resilient adaptation strategies is essential to safeguard both island communities and their biodiversity. As the first review of its kind, this study provides valuable evidence demonstrating the promise of NbS as an effective climate adaptation strategy, with broadly positive social, ecological, and economic outcomes, and potential to provide ‘triple-win’ outcomes and synergies across the ocean-climate-biodiversity nexus. Our evidence shows that NbS have potential to address critical threats facing SIDS globally, including coastal risks, economic instability, and food insecurity.

At the same time, NbS are not a one-size-fits-all solution for climate adaptation in SIDS. They need to be designed around the specific climate risks, priorities, and knowledge systems of each nation, island, and community. Even island communities facing similar threats may pursue different strategies based on cultural context, local knowledge, and lived experiences. Place-based knowledge informing NbS is essential to avoid NbS approaches that are maladaptive or misaligned with local priorities (Den Dekker-Arlain et al., 2025; Mcleod et al., 2018). Furthermore, it is crucial to recognize the structural challenges that influence NbS implementation in many SIDS, including legacies of colonization that affect trust and equitable inclusion, limited capacity, infrastructure, and financial resources, fragmented governance, and pressures linked to growing informal urbanization (Thomas and Theokritoff, 2024; Wolff et al., 2025). These structural constraints mean that NbS must be designed and evaluated in ways that are highly context-specific, responsive to local needs, and supported by strong enabling policy and finance. Without this recognition, NbS risk exacerbating inequalities or failing to meet their intended outcomes (Wolff et al., 2025). As SIDS continue to develop adaptation policies, there is an opportunity to integrate these considerations more fully into national planning to ensure NbS deliver meaningful climate adaptation outcomes to communities who need them the most.

However, significant gaps in supporting NbS implementation in SIDS remain. Academic and peer-reviewed research on NbS in SIDS is limited to a few countries and climate threats, with gaps in comprehensive reporting and understanding of how NbS can contribute to long-term resilience (Figure 9). With SIDS increasingly recognizing NbS in their national plans, the availability of robust scientific evidence to support implementation in island settings is key. To better understand NbS as effective climate adaptation strategies in SIDS, peer-reviewed research is needed across a wider range of island contexts that currently remain underrepresented. NbS research must also expand beyond agricultural applications to investigate

NbS’ potential to address a broader range of pressing climate risks, particularly ocean and coastal challenges, which are a central focus in many SIDS’ national plans (UN, 2024). At the same time, given the prominence of agricultural NbS in the literature, there is value in ensuring that this evidence is present in policy discussions.

Future progress will also depend on the development of robust evaluation frameworks that capture the full range of potential socio-ecological and economic benefits that NbS can provide, and on the consistent use of counterfactuals and baselines in reporting, to strengthen the evidence base. This is particularly important for ensuring that trade-offs and risks of NbS are captured, as they often go undocumented, limiting the ability to identify and prevent unjust distributions of NbS benefits and burdens within vulnerable island communities (Den Dekker-Arlain et al., 2025). Embedding Indigenous and local knowledges into NbS approaches is also essential—both as a lens through which NbS effectiveness is evaluated, and as a knowledge source to inform NbS design and implementation (Nelson and Reed, 2025). Similarly, integrating equity considerations into NbS design and implementation is critical to ensure inclusive and effective adaptation strategies. Addressing these gaps will strengthen scientific understanding of NbS and support evidence-based decision-making regarding NbS among policymakers, helping to advance effective and locally-relevant climate adaptation policy and planning at scale in SIDS.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: <https://doi.org/10.6084/m9.figshare.30147382.v1>.

Author contributions

ZB: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review and editing. KK: Investigation, Writing – review and editing. EO: Investigation, Writing – review and editing. LT: Investigation, Writing – review and editing. NS: Supervision, Writing – review and editing.

Funding

The author(s) declared that financial support was received for this work and/or its publication. This project was made possible through funding by the International Panel for Climate Change (IPCC), Jesus College at The University of Oxford, and The Natural Environment Research Council.

Acknowledgements

We would like to thank the wider members of the Nature-based Solutions Initiative for their guidance, support, and feedback

throughout the development of this manuscript. We are also grateful to Ludovic Branlant for his valuable support and for sharing insights related to the Pacific context.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was not used in the creation of this manuscript.

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