

Annual Review of Environment and Resources
**Climate Change and Small
Island Developing States**

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Keywords

small island developing states, Caribbean, Pacific, risk, adaptation, climate justice

Abstract

Despite their heterogeneity, small island developing states (SIDS) are recognized as being particularly at risk to climate change, and, as they share numerous common traits, the United Nations recognizes them as a special group. SIDS have been quite vocal in calling attention to the challenges they face from climate change and advocating for greater international ambition to limit global warming. Here, we unpack factors that are helpful in understanding the relationship between climate change and SIDS through a review of studies that span disciplines and methodologies. We assess patterns of hazards, exposure, and vulnerability; impacts and risks; awareness and knowledge; adaptation planning and implementation; mitigation; loss and damage; and climate justice to provide an overarching review of literature on climate change and SIDS.

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Small island developing states (SIDS):

group of countries that are recognized by the United Nations as a special group with shared circumstances that place them at risk to climate change

Vulnerability:

predisposition to be negatively affected

United Nations Framework Convention on Climate Change (UNFCCC):

international environmental treaty with the aim of preventing “dangerous” human interference with the climate system

Impacts: effects on natural and human systems

Risk: the potential for consequences on something of value

1. INTRODUCTION

Small island developing states (SIDS) have long been recognized as being particularly at risk to climate change. These nations are often described as being on the “frontlines of climate change,” as “hot spots of climate change,” or as being “canaries in the coalmine” (1–3). SIDS have been quite active in calling attention to their high vulnerability to climate change and have played a leading role in advocating for stronger ambition to limit global warming through the United Nations Framework Convention on Climate Change (UNFCCC) (1, 4). The Alliance of Small Island States (AOSIS) has been a strong negotiating group in the UNFCCC, highlighting that although they are negligible contributors to anthropogenic climate change, they are among the most vulnerable to its impacts (5). The AOSIS “1.5°C to Stay Alive” campaign was one of the driving forces behind including 1.5°C as part of the global temperature goal in the 2015 Paris Agreement and also supported the request for the Intergovernmental Panel on Climate Change (IPCC) to produce a special report on the implications of 1.5°C of global warming (6).

Internationally, SIDS are identified as a group of 38 United Nations (UN) Member States and 20 Non-UN Member/Associate Members that are located in three regions: the Caribbean; the Pacific; and the Atlantic, Indian Ocean, Mediterranean and South China Seas (AIMS) and are home to approximately 65 million people (7) (**Figure 1**). These nations are far from homogeneous, with significant differences in territorial area, governance systems, economic development, and geographic characteristics (8). However, they do share numerous features that have led to the UN recognizing them as a special group, including narrow resource bases, dominance of economic sectors that are reliant on the natural environment, limited industrial activity, physical remoteness, and limited economies of scale (9).

This review discusses recent research on SIDS and climate change, drawing from studies that span disciplines and methodologies. We provide an overarching review of the many factors that must be considered in understanding the relationship between climate change and SIDS. The review begins with an overview of patterns of hazards, vulnerability, and exposure in SIDS that is helpful to understand overall risk. We then detail current impacts and projected risks for these small island nations, drawing from the recent IPCC Special Reports and other relevant literature. Next, we assess research on environmental psychology that focuses on how different groups within SIDS experience and think about climate change. This leads into a discussion of adaptation

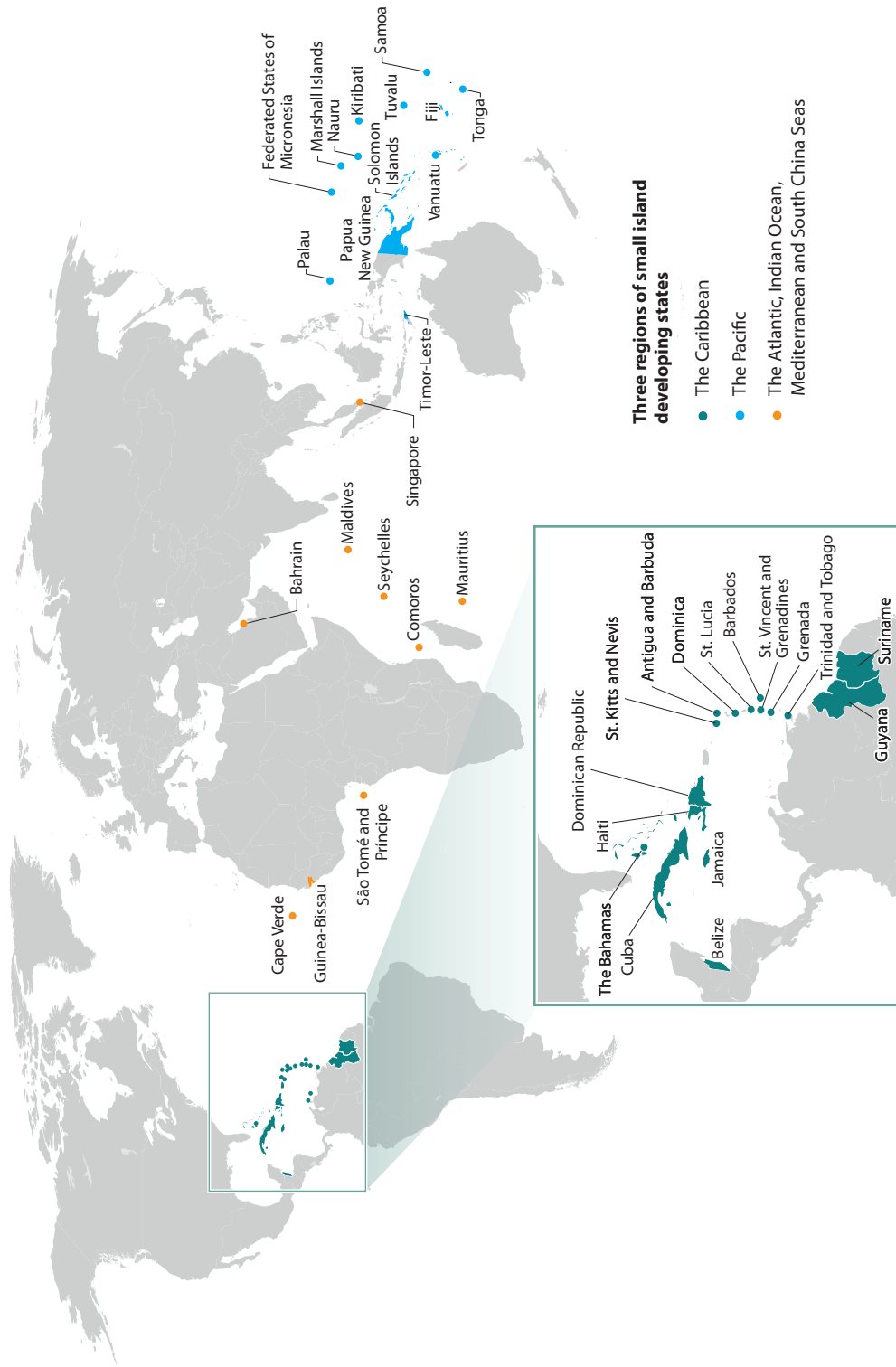


Figure 1

Small island developing states (SIDS) that are members of the United Nations (UN). SIDS are identified as a group of 38 UN Member States and 20 Non-UN Member/Associate Members that are located in three regions: the Caribbean (marked by *green areas/irides* on the map); the Pacific (*blue*); and the Atlantic, Indian Ocean, Mediterranean and South China Seas (*orange*). SIDS are home to approximately 65 million people. The Alliance of Small Island States (AOSIS) is a subset of 44 SIDS and has been a strong negotiating group in the United Nations Framework Convention on Climate Change. AOSIS has highlighted that although SIDS are negligible contributors to anthropogenic climate change, they are among the most vulnerable to its impacts. Figure adapted from a map created by Osiris (<https://commons.wikimedia.org/w/index.php?curid=23505603>) (CC BY-SA 3.0).

Hazard: climate-related physical events or trends

Exposure: the presence of things of value in places that could be negatively affected

trends in SIDS, including an evaluation of national adaptation planning and barriers to adaptation. Although much research on SIDS focuses on adaptation, the following section details studies on mitigation. Finally, we assess literature on climate justice in the SIDS context, that highlights the double inequality that these island nations face.

2. PATTERNS OF HAZARDS, EXPOSURE, AND VULNERABILITY IN SMALL ISLAND DEVELOPING STATES

The IPCC Fifth Assessment Report (10) set out a framework that is helpful to understand the risk that climate change poses for SIDS. Risk is determined by the interaction between climate-related hazards and the vulnerability and exposure of both human and natural systems. In this framing, hazards refer to climate-related physical events or trends, and exposure refers to the presence of things of value in places that could be negatively affected. Vulnerability encompasses a range of concepts and includes sensitivity to harm as well as capacities to cope and adapt. As the climate changes, the characteristics of hazards also change while vulnerability and exposure are affected by socioeconomic conditions, governance, as well as adaptation and mitigation efforts. Here we review broad patterns of hazards, vulnerability, and exposure that are found in SIDS, while recognizing that these island nations are heterogeneous and that hazards, vulnerability, and exposure are also dependent on context and scale.

Due to close connections between human communities and coastal environments, SIDS are particularly exposed to hazards associated with the ocean and cryosphere, including sea-level rise, extreme sea levels, tropical cyclones, marine heatwaves, and ocean acidification (11). These hazards have already been affected by anthropogenic climate change and are projected to continue to intensify as global temperatures increase. Marine heatwaves have doubled in intensity since the early 1980s and have also become longer, more intense, and more extensive (11). These heatwaves are expected to increase in frequency, duration, extent, and intensity with global temperature increase. The ocean is also becoming more acidic and less oxygenated. By 2100, the ocean is projected to shift to unprecedented conditions since the preindustrial period—becoming even warmer, further acidified, and less oxygenated—with rates and magnitudes of these changes increasing with higher greenhouse gas emissions (11).

Global mean sea level is currently rising at an unprecedented rate of 3.6 mm per year as compared to the past century, and extreme wave heights have also increased. Under high emission scenarios, there may be multi-meter sea-level rise—up to 5.4 m by the year 2300—in the centuries to come, and extreme sea-level events that were once centennial may occur annually by 2050. Global sea levels have risen since the mid-twentieth century, and sea-level rise for tropical regions—including small islands—has been larger than the global average (12, 13). Ocean waves have also strengthened over the past several decades due to ocean warming, particularly in the tropical Atlantic Ocean and Southern Oceans (14). Projected increases in wave power can combine with sea-level rise to exacerbate coastal hazards. However, wave power is not currently considered as a climate change indicator, which may lead to underestimation of coastal and ocean hazards (14).

Anthropogenic climate change has also already resulted in increased levels of precipitation, higher storm surges, faster winds, and increased intensity of tropical cyclones (15, 16). With 2°C of global warming, it is projected that the average intensity of tropical cyclones will increase along with amplified magnitudes of storm surge and precipitation, resulting in higher proportions of Category 4 and 5 tropical cyclones.

Hazards beyond the ocean and cryosphere also have implications for SIDS (Table 1). Atmospheric temperature extremes have already increased in frequency and intensity in SIDS and are

Table 1 Climate change–related physical parameters, projected changes, and corresponding hazards for tropical Atlantic, tropical Pacific, tropical Indian, and South Pacific regions (11)

Parameter	Projected change	Hazard
Temperature	Increase	Terrestrial and marine heatwaves
Ocean oxygen	Decrease	Marine hypoxia
pH	Decrease	Ocean acidification
Sea level	Increase	Coastal flooding, coastal erosion, tidal flooding, storm surge
Average precipitation	Decrease	Freshwater stress
Extreme precipitation	Increase	Inland and coastal flooding
Extreme storms	Increase	Coastal flooding, storm surge, extreme waves, extreme precipitation

projected to continue along this trend (17). Caribbean SIDS may experience up to six months per year of warm spell conditions,¹ with a global average temperature increase of 1.5°C (18). Heavy precipitation events in SIDS have also increased in frequency and intensity and are expected to further increase (17). While patterns vary among islands, many SIDS will face increasing drought and reduced levels of annual precipitation as global temperatures rise, leading to freshwater stress (19). An increasing drought risk is projected for Caribbean SIDS, with moderate to extreme drought conditions projected for global warming temperatures at or above 1.5°C for islands in this region (20).

In terms of exposure, SIDS have significant portions of their populations and assets in locations that are exposed to climate hazards (21). A common feature of SIDS is a high ratio of coastline-to-land area, with large portions of populations, infrastructure, and assets being located along the coast (17, 22). Many of these island nations are also located in the tropics and subtropics. These physical locations result in high exposure to changes in sea levels, coastal erosion, extreme sea-level events, tropical storms, and flooding. Many SIDS are also large Ocean States, meaning that their ocean spaces are several times larger than the country landmasses. These large exclusive economic zones also result in high exposure of marine resources to changes in the ocean.

Vulnerability of SIDS to climate change is complex. Economically, the very characteristics that make SIDS unique contribute to increased vulnerability to climate hazards. Sectors that are critical to many SIDS' national economies—such as tourism, fisheries, and agriculture—are reliant on environmental conditions and are thus affected by any changes to the environment (23, 24). For example, coastal-based tourism makes up more than 20% of the national gross domestic product (GDP) for more than half of SIDS and more than 50% of the GDP for particularly tourism-dependent islands (8). This makes these sectors, and resultantly the economic stability of these countries, sensitive to any environmental change brought about by climate change. SIDS are also economically vulnerable to extreme events and resultant disasters. Due to their smaller economies and populations, a single large-scale disaster can result in damages of nationally significant proportions (23). For example, in 2017 Hurricane Maria resulted in damages of more than 225% of the annual GDP of Dominica (25). In the Pacific, the estimated economic cost of Cyclone Pam (2015) on Vanuatu across all sectors was approximately 64% of the country's GDP, and in Fiji, Cyclone Winston (2016) displaced more than 130,000 people (26).

Vulnerability also encompasses adaptive capacity and there are many studies that focus on the ability of SIDS to adjust to the risks posed by climate change. Many national governments in SIDS have insufficient personnel and funds devoted to addressing climate change and are also

¹Warm spell conditions are the annual count of days with at least six consecutive days when temperature is greater than the 90th percentile. The 90th percentile for each day is determined from the baseline years using a five-day window centered on the day.

faced with data constraints that limit the ability to assess risk and plan appropriate responses (27, 28). Adaptation programs often provide resources for short periods of time, which then threatens the long-term sustainability of projects to address climate change (29, 30). Benjamin & Thomas (31) highlight that the effects of climate change lead to an “unvirtuous cycle,” whereby adaptive capacity has the potential to become more limited over time due to the burden of addressing extreme events. SIDS already have limited capacity to respond to and recover from extreme events, often relying on international assistance. This limited capacity is further exacerbated by the need to divert resources into disaster response from existing public programs that may increase capacity—such as sustainable development and adaptation—leading to increased capacity constraints. This cycle highlights the link between sustainable development and climate change. Sustainable development challenges faced by SIDS—including insufficient urban planning, competition for land use, unsustainable natural resource extraction, and ineffective water management—contribute to increased vulnerability to climate change (32, 33).

Vulnerability is also very much dependent on context and scale. Different socioeconomic conditions lead to some SIDS being assessed as more vulnerable than others (34, 35), and much research highlights the differential vulnerabilities found at subnational scales within SIDS (36–38). Particular groups, including those with livelihoods that are dependent on natural resources, squatter households, and female-headed households, are found to be more vulnerable than other groups (39, 40). A combination of demographic and economic characteristics—such as cultural norms, inequitable gender roles, and unequal access to resources and power—lead to weak coping and adaptive capacities for particular social groups.

3. CURRENT IMPACTS AND PROJECTED RISKS

Hazards, exposure, and vulnerability interact to culminate in existing impacts and projected risks. SIDS are recognized as already experiencing impacts and facing significant risks from both rapid-onset events, such as storms and flooding, and slow-onset processes including sea-level rise, land erosion, and changes in the global water cycle (7, 41). More specifically this includes marine inundation of low-lying areas, coral bleaching, saline intrusion into terrestrial systems, degrading ecosystems, species shifts, habitat loss, climate-induced diseases, as well as casualties and damage from extreme events (7).

3.1. Current Impacts of Climate Change

Sea-level rise has resulted in contraction of habitats, shifts in the geographical location of coastal species, loss of biodiversity, and reduction in ecosystem services (11). Numerous Pacific Island SIDS have already noted with concern increased sea levels and associated land loss. In a stark example, several low-lying Pacific Islands in the Solomon Islands and Micronesia have already been lost—including Kale and Rapita in the northern Solomon Islands—and more are experiencing severe erosion due to sea-level rise since the mid-twentieth century (42, 43). Severe erosion on the islands of Hetaheta and Sogomou in the northern Solomon Islands has led to 62% and 55% island loss, respectively, over the twentieth century. On the island of Nuatambu, 51% land loss in the village area and subsequent 50% house loss directly attributable to shoreline recession has led to the forced relocation of communities (42). Sea-level rise has also increased occurrences of tidal flooding, known also as sunny day flooding or nuisance flooding, in which coastal low-lying areas are temporarily inundated during high tides (44). Observed sea-level rise has also increased the salinity of several coastal aquifers. For low-lying Pacific islands and atolls, coastal aquifers are the only source of freshwater supply, and sea-level rise has led to decreased water quality of this freshwater supply (13).

Extreme precipitation and sea levels are also often linked to flooding (45). Extreme weather, linked to tropical storms, results in significant impacts in island nations (15). Recent Atlantic Hurricanes Irma (2017), Maria (2017), and Dorian (2019) were extreme storms that exhibited rapid intensification prior to making landfall, causing extensive damage on several Caribbean SIDS. Sea-level rise has exacerbated the impacts of coastal flooding from tropical cyclones and storms, by increasing storm surge and incidences of overwash events, with storm surges and damage penetrating farther inland than a few decades ago (13, 41).

Marine heatwaves and ocean acidification have resulted in large-scale coral bleaching events that are happening more often and have resulted in reef degradation (11). Recovery of coral from these bleaching events is slow, taking more than 15 years, if recovery happens at all. Coral reefs provide critical habitats for fish and serve as fishing grounds for several island nations. Coral reef loss—through bleaching via high ocean temperatures, and human-induced disturbances (e.g., unsustainable coastal development, overfishing, pollution)—has had cascading effects on associated living resources, both on direct consumption by local communities and through disturbances to broader food webs (41, 46).

Already observed coral reef loss has had a particular impact on fisheries in SIDS, with fish becoming scarcer and causing challenges to fisheries governance and regulation of fishing between national jurisdictions. Changes to the ocean have also been related to an increase in the frequency and extent of algal blooms (11, 47). Sargassum seaweed has plagued the Caribbean region in particular. There has been an increased presence of pelagic sargassum in the Caribbean since 2011 (24). Sargassum blooms manifest as large mats and enter into the Caribbean Sea from the Atlantic Ocean, resulting in seaweed drifts that adversely impact fisheries and coral. Furthermore, coastal strandings of the seaweed accumulate up to several meters high along beaches, thus having additional negative coastal impacts. These algal blooms have negatively affected food security, tourism, local economies, and human health in SIDS.

Changes to ocean characteristics such as acidification and warming due to climate change along with human activities has led to almost 50% of coastal wetlands across the globe being lost while at the same time marine species are declining and/or have been shifting away from the tropics and toward the poles, leading to changes in ecosystem structure and functioning (11). These ecosystems—including mangrove forests and seagrass—provide important ecosystem services in SIDS. They act as carbon stores, prevent coastal erosion, provide protection from extreme sea-level events, and support biodiversity.

For many SIDS, the reliable, safe, sustainable, and affordable access to potable water remains a critical issue. Typical sources of potable water for SIDS communities include groundwater and surface water, which are commonly recharged during the wetter season of the year (7). Sea-level rise, storms, and changes to precipitation have affected these sources, leading to further stress on freshwater availability. Several Caribbean islands have experienced droughts, lengthier dry seasons with conversely shorter rainy seasons, and increased land temperatures (24, 34).

3.2. Projected Risks of Climate Change

Potential risks stemming from sea-level rise include salinization, flooding, permanent inundation, erosion, and pressure on ecosystems, and will persist well beyond the twenty-first century (41). There is high confidence that small island states are particularly at risk from exposure to multiple and compound climate-related risks with increasing global warming. These include long-term risks of coastal flooding and impacts on populations, infrastructures and assets, freshwater stress, and risks across marine ecosystems and critical sectors, which are projected to increase with increasing global warming (17).

Tropical regions including small islands are expected to experience the largest increases in coastal flooding frequency, with the frequency of extreme water-level events in small islands projected to double by 2050 (48). Furthermore, extreme sea levels that are historically rare will become more common under all projections of global warming, and small islands are expected to experience such events annually by 2050 (11). Wave-driven coastal flooding risks for reef-lined islands may increase as a result of coral reef degradation and sea-level rise (49). A study of sea-level rise threats to low-lying atoll islands (50) examined the nonlinear interactions between sea-level rise and wave dynamics and found that by mid-century, based on current emissions trajectories, most atoll islands will experience annual overwash. Such frequent events would make these atolls inhabitable due to infrastructure damage and loss of freshwater aquifers.

Increases in heavy precipitation associated with tropical cyclones is expected at 1.5°C of global warming, with further increases at higher global temperatures. Although a decrease in total number of storms is projected with climate change, the number of those storms that become intense is expected to increase (41). Six of the ten countries most at risk from a one-in-250 year cyclone are SIDS (7).

Further increases in ocean temperatures are expected with global warming, with more frequent marine heat waves, resulting in changes to coastal and marine ecosystems. Total marine animal biomass in the subtropical zone (30°N–30°S), for example, is expected to decrease by 7–9% by 2050, and 7–23% by 2100, depending on the warming scenario (11). Projected global coastal wetlands loss is estimated between 20% and 90% by 2100, with the mangrove habitats of small islands considered particularly vulnerable to sea-level rise (11).

Economic risks of climate change for SIDS are projected to be higher than the global average, with projected average annual losses (AAL)² by 2030 between 0.75% and 6.5% of GDP for Pacific SIDS compared to the global average of 0.5% (7). In the Caribbean, climate change damages are projected to grow from 5% of GDP in 2025 to more than 20% of GDP by 2100, assuming no regional action is taken to mitigate or adapt to climate change (7). Climate change is expected to have negative impacts on coastal properties and their value through the loss and damage caused by sea-level rise, increased storm intensity, floods, and other extreme events, particularly in tropical SIDS (11). Due to high coastal exposure, storm surges further exacerbate tropical cyclone AAL in SIDS. Cayman Islands and Antigua and Barbuda have the highest relative AAL globally in relation to cyclone wind, whereas The Bahamas, Montserrat, and Dominica are at the highest relative risk with respect to storm surges (7).

Risks for coastal tourism, particularly in subtropical and tropical regions where many SIDS are located, will increase with climate change through increasing heat extremes, intense storms, and/or loss of beach and coral reef assets (11). Coastal tourism infrastructure and beach assets remain unquantified for most SIDS that economically depend on coastal tourism. One projection, however, is that 1 m of sea-level rise could partially or fully inundate 29% of coastal resorts in Caribbean countries and render a substantially higher proportion (49–60%) at risk to associated coastal erosion (15).

An estimated 30 million people globally are nearly entirely dependent on coral reefs and their ecosystem services for their livelihood. Coral reefs are projected to decline by 70–90% at warming levels 1.5°C and larger losses (>99%) at warming above 2°C (11). Further negative effects are expected in the fisheries sector, as well as for the tourism sector, as coral reefs serve as recreational attractions in several tropical islands.

Climate change is recognized as one of the most important factors affecting agriculture water supply and food security in SIDS (51). Risks include instability of food supply, disruption to

²AAL are estimated economic stresses due to climate change.

Table 2 Current impacts and projected risks to natural and human systems

	Climate change impact (11)	Risk at 1°C (17)	Risk at 1.5°C (17)	Risk at 2°C (17)
Ecosystem				
Coral	Negative	H	VH	VH
Coastal wetlands	Negative	M ^a	H ^a	H ^a
Mangrove	Negative	U	M	M
Human system				
Fisheries	Negative	M	H	VH
Tourism	Negative	U-M	M	M

^aThe specified data use coastal flooding risk provided in Reference 17.

Abbreviations: H, high; M, moderate; U, undetectable; VH, very high. (11, 17).

food access, and changes to crop yield and food availability (52). On many small islands, including SIDS, freshwater stress is expected to occur as a result of projected aridity change (19). SIDS are particularly at risk due to the large proportion of the population whose livelihoods are dependent on agricultural production. Several SIDS rely on high-value crop production such as bananas and plantains as significant contributors to labor and livelihoods (51). These crops are adversely affected by hurricanes, floods, and droughts, and those impacts are expected to become more extreme with climate change. Further threats include fungal diseases, which threaten the sustainability of banana industries in SIDS. Due to the sector's heavy reliance on freshwater, agriculture is particularly vulnerable to potential reductions in freshwater availability in the future.

It is expected that climate change will increase risks for human health (17). Of particular concern to SIDS is the increasing risk of vector-borne diseases including malaria and dengue fever, with potential shifts in their geographic range, prolonged transmission seasons, and increased biting rates (7, 20). There is also increased risk of food- and water-borne diseases such as cholera with the possibility of shifting geographic and seasonal distribution. Undernutrition from reduced food production is expected due to increased temperatures, precipitation changes, and increase in frequency and intensity of extreme weather (7). These adverse health risks will be particularly acute in low- and middle-income societies, which include SIDS. Higher temperatures are expected to adversely affect the health of some island inhabitants who already suffer through heat waves and associated increased outbreaks of vector-borne diseases (7). Due to the relatively small natural variability of temperatures in tropical SIDS, there is potential for elevated risks to human health from increases in average temperatures as well as increases in the number of extreme temperature events (17) (Table 2).

4. ENVIRONMENTAL PSYCHOLOGY: KNOWLEDGE, AWARENESS, AND PERCEPTIONS

Given the extent of impacts and risks facing SIDS, one must understand how different groups within SIDS experience and think about these challenges. Environmental psychology explores knowledge, awareness, perceptions, concerns, and behaviors to climate change for different groups. These studies aid in identifying which groups are most at risk to climate change, as there are differential vulnerabilities and exposures among the population in SIDS (53). Environmental psychology research also provides information on how potential adaptation strategies may be best formulated for different groups (54). This field of research has developed significantly in the past two decades, particularly for SIDS. Studies have focused on knowledge and behaviors to the

greatest extent with a smaller number of studies examining perceptions and concerns—at times using these terms interchangeably.

In terms of knowledge about causes and consequences of climate change, case studies find that many residents of SIDS have high levels of awareness of climate impacts (54, 55). For example, a study of fishers' knowledge of climate change in the Caribbean found a high level of awareness that deforestation and burning of fossil fuels lead to climate change (56). In The Bahamas, young females were found to have a high awareness of climate change (57), whereas in St. Vincent and the Grenadines, farmers recognized a difference in weather patterns (58). Awareness of climate change is affected by numerous factors, with different studies finding that those with higher levels of education and wealth, as well as younger people, have increased awareness (39, 59–61). Awareness of climate change is also lower in some rural communities (62).

Other studies have focused on the source of knowledge about climate change, as this helps to identify avenues to disseminate information to vulnerable communities. In the Caribbean, the most popular sources are friends, neighbors, and television, and the Internet is the least cited source (56). Religious leaders are also trusted sources of information about climate change adaptation (55).

In terms of barriers to knowledge, a common theme is the lack of accurate knowledge about climate change. In their study of the Caribbean, Vignola et al. (63) indicated that people have limited understanding about the scientific underpinnings of climate change. Additionally, a study on Fiji Islands shows that any unexplained natural hazard is attributed to climate change, indicating that knowledge of climate change is not always accurate or fully understood (39). This is also highlighted by Altschuler & Brownlee (55, p. 625), who found that some residents “used global climate change as an explanation for broad social-ecological change,” instead of attributing the causes to local practices. Betzold (62) found that at times there can be a language barrier in disseminating information about climate change and adaptation measures, as translations could mean multiple things. In the Oceania context, a barrier to knowledge was that people lacked access to the central government and are geographically distant from government offices, making it difficult to be well-informed about government policies (62).

There is also growing literature on perceptions of climate change among SIDS residents. Perceptions often refer to a person's thinking or belief about an issue. The research has addressed and documented thus far four areas. First, studies have examined examples of actual perceptions or concerns about climate change among different social groups. Baptiste (64) reported on the perception of climate change and the way it should be addressed in the Caribbean, specifically among scientists, policymakers, and fishers in Trinidad and Tobago. Scientists viewed climate change in the global context, having local impacts such as irregular weather patterns, sea-level rise, and coral bleaching that affect fishers' livelihoods; policymakers were more focused on the fishing community and the potential need for alternative livelihoods as climate impacts increase (64). Another study on fishers' perceptions showed that their perceived effects of climate change are mainly “related to changes in wave and tidal patterns, changes in fish migration patterns (fish species), changes in storms, changes in sea surface and air temperatures, and changes in sea level (coastal erosion)” (65, p. 48). Other studies note that climate change is not always seen as a pressing issue among local SIDS populations. Along with environmental concerns, people worry about their daily lives and invest more resources into addressing these issues of immediate concern rather than perceived climate change impacts (60).

Second, some studies have looked at factors that influence perceptions. Residents' perceptions on the impact of climate change on their environment and livelihood depend on their environmental knowledge and awareness as well as their view of the risks (55). Smith's (58) study of farmers in St. Vincent and the Grenadines found that factors that influence perceptions include religion,

whether or not climate impacts are experienced, knowledge, and lack of information. Once impacts are experienced, a person is more likely to have adaptation measures in place (58). Chandra & Gaganis (39) also found that people think that natural hazards are related to religious beliefs. The authors indicated that “in hindsight, increasing incidence of natural disasters were related to religious scriptures, particularly as signs of an ending world” (39, p. 263). Another group of studies found that perception is based on intuition and experience rather than on scientific information (57). Some groups did not respond to the environmental changes that they saw, given climate change was seen as a distant problem (57, 62). For example, Smith (58, p. 83) indicated that even if there is risk perception, people do not necessarily adapt, because “persons are often of the belief that the system will not affect them.” Moreover, Baptiste (64, p. 71) indicated that “fishers saw climate change as something that was beyond their control or inevitable.”

Third, a few studies have examined which stakeholder is perceived as being responsible for responding to climate change. In Jamaica, fishers believe that they are not responsible for causing climate change nor for resolving the issue; rather, they believe that the government and environmental organizations should be responsible (56). This sentiment about government responsibility was seen to be a common perception in other studies (63). For example, in a study of national-level policies to climate change in the Caribbean, Robinson (66) stated that that private sectors think that climate change is the government’s responsibility. Similarly, in The Bahamas, residents see the local government as being responsible for climate change (59).

Finally, studies have looked at how perceptions influence action to respond to climate change. In St. Vincent and the Grenadines, farmers’ “lack of intention to adapt can also be linked to different forms of perception that are related to their experiences, lack of knowledge, and spiritual beliefs” (58, p. 74). Smith (58) points out that attachment to place and poverty are barriers to adaptation. Vignola et al. (63) and Kuruppu (67) similarly found that adaptation is influenced by religious beliefs. “Faith that God would not allow climate change to damage islanders’ livelihoods often serves as a justification for inaction” (62, p. 485). Although not explicit, it can be implied that the framing of climate change can also encourage or hinder adaptation. For example, viewing the problem as an economic or development issue rather than environmental challenge affects how the problem will be addressed (66).

5. ADAPTATION PLANNING AND IMPLEMENTATION

Füssel (68, p. 268) defines adaptation planning as “the use of information about present and future climate change to review the suitability of current and planned practices, policies, and infrastructure.” Adaptation planning processes are commonly described as a series of sequential steps (69) or as an iterative planning cycle (70, 71). Central to these framings are the concepts of iteration and context. The iterative nature of adaptation is stressed in both academic literature and practical planning approaches (72) and reflects the dynamic, ongoing nature of climate change and the evolving context in which adaptation occurs. As adaptation is specific to a given place, adaptation planning must account for the risks to climate change driven by biophysical, sociocultural, and economic characteristics, and implementation must reflect the unique contexts that can facilitate or constrain the effectiveness of adaptation actions. Many adaptation planning frameworks and guidance documents (69, 72, 73), including those shaping much adaptation planning in SIDS, emphasize the importance of detailed preparatory work, including capacity, awareness, and consensus-building, as well as a thorough assessment of current and future vulnerabilities. Indeed, such steps which build adaptive capacity can reduce the risk of maladaptation (74) and are essential before adaptation options can be considered, prioritized, and implemented. Monitoring and evaluation has gained increasing attention as an important stage of adaptation planning (75, 76). It

National Adaptation Plans (NAPs):

means for countries to systematically identify medium and long-term adaptation needs under the United Nations Framework Convention on Climate Change

Nationally Determined Contributions (NDCs):

national plans for reductions in greenhouse gas emissions under the United Nations Framework Convention on Climate Change

presents numerous distinct challenges (77) for practitioners and, in response, a growing number of resources have been developed.

Processes of planning and implementation can be undertaken at a variety of spatial scales from regional, national to subnational, community, household, and even individual levels (78, 79). The past decade has seen the emergence and growth of adaptation planning and implementation activity in SIDS, consistent with a broader trend occurring globally to formalize understanding of climate change impacts and to set out practical responses (72, 80, 81). This increase in adaptation efforts reflects the urgency of climate change but is also a push from donors to frame adaptation investments in the context of a clearer, longer-term adaptation planning framework.

The starting point for formalized adaptation planning for many SIDS has been the development of a National Adaptation Programme of Action (NAPA), which enabled least developed countries (LDCs) to identify priorities for addressing the most urgent climate impacts (82). Under the UNFCCC Cancun Adaptation Framework, a process was established to enable LDCs to formulate and implement National Adaptation Plans (NAPs), providing a means of systematically identifying medium and long-term adaptation needs and building on their experience in preparing and implementing NAPAs. The integration of NAPs with other key policy frameworks is also important, for example, Nationally Determined Contributions (NDCs) and NAPs can be complementary and mutually supportive if well-coordinated (83). Although relatively few SIDS have formally submitted a NAP to the UNFCCC NAP Central repository, many have developed equivalent national adaptation planning documents (27). In the Pacific, for example, there has been a trend toward developing Joint National Action Plans, which bring together climate adaptation and disaster risk reduction (DRR) in a single coherent framework and effectively fulfil the role of a NAP (84).

A major challenge for many SIDS has been to enhance the horizontal and vertical reach and connectivity of adaptation planning to link to subnational and sectoral planning and implementation efforts. An extensive review of adaptation planning documents across the Caribbean found that most SIDS within the region are actively engaged in adaptation planning but that this was largely concentrated at the national scale (80). This may be indicative of a broader challenge of linking national-level adaptation processes to practical implementation of adaptation actions. In their global review of NAPs, Woodruff & Regan (85) found that plans were generally weak in articulating implementation and monitoring measures, which may be required to translate plans into action and to monitor progress.

The focus of regional adaptation efforts tends to be through the provision of support and coordination at the national level with the extent and focus of such support varying considerably across and within the three SIDS regions. These differences may result from a combination of geography, regional governance, institutional capacity and investment, and socioeconomic and cultural ties which may bind some regions, and subregions, more, or less, closely together. In the Caribbean, the Caribbean Community provides a framework for improved integration and cooperation at a political level, and the Caribbean Community Climate Change Centre (CCCCC) provides practical support and coordination (80). In the Pacific Region, the Framework for Resilient Development for the Pacific brings together adaptation, mitigation, and DRR into a single coherent regional framework (86). The Secretariat for the Pacific Regional Environment Programme (SPREP) leads regional-level adaptation support in the region, but is supported by the work of the Pacific Community, the University of the South Pacific, and others. This enhanced regional coordination has led to the development of tools and web portals to support adaptation. For example, the CCCCC has developed the Caribbean Climate Online Risk and Adaptation Tool to assist users in identifying appropriate adaptation actions and recommends four end-to-end climate risk management tools to support adaptation planning (8). In the Pacific, SPREP has established

the Pacific Climate Change Portal as an information repository and a home for regionally relevant tools.

A wide range of adaptation options can, and have, emerged from adaptation planning processes, as detailed in **Table 3**, and vary depending on their local context. However, as highlighted by the IPCC, limits to adaptive capacity exist at 1.5°C of global warming and become more pronounced as warming increases (15). This is especially true in SIDS, where physical limits may be reached in a matter of decades due to the low-lying nature of islands and atolls and where geographic isolation and small populations can reduce the economic feasibility of actions.

Numerous studies focus specifically on the implementation of adaptation action in SIDS (66, 94–96). In a review of 16 SIDS, Robinson (66) found vulnerability and impact assessments to be the most common action, suggesting a focus on earlier, preparatory steps within the adaptation cycle. Many examples of subnational and community vulnerability assessments can be found in SIDS. Yet, interestingly, Thomas et al. (80), in their Caribbean-focused study, found that despite being a key stage in adaptation planning, inclusion of hazard, impact, vulnerability, or risk assessments (HIVRA) were at best patchy. In 22% of adaptation planning documents, there was no reference to such assessments, and only 9% of the documents conducted a primary HIVRA focused on the particular adaptation plan. This reinforces the view that more needs to be done to connect the results from local or sectoral vulnerability and risk assessments to adaptation planning processes, especially at the national level.

The translation of national-level adaptation to specific sectors is an important step toward implementation of practical adaptation actions, yet within SIDS there has tended to be a relatively narrow range of sectors considered, with a typical focus on coastal zone, agricultural, and water sectors (80). There is a logic to prioritizing those sectors either facing the most immediate impacts or who have already begun adaptation planning; however, there is an evident need to more systematically engage sectors and to ensure that synergies between sector-level adaptation actions are maximized. Given limited progress in this area, attempts to integrate adaptation planning into sectors in SIDS can yield valuable lessons. Grenada's approach to integrating adaptation planning across sectors highlights the value of using national adaptation planning to link national policies to local and sectoral activities and emphasizes the importance of establishing clear, cross-sectoral institutional arrangements and the need to invest in the capacity of these institutions (97).

Other studies have examined types of adaptation measures that are used by different stakeholders in SIDS at the local level, largely focusing on specific livelihoods (61, 98, 99). For example, fishers in the Caribbean have adapted to climate change by going further out to sea, reducing the number of fishing days, and changing the type and site of fishing (56, 65). However, it is largely the wealthiest fishers that have the resources available to implement these strategies. Additionally, some specific adaptation measures that farmers use are contouring, irrigation, and replanting (58).

Despite the rise in adaptation strategies at multiple scales in SIDS, there remain significant barriers to effective implementation, which are well described in a range of literature and highlighted in **Table 3** (62, 81, 100). In their global-scale analysis of predictors of national adaptation actions, Berrang-Ford et al. (101) identified institutional good governance as a critical prerequisite for national adaptation action. Mackay et al. (102) identified the lack of governmental policies and institutional partners as one of the barriers for climate change-integrated knowledge management and by extension adaptation. This provides a timely reminder to SIDS of the need for such critical institutional building blocks to be in place in order to make effective use of climate finance opportunities. Betzold (62) also highlights institutions as a key barrier to adaptation in SIDS, finding that religious leaders have considerable latent potential in terms of community outreach and influence (103).

Table 3 Examples of adaptation options, barriers and limits in small island developing states

Adaptation option	Risks addressed	Barriers	Limits
Ecosystem-based approaches: coral reef restoration, mangrove replanting	Coastal erosion, loss of biodiversity, coastal flooding from storm surges	Competing land uses (e.g., tourism versus mangroves) Non-climate stressors on ecosystems, reducing effectiveness (87)	Biophysical limitations relating to ocean acidification, ocean temperature, sea-level rise, and species adaptation are likely to arise during the twenty-first century (41, 88). Economic and social barriers arise well before the end of the century (41). Space and competing land uses (89). Increases in extreme events (e.g., marine heatwaves) leading to catastrophic events (e.g., mass mangrove die-off) (90).
Strengthened building codes, retrofitting of infrastructure	Damages from tropical storms	Costs Governance (including compliance) Political and public acceptability Trade-offs with short-term development priorities (91)	Increases in extreme and unprecedented events (11).
Sea walls, groins	Coastal flooding	Costs/cost-effectiveness Potential displacement of impacts Political and public acceptability Adverse impacts on biodiversity and natural systems (91)	Prohibitive costs (including maintenance) linked to economic, financial, and social barriers. Technical limits to hard protection are expected to be reached under high emission scenarios (RCP8.5) beyond 2100 (41).
Climate resilient agriculture	Declines in agricultural production (reduced yields) Increased food insecurity Exposure to food price spikes	Social and cultural acceptance of new techniques and crops Increasing reliance on imported food products (links to cultural change and social preferences) Small population size reduces commercial viability of adaptation options (92).	Multiple interacting impacts reduce adaptation options (e.g., drought, extreme heat, and soil salinization). Loss of agricultural land. Climate-related migration leads to demographic change/changes in the capacities of agricultural labor force (38).
Rainwater harvesting	Freshwater stress	Predominately household level	Does not overcome related freshwater issues, e.g., salinization of freshwater lens in low-lying atolls.
Ridge-to-reef and whole-island approaches	Multiple impacts and interconnected stressors	Complexity Public and political acceptance Requires high level of commitment Trade-offs will be exposed (93).	Less likely to face limits than isolated adaptation options due to holistic approach (e.g., changes in agricultural practices can reduce impacts of run-off on reef systems).

Climate information, and more specifically, evidence and tools, is a further challenge for adaptation in SIDS (104). In some cases, these relate to a lack of information, including data coverage or spatial scale, but also often relate to weak information knowledge management (102). There is an increasing appreciation that the provision and management of information and knowledge alone is insufficient to support effective adaptation and, consequently, there is expanding literature on climate knowledge brokerage and strengthening the science-policy interface in SIDS (105–107). Knowledge brokers act as filters, interfaces, and translators between knowledge producers and users (105) and play a vital role as trusted sources of contextually relevant climate information across different disciplines, fields, and sectors. There appears to be a growing appreciation of the importance of knowledge brokerage in SIDS in both the Caribbean and the Pacific, yet there remain very evident gaps in mapping and supporting knowledge brokers (108).

As some of the most vulnerable nations to climate change, SIDS have a compelling need for climate finance as a critical enabler for enhancing adaptation planning and implementation. Evidence to date suggests that international adaptation finance flows have been insufficient and that SIDS have faced challenges in accessing finance (109). In some SIDS, there can be little doubt that multiple international reporting obligations, adaptation planning, project development, and implementation commitments combine to form bottlenecks within capacity-limited government institutions responsible for climate change (29). Furthermore, lack of funding acts as a barrier, as it influences the extent to which adaptation programs could be implemented at both local and national levels (109, 110). An inability to track adaptation efforts remains a barrier to adaptation in many SIDS (85, 104). Numerous studies emphasize the need to understand the long-term effectiveness of adaptation in SIDS and what works, in which contexts and why (77), and for suitable long-term systems to be in place to enable this to happen (29, 81). Such learning is critical to an iterative, context-appropriate adaptation process that responds to national and subnational needs.

6. TRENDS IN MITIGATION

Although SIDS are at high risk to climate change and attention has been focused on adaptation, SIDS have also made advancements in mitigation. NDCs of SIDS highlighted existing and proposed mitigation efforts, with many providing ambitious goals for reducing greenhouse gas emissions. However, these documents also highlighted that their emissions have been negligible on a global scale—less than 1% of global emissions come from SIDS—and that the majority of emissions in these island nations arise from importation of fossil fuels (111). Thus, many SIDS focused on ways to convert to renewable energy, with a few countries committing to converting 100% of their energy supply to renewable sources. In addition to reduced emissions, shifting to renewable energy can be a DRR strategy as these forms of energy do not rely on externally supplied fuels to be shipped in to disaster areas where ports or electrical supply infrastructure may be damaged (112). Another perceived benefit of shifting to renewable energy is the opportunity to become energy sovereign and reduce reliance on costly imported externally sourced fossil fuels (113). However, the shift to renewable energy sources does not automatically result in self-sufficiency. There may still be a need for externally sourced technology and expertise to operate and maintain renewable energy infrastructure in SIDS (112).

Numerous SIDS have also vocalized goals of becoming carbon neutral. For example, the Maldives has expressed their desire to become carbon neutral by 2030, and Dominica has stated their goal of becoming carbon negative by 2020 (112). However, the reliance of many SIDS on tourism as a key economic sector makes carbon neutrality challenging. In many cases, tourism in SIDS is carbon intensive, due in part to the emissions associated with transporting tourists via air and sea to island destinations (114). However, there have been national initiatives aimed at

assessing the carbon footprint of tourism activities within islands and taking measures, such as improved energy efficiency, to reduce emissions (115).

Some of the very characteristics of SIDS also contribute to making mitigation challenging. Limited economies of scale makes initial investments in renewable energy expensive while low levels of economic development result in only medium to upper class citizens being able to afford renewable energy systems (113). Other barriers to renewable energy in SIDS include the need for new policies, regulatory frameworks, and research and development to ensure that technologies are adapted for specific national contexts (113). The need for human, technological, and financial support to achieve mitigation goals was also highlighted in many of the NDCs submitted by SIDS (111).

7. LOSS AND DAMAGE

Loss and damage is an area where SIDS have been particularly active in the international climate policy arena. Although loss and damage is understood in different ways by different groups, it can be loosely defined as adverse impacts of climate change that occur despite adaptation and mitigation (116, 117). At the very onset of the UNFCCC, SIDS advocated for loss and damage to be included in the Convention and have continued to be strong advocates for loss and damage to form the third pillar of the UNFCCC, along with mitigation and adaptation (118). Most SIDS included the need for the UNFCCC to address loss and damage in their NDCs and detailed both existing and projected loss and damage due to slow onset and extreme events (27). Research on this issue with a SIDS focus has explored the trajectory of how loss and damage has been handled within the UNFCCC (118–120), the status of national policies and mechanisms that include loss and damage (27, 121, 122) as well as noneconomic loss and damage and human rights (123, 124). These studies highlight that loss and damage is a critical issue for SIDS that face significant risk from climate change, but also that there is much work to be done at both international and national levels to develop strategies to avert, minimize, and address loss and damage in SIDS.

Loss and damage has a close relationship with limits to adaptation. This is well illustrated through discussion of climate-induced migration in SIDS. As the impacts of climate change become more acute and risks are projected to increase, there has been much exploratory research on climate-induced migration. Within this context, it is recognized that residents of SIDS may migrate for a host of reasons, including for better livelihood options and increasingly due to sea-level rise (41). However, many islanders view migration as a last resort that would come after limits to adaptation have been reached, such as the failure of ecosystem-based adaptation and hard infrastructural measures to protect against sea-level rise and coastal erosion (123–125). Thus, climate-induced migration can be viewed as a response to loss and damage that would be incurred after limits to adaptation have been surpassed (11). Some SIDS, particularly in the Pacific, have begun to consider climate-induced migration. For example, the Federal Republic of Marshall Islands 2050 Climate Strategy identifies elevation of assets, consolidation of population to elevated islands and relocation as options under consideration (126), whereas some SIDS such as Kiribati have already purchased land in other countries to facilitate migration (121).

8. CLIMATE JUSTICE

The term climate justice offers a normative framework that reconceptualizes anthropogenic climate change as a political and ethical issue, rather than one that is purely environmental or physical in nature, that can be addressed solely by scientific intervention and rational planning. It is no surprise that SIDS are now at the forefront of climate justice debates, given their disproportionate

risk to climate change compared to their historically negligible contribution to global greenhouse gas emissions. These countries experience what Füssel & Klein (127) refer to as a double inequality, where they have contributed little to the overall causes of climate change, while demonstrating a low capacity to resist or recover from its effects. Ideas around climate justice have thus emerged and coevolved as both a field of political activism and academic enquiry for SIDS and other developing nations that are now at the frontlines of climate change. This has spurred a coordinated response from the SIDS community aimed primarily at highlighting the unique and existential challenges small islands face because of climate-induced changes. The formation of AOSIS in 1990 represents the first and main mechanism used by small island and low-lying coastal developing states to lobby for changes within the UN system, particularly with regard to addressing the threats posed by global warming (118). Since its establishment, the coalition has been at the forefront of climate negotiations and has played an instrumental role in ensuring a strong focus on the justice implications of climate change for SIDS at the global stage.

By placing current day manifestations of climate change vulnerability in historical context, proponents of climate justice often point to the uneven and unjust effects of global warming, resulting in those who are least responsible for climate change suffering its gravest consequences. Added to this is a foregrounding of the historical and modern-day forces driving inequality and the way these forces create different vulnerability outcomes for different groups of people. A central theme in the climate justice literature is a recognition that future climate change impacts will be unevenly felt and will disproportionately affect those nations and communities that are least capable of responding to these threats.

Earlier writings on climate justice focused on climate change mitigation (128), which hinged primarily on notions of responsibility, particularly regarding who should be held accountable for the current levels of greenhouse gas emissions as well as liability and compensation over matters related to damage and loss induced by climatic changes. This has resulted in two main strands of discourses, one based more on distributive (outcome) questions of justice, and the other on procedural (process) notions of fair and just treatment (129, 130). Distributive justice posits that the benefits and burdens of climate change will be differentially distributed across space and time, requiring a redistributive response. Procedural justice, however, posits that fair distribution of the benefits and burdens of climate change (including society's responses to its threats) can only be achieved if all affected parties are involved in an equitable decision-making process (129).

Since then, debates around climate justice have expanded to examine a range of equity issues related to vulnerability, impacts, and just adaptation pathways (131). Tied to this shift is a growing recognition that global efforts to curb greenhouse gas emissions have so far been inadequate, and that even if drastic steps are now taken to reduce future emissions, some degree of future climate change is inevitable. Added to this is a growing recognition that there are ecological and societal limits to adaptation (92), and that even under modest rates of future global warming, adaptation may still not prevent all the impacts of climate change from occurring (132, 133). This has seen a growing body of work exploring the justice dimensions of climate adaptation. In general, these studies have raised important questions concerning the procedural fairness of climate adaptation policies and programs, including matters related to adaptation financing, participatory and rights-based approaches in the development of climate policy, recognition of the diverse communities being impacted by climate change, and the capacities required by these communities to deal with future climate impacts (134, 135).

The past decade has seen a small but growing body of academic literature explicitly linking SIDS vulnerability to climate change with climate justice debates (see, for example, 136–138). For the most part, these papers have focused on the redistributive or reparative implications of available climate mitigation and adaptation pathways for SIDS and are framed largely from the

perspective of a North–South divide. These studies have pointed to the limited progress made in international climate negotiations and climate financing so far, while recognizing the unique situation of SIDS. Although there have been some recognizable advancements made in global climate negotiations around notions of climate justice, for instance the inclusion of principles like “common but differentiated responsibilities” in the UNFCCC, there is a general recognition that international climate agreements have so far failed to provide an adequate avenue of redress for the SIDS community. The continued North–South divide over treatments of adaptation and loss and damage is a clear indication of the inability of the international community to arrive at a consensus on these key policy issues that are deemed of utmost importance for SIDS (119).

One of the most contentious issues currently relates to future emissions reduction targets, which has seen the SIDS community advocating for a cap of 1.5°C on additional global warming above preindustrial levels and inclusion of 1.5°C in the 2015 Paris Agreement (6). However, many uncertainties remain as to the extent of nation states’ commitment to the obligations embedded in this historic climate agreement, and whether the mechanisms set out under the final agreement are even sufficient to keep global warming to tolerable levels (139–141). Implicit in these projections, however, is the realization (and acceptance) that some future impacts are inevitable. In fact, even if all NDCs were to be realized, the world would still be on track to warm over 3°C by the end of the century (15). Such a scenario is likely to reach dangerous and irreversible levels with serious adverse implications for both human and natural systems worldwide, particularly for SIDS (15).

These discourses have triggered some discussion around the existential and developmental implications for SIDS, with the risk climate change poses with regard to the potential loss of territory, displacement of coastal settlements, and disruptions to national economies, placed front and center in ensuing climate justice discourses. Issues of climate mobility and displacement linked to current and projected sea-level rise have emerged as a key adaptation and loss and damage priority for numerous small and low-lying island states in the Pacific (142–144). Recent damaging impacts of hurricanes and other extreme climate events in the Caribbean have triggered questions around the justice implications and transformative potential of the post-hurricane reconstruction efforts that are unfolding across the region (145).

In general, many of the current climate justice discourses around SIDS are still largely organized around a range of distributional questions that consider the unequal burdens SIDS face in dealing with the consequences of global climate change. Although these studies have been useful in offering a normative framework that acknowledges historical responsibility alongside present-day inequalities, their theorizing of justice has tended to address justice claims from the standpoint of nation states. There is, however, growing recognition that these analyses are insufficient to understand cases of injustice and social movements that unfold below the nation state. For instance, a few studies have pointed to issues such as struggles over indigenous land rights and the uneven distributional impacts of climate financing, to show how already marginalized groups tend to benefit the least from adaptation and mitigation interventions. Likewise, initiatives such as the AOSIS “1.5°C to Stay Alive” campaign highlight the important role played by nonstate actors (including musicians and other artists) and social media in the climate justice movement.

Perhaps even more problematic is the limited treatment and acknowledgment of both intergenerational and interspecies forms of injustice in the current literature. Given that the impacts of climate change are projected to linger for centuries, there is a need for proponents of climate justice to consider the distributional implications for not only the current global population, but also for future generations. Likewise, there are calls for conventional theories of justice to attend to the threats climate change pose to nonhuman nature as well, including issues related to biodiversity loss and species extinction.

9. CONCLUSION

This review of recent research on SIDS and climate change has assessed the varied literature and factors that are helpful in understanding why these small island nations are so widely acknowledged as being particularly at risk to climatic change. Although SIDS vary in numerous ways, they do share some similar characteristics that lead to their recognition as being particularly challenged by climate change. The scientific literature is clear that hazards affecting SIDS have already increased due to anthropogenic climate change and that these hazards are projected to continue to intensify with higher levels of global warming. SIDS have high exposure to these hazards and the socioeconomic characteristics of these nations contribute to their acute levels of vulnerability. These patterns of hazards, exposure, and vulnerability across SIDS lead to a range of current impacts and projected risks that affect every aspect of life.

Although residents of SIDS may have high levels of awareness of climate change, such awareness and knowledge may not be scientifically accurate and may be conflated with other human activities. Many SIDS residents also view climate change as a distant problem that may be beyond their control to affect. Individuals in SIDS also view national governments as being primarily responsible for addressing climate change.

Adaptation planning and implementation in SIDS has been the focus of much activity and research, particularly at the national scale. National adaptation planning documents have been developed in many SIDS, but there is still room for integration with subnational and sectoral planning and implementation. Regional organizations such as CCCCC and SPREP provide adaptation support and enhance regional coordination while also developing numerous tools to support both planning and implementation. However, although there have been advancements in adaptation measures at both national and subnational scales, there are numerous barriers to adaptation that affect SIDS, including the need for institutional good governance, climate information, finance, and effective monitoring and evaluation of adaptation efforts.

Despite making negligible contributions to global greenhouse gas emissions, SIDS have also focused on mitigation. The NDCs of many SIDS focus on shifting to renewable energy, an opportunity to reduce emissions while also reducing risk to extreme events and moving toward energy sovereignty. Some SIDS have developed ambitious mitigation plans to become carbon neutral or even carbon negative. However, the need for human, technological, and financial support to achieve mitigation goals will need to be addressed.

In the international political arena, SIDS have been strong advocates for the inclusion of loss and damage in international climate discourses. These negative impacts of climate change are seen to pose significant threats for small islands and in some cases may lead to the need for migration—a response that is viewed as becoming necessary after limits to adaptation have been reached. The challenges of SIDS in advancing loss and damage in the UNFCCC are linked to issues of climate justice, which frames climate change as a political and ethical issue. Climate justice literature on SIDS has focused largely on the redistributive implications of climate change at the national scale and the significant North–South divide that is particularly evident in UNFCCC negotiations.

This review of climate change and SIDS has largely focused on insights at the national scale, in order to provide an overarching review of the many issues that are included in such a broad topic. However, there are a host of studies that explore the nuances of climate change within SIDS, as these challenges and responses are influenced by particular contexts and scales. SIDS are also recognized as places where there is much room for further research to understand how these small, developing nations will experience and address the significant challenges brought about by climate change.

SUMMARY POINTS

1. Patterns of increasing hazards, high levels of exposure, and acute vulnerability interact to result in high risk of small island developing states (SIDS) to climate change.
2. SIDS are already experiencing significant impacts, and risks are projected to be high, particularly due to tropical cyclones and sea-level rise.
3. SIDS have been strong advocates in the United Nations Framework Convention on Climate Change (UNFCCC) for increased ambition in mitigation, adaptation, and loss and damage and have also made progress in these areas at the national scale.

FUTURE ISSUES

1. As climate impacts increase in small island developing states (SIDS), additional research focusing on identifying these impacts as well as scalable ways to respond to these impacts will be needed.
2. Much research on adaptation in SIDS has focused on incremental adaptation, but there may be an increasing need to consider transformational adaptation as impacts increase. Research exploring the nuances of limits to adaptation and transformational adaptation in SIDS is required.
3. Intergenerational climate justice has become an area of global focus as citizens become more engaged. Research on intergenerational justice in SIDS, particularly in light of climate-induced migration, needs further study.

DISCLOSURE STATEMENT

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