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Balancing Climate Resilience and Adaptation for Caribbean Small Island Developing States (SIDS)

Building Institutional Capacity

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Abstract

Although the Caribbean's Small Island Developing States (SIDS) minimally contribute to global greenhouse gas emissions, they face disproportionate climate risks and are particularly susceptible to systemic economic threats posed by climate change and subsequent increases in climate variability. Historically, strategic programs and investments have sought to develop more robust and adaptive engineered systems to absorb climate threats. However, such initiatives are limited and under-resourced in the SIDS' context. This article reviews existing climate strategies in the Caribbean and then critically examines current gaps and barriers relating to climate impact knowledge, needs, and implementation. This examination can assist Caribbean SIDS leadership to identify opportunities to transition from a vulnerability-reducing mindset to one of resilience and transformative adaptation to improve long-term economic outlooks, social welfare, and environmental stewardship despite recurring and escalating climate risks.

Preface

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COL Christian Patterson was commander of ERDC, and Dr. David W. Pittman was the director.

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Balancing climate resilience and adaptation for Caribbean Small Island Developing States (SIDS): Building institutional capacity

INTRODUCTION

Research and experience have established that climate change poses a systemic threat to economic prosperity, social welfare, and environmental health across the globe. The geographic location and predominantly coastal development patterns of Caribbean Small Island Developing States (SIDS) make them particularly vulnerable to a range of acute climate shocks (e.g., high-intensity hurricanes) and chronic stressors (e.g., sea-level rise; Robinson, 2020). Recent climate-related disasters have triggered tens of billions of dollars in property losses, thousands of lives lost, and corresponding absolute declines in gross domestic product (GDP) for every hurricane that strikes the region each season (Galindo Paliza et al., 2022).

Caribbean SIDS are "far from homogenous" (Thomas et al., 2013, p. 6.2), but they share common elements including remote geographies and high coastline-to-land ratio areas, with much of the population and critical infrastructure systems located close to the coast (Vosper et al., 2020). Caribbean SIDS populations and physical infrastructure such as roads, air and seaports, utilities, and telecommunication are exposed to long-term environmental stressors, as well as to acute hazards including hurricanes, tropical hurricanes, and flooding (Mycoo, 2018; Thomas et al., 2013; Vosper et al., 2020).

In September 2017, Hurricane Irma damaged or destroyed approximately 95% of the structures on the island of Barbuda, 90% of the structures on Saint Martin, and 90% of the roads on Anguilla (Cangialosi et al., 2018). Two weeks later, Hurricane Maria struck the northeastern Caribbean—primarily Dominica, Saint Croix, and Puerto Rico—becoming one of the deadliest hurricanes in recorded history (Vosper et al., 2020). In September 2019, Hurricane Dorian left over 3000 homes in the Bahamas uninhabitable and damaged or destroyed hospitals, schools, and fisheries (Pan American Health Organization, 2019). Such hazards are predicted to grow disproportionately in the Caribbean (Vosper et al., 2020). Although climate models estimate that the global average intensity of Category 4 and 5 storms will increase by 5% under a 2 °C global warming scenario, the average intensity of Category 4 and 5 storms in the Caribbean will increase by 13% (Knutson et al., 2020; Spencer & Strobl, 2020).

Since the 1960s, hurricanes have accounted for approximately 95% of total natural disaster-related damages in the Caribbean (Burgess et al., 2018); however, various Caribbean SIDS also face seismic and volcanic activity threats. For instance, the 2021 Saint Vincent and the Grenadines volcanic eruption displaced between 20 000 and 30 000 people on the island of St. Vincent in the southern part of the Lesser Antilles (Andrews, 2021; Global Volcanism Program, 2021). In addition to such acute hazards and disruptions, Caribbean SIDS face increasing sea and air temperatures, mean relative sea level rise, projected increases in wave power, increased extreme precipitation, and long-term droughts, among other environmental stressors (Thomas et al., 2020).

Hazard-affected communities must address ecological, socioeconomic, and human health and welfare challenges that can emerge and cascade following a disaster. Longer-term considerations are particularly critical for Caribbean SIDS. Their specific social, economic, and historical challenges must be considered in the design and implementation of climate resilience and adaptation policies. Many SIDS rely on the natural environment for key economic sectors, including agriculture (Barker, 2012), fisheries (Lincoln Lenderking et al., 2021), and tourism (Arabadzhyan et al., 2021), and the economic stability of these industries is sensitive to environmental change (Thomas et al., 2020). Economic risks for the Caribbean SIDS are predicted to be higher than the global average of 0.5% average annual losses of GDP by 2030; their predicted average annual loss is between 0.75% and 6.5% of GDP in this timeframe (Thomas et al., 2020; UN-OHRLLS, 2015). This disproportionate impact on average annual GDP is in part attributed to their "… small population size, remoteness from international markets, high transportation costs, vulnerability to exogenous economic shocks and fragile land and marine ecosystems [which] make SIDS particularly vulnerable to biodiversity loss and climate change because they lack economic alternatives" (United Nations, 2022). Caribbean SIDS also face high import and export costs, given their remote geography, challenging economies during hazards as well as during "blue sky" conditions (United Nations, 2022). Such challenges reaffirm the need for both short-term resilience interventions and long-term adaptive capacities for guiding transformations.

Small Island Developing States stakeholders and the international community alike have articulated a need for resilience strategies to provide long-term improvements in societies' ability to respond to rising climate risks (Petzold & Magnan, 2019). In this effort, resilience refers to a system's capacity to recover critical functions and adapt following a disruptive event (Galaitsi, Keisler, et al., 2021), such as with resources, knowledge, and human and physical infrastructure that can support recovery after an acute event. What lingers are uncertainties about what form these resilience strategies should take and how to determine what assets and populations should be prioritized for investment. Investments in short-term resilience performance must be balanced with investments in long-term adaptations that offer broad opportunities for collateral co-benefits and risk reduction.

An institutional approach to resilience can begin by defining: (i) what systems must have some measure of resilience performance to what level of disruption and (ii) what types of outcomes are desirable postdisaster. While each state and community will produce unique answers to these questions, common elements include the systemic capabilities needed for basic service delivery and for facilitating societal adaptation to improve beyond prior baselines (Linkov & Trump, 2019).

This article explores the resilience concepts of bouncing forward and bouncing back following a disaster, and of resilience-by-intervention (RBI) and resilience-by-design (RBD). The concepts are illustrated using current climate policies and recent disaster responses in Caribbean states. We then outline future opportunities for internalizing these approaches for best results in an environment characterized by both escalating climate change and competition for external multilateral and philanthropic resources to support responding to the effects of climate change.

Conceptualizing resilience practice in the Caribbean

In a postdisaster context, the impacts may be both measurable and unmeasurable. Some of the impacts may be poised to produce further harm as people cope without critical services like electricity, clean water, sanitation, waste disposal, and safe housing. Residents who weathered the initial disaster can subsequently face heat stroke, disease transmission, and physical hazards, among others threats to well-being (Masood et al., 2021).

When critical systems fail, the effects can cascade into other systems and timescales that would not have otherwise been affected. For example, a person might become ill from unsanitary water, but this can become life-threatening if they cannot access care at the local hospital due to power outages or lack of medicine delivery. Furthermore, the same system outages affecting residents also affect important infrastructure, like hospitals, schools, communications, transportation, and other critical elements of the supply chain (Charles et al., 2022). After Hurricane Maria, over 3000 deaths in Puerto Rico have been attributed to the hurricane's impacts on already-vulnerable systems, especially the power outage that reduced hospital services, telephone communications, and government response capabilities (Rodríguez-Madera et al., 2021). Hospital outages in the Bahamas accounted for at least one death after Hurricane Dorian (Russell, 2019).

Conceptualizing strategies for recovery requires balancing the short- and long-term needs of a society, as well as resources for recovery and options for building capacity. The concepts of bouncing back, bouncing forward, RBI, and RBD provide distinct but complementary strategies for recovering from anticipated climate impacts that will likely escalate in the future.

"*Bouncing back*". To date, postdisaster recovery and resilience strategies in the Caribbean have largely prioritized recovering to the preperturbation state—what may be referenced as "bouncing back" (Sandoval & Sarmiento, 2020). The resilience of "bouncing back" implies that critical systems recover functionality at sufficient levels to prevent cascades, such as by addressing the emergency needs of the local population and systems.

Bouncing back can encompass prioritizing supply chains for emergency items, providing transport for essential workers, and ensuring sufficient fuel for hospital generators (Cortés et al., 2020). For example, in regions where bridges are likely to be affected, alternative routes could be available, such as backroads that do not support large trucks (Xu et al., 2021). Smaller trucks capable of navigating such backroads should also be available to carry emergency items; such trucks will be smaller in volume from normal shipping capacity. Similarly, accommodations and necessary infrastructure could enable emergency transport via small cargo planes. Such activities ensure that the provision of critical services and resources can continue even while a broader and more permanent recovery process is underway.

Planners must ask the question: What do we need to provide residents to protect their health, safety, and life? Thereafter, the challenge is to identify and foster disaster preparations and responses in order to provide these services as quickly as possible. For instance, when resources like clean water are reduced, bouncing back can mean directing limited resources to the places where they are most needed (e.g., first for drinking, then for cooking, then personal hygiene, etc.) (Klise et al., 2022).

Such a theory of resilience can extend beyond social systems and human survival to environmental systems that have a short window to prevent absolute destruction of sensitive habitats and natural capital (Ferro-Azcona et al., 2019). This might include agricultural, terrestrial, coastal, and/or marine systems that justify upfront efforts to protect long-term viability for the provision of ecosystem services (McPhearson et al., 2022). Important components of Caribbean economies, ranging from agriculture to tourism, rely on the local environment; some ecosystem services must be prioritized in emergency recovery responses. This will ensure that elements with the most consequences from disruption can bounce back before problems worsen, particularly as it relates to the absolute and irreversible loss of natural capital. However, preparing for changing future conditions requires moving beyond only "bouncing back" to "bouncing forward."

"*Bouncing forward*". In theory, bouncing back should meet the needs of postdisaster coping and survival. Activities to bounce back, such as the two-month US Operation Unified Response following the 2010 earthquake in Haiti, have saved lives and stabilized economic systems, but they do not address systemic problems that contribute to vulnerabilities to emerging climate shocks and stresses. Critical questions remain: Is the current systemic configuration one that is structured for appropriate responses to commonly expected disruptions? And, if not, what normative goals should states strive to achieve as they progress through postdisaster recovery and seek to adapt to a new ordering of resources and environmental conditions?

Small Island Developing States understand the need to go further: they seek to "bounce forward" in order to adapt systems to changing social, economic, and environmental conditions (Muñoz-Erickson et al., 2021). Recovery and adaptation processes often represent immediate opportunities to rebuild physical assets and reconfigure socioeconomic incentive structures that reduce risk and advance socioecological welfare. Small Island Developing States and other localities can cultivate a social and institutional culture that seeks to not only bounce back from climate-attributed impacts but also bounce forward.

Bouncing forward can entail investing resources to address parallel public policy goals that are often co-aligned with known vulnerabilities while balancing and advancing societal values like public safety, social welfare, distributional equity and procedural justice, and environmental sustainability (Chelleri & Baravikova, 2021; Hynes et al., 2020). Examples abound, such as significant investment into jobs diversification and training for households in Japan affected by the Fukushima Nuclear Disaster (Zhang et al., 2019), Paris' reconfiguration of its open space during the COVID-19 lockdown (Walt, 2020), and the Caribbean's restructuring of policies to anticipate climate stressors after Hurricanes Irma and Maria (Moulton & Machado, 2019).

Bouncing forward requires resilience-centered investments to adapt to future conditions tomorrow—often referred to as adaptive capacity (Siders, 2019). Examples could include moving electrical wires underground to reduce physical vulnerability from wind and reduce long-term utility costs or repopulating agricultural or riparian environments with more resilient vegetation and biomass that serve to mitigate flood risks in the short term and promote water quality, particularly for supporting tourism, in the long term.

Bouncing back and bouncing forward can be conceptualized as opportunities that can be enacted within traditional "recovery and response" phases of crisis planning and mitigation. They are both ways of expending resources to support social and environmental well-being. However, these resources must first be obtained, which merits the exploration of resilience, both by design and by intervention.

Resilience-by-intervention. Resilience-by-intervention is centered on interventions that are externally defined and resourced, in terms of the system affected, to promote resilience and recovery in the short term. Interventionist approaches, such as private aid groups or international organizations, rely upon transfers of resources and capital from one body to another (e.g., from other countries, philanthropic organizations, multinational emergency response agencies). Resilience-by-intervention supports system recovery (Galaitsi et al., 2022; Horton et al., 2022), but often at the direction or goal of meeting specific priorities of the external resource manager. This arrangement can effectively stimulate resilience in situations with clearly defined losses, and when those losses are of a relatively low resource cost for the external system. In other words, RBI is driven by tactical interventions with well-defined parameters of performance and resourced with the expectation of a return on investment discounted to reflect positive economic returns.

For the past several decades, Caribbean islands have nurtured strong relationships with philanthropic global donors who have supported recovery after disasters, in the form of funding, technical support, and resources. This is generally consistent with RBI to the extent that such donors have an interventionist approach that is more tactical than strategic with a sharp and narrow focus on a limited number of social welfare indicators: how many children are fed, how many schools are built (Salamon, 2014). Such funds are channeled through existing institutional frameworks or programs (e.g., the US Department of Commerce's Economic Recovery Support Function, as defined in the National Disaster Recovery Framework) and are often targeted for specific projects or activities.

Resilience-by-intervention disaster response strategies are practical and often necessary insofar as postdisaster communities lack the financial and operational ability to quickly meet the needs of infrastructural, humanitarian, and financial challenges. In theory, disasters can be a stimulus to completely overhaul and upgrade disrupted infrastructure systems (Cassim et al., 2020). In practice, RBI is often utilized as a rebounding mechanism—spurring recovery back to or not significantly dissimilar from predisaster system design in order to safeguard life-saving and life-sustaining activities at the lowest cost independent of lifecycle impacts and lifecycle costs (Hynes et al., 2020; Makara, 2021; Schweikert et al., 2020). Resilience-by-intervention is often limited in scope and often based on timely and costly standardized delivery processes that require conventional assessments that benchmark to the status quo before recovery funds can be allocated (Hynes et al., 2022). These limitations make it more difficult to address the long-term implications of recovery (Berke & Beatley, 1999). This leaves islands equally or even more vulnerable to the next disaster. Cross-sector cobenefits are more difficult to demonstrate in existing accounting frameworks. Infrastructural recovery projects, such as bridges or electrical grids, must fit donor prerogatives, and this may constrain a government's ability to invest in other projects that require more upfront capital costs in exchange for more robust resilience performance (e.g., philanthropic drive bouncing back vs. government-sponsored bouncing forward). In this sense, donors often support short-term results that are misaligned with the accrual of long-term resilience and adaptation co-benefits. For instance, the World Bank's post-Hurricane Maria funding for Dominica's recovery included resources for the Emergency Agricultural Livelihoods and Climate Resilience (World Bank, 2020). However, the designated interaction between these projects and programs—even from the same funder—hampered opportunities for synergistic long-term alignments. For instance, common infrastructural linkages associated with potable water and irrigation were overlooked. Partnerships between philanthropy, governments, and nongovernmental organizations like the World Bank, the Inter-American Development Bank, and others need to recognize a variety of short- and long-term co-benefits associated with any given capital investment.

Likewise, the scale of disaster recovery costs can eclipse the ability of external bodies to recover disrupted island systems independently and fully, leaving disaster-struck areas with insufficient resources to stimulate systemic recovery for dependent systems. As such, while shared pools of climate and disaster financing are a necessity for small states like SIDS, they are likely to become insufficient over time to facilitate island resilience to climate stressors that are increasing in their reoccurrence and magnitude. Such approaches tend to be reactive insofar as they fix a problem when it occurs without addressing the cause of the occurrence. Given the increasing costs of climate-related disasters, the availability of future resources for such interventions is likely to diminish for all geographic regions around the world, SIDS included, as competition for limited resources accelerates (Keenan, 2019). As such, complementary approaches to stimulate SIDS resilience must include self-organized components independent of interventionist assistance and logistics: RBD.

Resilience-by-design. By contrast, RBD is defined as the endogenous origination and resourcing of a system's interventions. This idea has been previously contextualized for pandemic response (Galaitsi, Kurth, et al., 2021), supply chains (Mahoney et al., 2022; Trump et al., 2022), and disaster recovery (Lee, 2016). These interventions are the product of self-organization and internal political priorities, and their activation is largely independent of externally defined values and economic returns. Resilience-by-design is focused on designing and resourcing such adaptive capacities to seek to provide greater societal and environmental co-benefits through transformative adaptation over the long term.

Where recovery through RBI requires the transfer of resources from one actor to another, RBD approaches incentivize the self-organization of systems by promoting internal system redundancies or adaptive capacities (Hynes et al., 2020, 2022). Resilience-by-intervention can be attractive to systems whose disruption would be particularly grave and where any downtime is unacceptable as a matter of life and death (e.g., hospital infrastructure). Resilience-by-design can include providing redundancy such as reserve resources or infrastructure components that can easily substitute for degraded or destroyed counterparts. Additionally, RBD adaptive measures may include management strategies that shift infrastructure operations when certain critical functions are performing inadequately. Resilience-by-design requires a risk-agnostic approach that identifies system brittleness and nested dependencies that may cascade into broader systemic disruption (Park et al., 2013). This contrasts with a risk-directed approach, where individual components of a system are hardened against specific hazards. In this way, RBD better positions systems against a wide array of possible threats by emphasizing rapid recovery and adaptation regardless of what system component is disrupted (Linkov et al., 2021). Likewise, RBD systems are better able to respond immediately to environmental change and are not reliant upon independent actors to assess disruption, gather resources for intervention, and agree to intervene (Trump et al., 2021).

The consequences of systemic disruption are socially, financially, and infrastructurally grave in the Caribbean SIDS, but crafting RBD strategies may help stimulate disaster recovery efforts far sooner than interventionism alone. External aid will likely remain vital to continued recovery, and to ensure that all segments of society receive necessary aid, but RBD can be a useful complement for SIDS climate strategy. However, uncertainties remain regarding (i) what direction RBD policies might be crafted and implemented and (ii) what endpoints should be emphasized for bouncing back and bouncing forward. The following sections of this article unpack selected examples of how resilience has been incorporated at various levels of scale among the SIDS countries, as well as how a fusion of RBI and RBD approaches could be better designed to foster maximal national resilience to future climate stressors.

The article argues that both RBI and RBD are contextually valuable approaches that offer reciprocal benefits, but that in the long term, RBD offers a superior capacity for effective, efficient, and fair adaptation. This is in part because it builds on internal processes for resourcing and negotiating priorities (Galaitsi et al., 2023; Trump et al., 2020).

Figure 1 shows the four concepts together, with quadrants representing different combinations.

Armed with this understanding of these concepts, this article now examines the state of climate-related strategies in the Caribbean.

Existing climate-related strategies in the Caribbean

Existing climate-related resilience strategies and initiatives in the Caribbean range from site-specific projects to national-scale initiatives. However, there is widespread consensus among internal and external stakeholders that these strategies are generally deficient, given the scope of disruptions expected with the acceleration of climate change. Caribbean SIDS have often either lost localized hazard mitigation knowledge or have failed to develop a strategic vision for how historic and existing climate resilience and adaptation interventions may scale across geographies and institutions (Mercer et al., 2012). Small Island Developing States can benefit from sharing knowledge about national plans and strategies, with the ambition of promoting experimentation, cross-learning opportunities, and shared resources. Table 1 presents a selection of recent climate-related resilience policies and initiatives that are intended to incentivize and/or regulate interventions across multiple stakeholders. Though nonexhaustive, these policies and initiatives help set the precedent for understanding the existing scope of RBI and RBD investments among Caribbean SIDS.

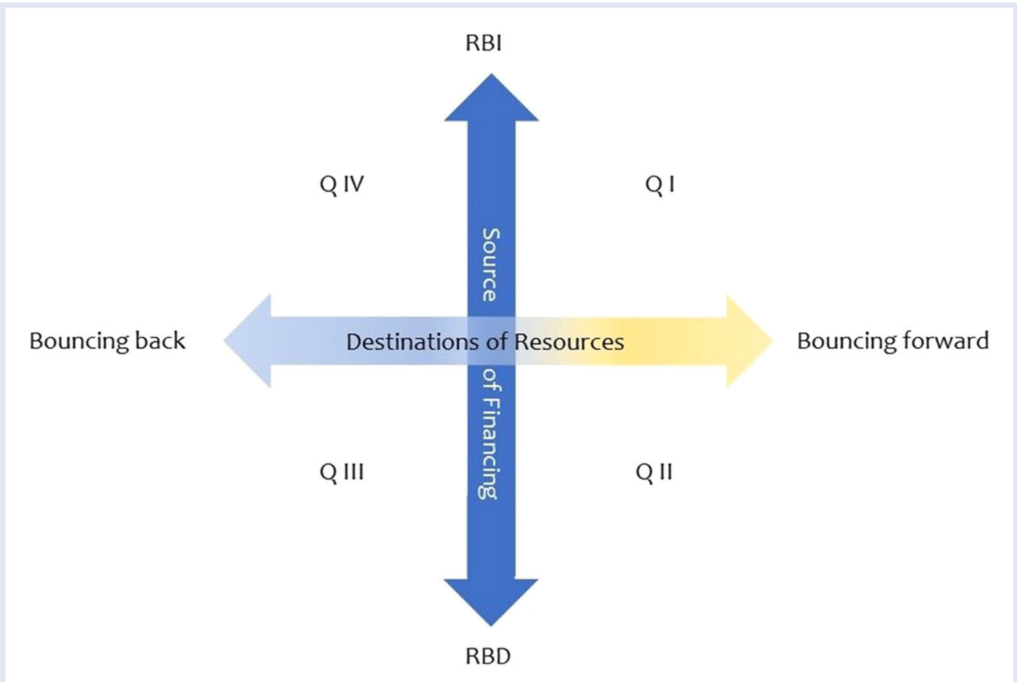

FIGURE 1 Resilience-by-intervention (RBI), resilience-by-design (RBD), bouncing forward, and bouncing back as interacting concepts for disaster response

TABLE 1 Review of climate-relevant resilience policies and initiatives in Caribbean SIDS

Location (unit of analysis)	Plan	Threats	Vulnerabilities	High-priority initiatives, actions	Measurable indicators	Resilience-by-intervention or resilience-by-design
Haiti	Haiti earthquake postdisaster needs assessment (World Bank, 2010).	Haiti's 2010 earthquake.	• High incidence of poverty. • Existing difficulties accessing food and public services. • Homes and educational, medical, governmental buildings could not withstand storm. Part of the Port-au-Prince's port was destroyed. • Pollution and environmental degradation.	• Prepare for the following rainy season by making victims of earthquake secure, and understanding and communicating risk. • Provide well-being, nutrition, and care to Haiti's children, as well as access to schooling and basic services. • Incorporate the environment within recovery efforts. • Incorporate risk and disaster management measures into the (re) construction process. • Encourage employment. • Reconstruct the state and economy to serve all the people of Haiti. • Relieve congestion around Port-au-Prince by incentivizing people to live further from the city center.	• Many indicators. Some examples: number of displaced persons without access to land, number of reconstructions meeting building standards, number of national and local companies involved in reconstruction.	Resilience-by-intervention
Saint Vincent and the Grenadines	St. Vincent rapid environmental impact assessment, May 2021.	2021 Volcanic eruption of Soufriere volcano.	• Low ability of survivors to meet needs without recourse to additional direct extraction from the environment or external assistance. • Inequitable distribution of assets among population. • Many existing climate-related hazards. • COVID-19. • Others.	• Fuel. • Personal safety. • Domestic resources. • Waste management (liquid, solid). • Reduction of disease vectors. • Shelter. • Water. • Changes in environmental conditions, based on policies.	• Many indicators. Some examples: Water per person per day, kil-calories per person per day, fuel availability, shelter space, access to hygiene, health care.	Resilience-by-intervention

(*Continued*)

TABLE 1 (*Continued*)

Location (unit of analysis)	Plan	Threats	Vulnerabilities	High-priority initiatives, actions	Measurable indicators	Resilience-by-intervention or resilience-by-design
Dominica	Postdisaster needs assessment, Hurricane Maria, 2017 (Government of the Commonwealth of Dominica, 2017).	Winds, rain.	• The steep topographic conditions and rugged interior mean human settlements and physical development are highly concentrated along narrow coastal areas. • Underdeveloped infrastructure, including roads.	• Reconstruction of physical assets. • Resumption of production, service delivery, access to goods and services. • Restoration of governance and decision-making processes. • Reduction of vulnerabilities and risks.	• Retain skilled people within country. • Prepare residents to engage in value-added activities based on restoration of natural environment. • Support entrepreneurial activity. • Engage people in development of recovery strategies. • Seek support of diaspora community. • Resilience to climate change should be incorporated into new initiatives.	Resilience-by-intervention
Dominica (National)	"Climate resilience and recovery plan (2020–2030)" (Government of the Commonwealth of Dominica, 2020).	Hurricanes. Tropical storms. Sea level rise. Landslides/mudslides. Ocean salinity/ temperature. Volcanic activity. Earthquakes. Tsunamis.	• Limited land area. • Scarce freshwater supplies. • Dependence on tourism and coastal resources.	• Enhanced social safety net. • Community emergency readiness. • Resilient housing scheme. • Koudmen Domnik (conscious volunteer initiative). • Resilient Dominica physical plan. • Innovative insurance solutions. • Agricultural resilience practices. • Enhanced public sector performance management framework. • Institutionalize data-driven decision-making. • Blue economy investment fund.	• Computerized welfare system. • Plan emergency response actions and resources to equip the nation for 15 days per hurricane season per year. • Mapping vulnerable communities and retrofitting homes via low interest loans. • Coordinate volunteer projects. • Finance and plan for resilient critical infrastructure. • Hydrological surveys for natural and anthropogenic threat identification.	Resilience-by-design

(*Continued*)

TABLE 1 (*Continued*)

Location (unit of analysis)	Plan	Threats	Vulnerabilities	High-priority initiatives, actions	Measurable indicators	Resilience-by-intervention or resilience-by-design
					• Develop information and communications technology system for government service continuity. • Innovate and educate on private insurance schemes. • Develop a scientific approach to reduce agriculture and fishery vulnerability via resilience crops and infrastructure. • Budget-setting process and criteria to prioritize and weigh resilience-related indicators. • Establish geographical information systems for data-driven investment and planning decisions. • Leverage private sector investment.	
Grenada (National)	"Building capacity for coastal ecosystem-based adaptation (EBA) in Small Island Developing States" (United Nations Department of Economic and Social Affairs [2015]; United Nations Environment Programme [2015]).	• Degradation of coral nurseries via sea level rise, intensifying storms, land-based pollution, sedimentation, over-fishing. • Removal of mangroves for fuel, building materials.	• High population density. • Degradation of mangroves and coral reefs limits natural coastal protection. • Limited land area. • Scarce freshwater supplies. • Dependence on tourism and coastal resources.	• "Enhance and demonstrate integrated planning tools and technical guidance to assist decision-making and effective stakeholder consultation in the development of coastal EBA intervention." • "Support relevant authorities and communities where climate change already places intense pressure on human livelihoods and coastal and marine resources in the selection,	• Training coral gardeners. • Manuals for coral restoration methodology and for monitoring and evaluation. • Develop a strategic plan for surrounding areas.	Resilience-by-design

(*Continued*)

TABLE 1 (*Continued*)

Location (unit of analysis)	Plan	Threats	Vulnerabilities	High-priority initiatives, actions	Measurable indicators	Resilience-by-intervention or resilience-by-design
				planning and implementation of practical EBA measures." • "Support regional capacity-building and global transfer of good practices and experiences gained to other coastal regions as a means to scale up EBA development and implementation, including informing supportive adaptation policies, strategies and adaptation plans."		
Cuba (Municipal)	Caribbean risk management initiative.	• Natural disasters, such as hurricanes and tropical cyclones. • Climate change-related threats. • Difficulties associated with resettlement of individuals following disasters.	Frequent hurricanes and tropical cyclones (from January 2005 to January 2015, Cuba was hit by 15 tropical cyclones, of which 11 were classified as hurricanes).	• Develop "a new methodological and technological model for strengthening local capacity in risk management: a municipal-level risk-reduction center complemented by community early warning points." • Build and maintain risk reduction management centers that are "a new methodological and technological model for strengthening local capacity in risk management: a municipal-level risk-reduction center complemented by community early warning points." • Enable "communities to significantly reduce the impact of hurricanes by	• Number of centers built. • Number of successful relocated settlements. • Quantity of individuals protected as a result of risk management center predictions and information dispersal. • Cooperation between different localities and centers when it comes to actions to prevent or lessen the impact of hurricanes and disasters.	Resilience-by-design

(*Continued*)

TABLE 1 (*Continued*)

Location (unit of analysis)	Plan	Threats	Vulnerabilities	High-priority initiatives, actions	Measurable indicators	Resilience-by-intervention or resilience-by-design
				facilitating community awareness and preparedness."		
Anegada, British Virgin Islands (Local, Community)	The Anegada vulnerability and disaster risk profile	• Hurricanes, tropical cyclones, and other natural disasters. • Climate change-associated risks, such as flooding and sea level rise.	• "Insufficient capacity to manage climate disaster risk (hurricanes and tropical cyclones) due to its limited resources and its distance from Tortola." • Limited infrastructure. • Limited ability to provide services in case of disaster or crisis.	• Reduce injuries, loss of life, property damage. • Prevent the loss of livelihoods. • Prepare schools and communities for potential disasters.	• Develop the Anegada vulnerability and disaster risk profile. • Attain the SAFE school certification for schools where the pilot program was launched, which is awarded following an assessment of compliance with the School Health and Safety Policy. • Create the Anegada Zonal Disaster Management Team (AZDMT). • Establish cooperation among the AZDMT and the local community with the goal of increasing overall community preparation for potential disasters.	Resilience-by-design

Abbreviation: SIDS, Small Island Developing States.

There is potential for the initiatives in Table 1 to be scaled and translated to other SIDS. For example, the United Nations Environment Programme (UNEP) has initiated the project *Building Capacity for Coastal Ecosystem-based Adaptation in Small Island Developing States* in Grenada. This UNEP initiative aims to realign, better coordinate, and monitor Grenada's marine protected areas (MPAs) to protect ecologies within and dependent on coral and mangrove health. The initiative also aims to benefit local stakeholders and incentivize them to engage in MPA ecosystem-based adaptation interventions. From this multistakeholder perspective, the program is being utilized as a catalyst for broader strategic accountability for resilience planning (Scobie, 2018). However, Grenada is not alone in pursuing a national strategy.

The government of Dominica has spearheaded nationwide climate resilience and adaptation policies and initiatives, largely by way of the National Resilience Development Strategy (2018) and the Climate Resilience and Recovery Plan (2020–2030). Prompted by Hurricane Maria's intensity, damage, and the vulnerabilities that it revealed in 2017, Dominica aims to achieve sustainable communities, infrastructure, ecology, resilience culture, and economic growth considering current and future climatic, climate-amplified, and nonclimatic challenges. To achieve their defined "Climate Resilience Targets" by 2030, Dominica has outlined 10 multijurisdictional, cross-sectoral initiatives that incentivize behavioral change and intervention from the individual to national scales. It is noteworthy that the initiatives are intentionally measurable so that progress can be monitored. The place-based *Climate Resilience and Recovery Plan* considers Dominica's unique socioeconomic and equity vulnerabilities, indigenous perspectives, and public risk communications to inform the outlined strategies. Likewise, Dominica's approach is unique in placing resilience objectives as a whole-of-government effort, where all planning and project development must include resilience as a core function of any infrastructural or environmental effort.

Developing or improving national resilience and adaptation strategies will require engagement on the part of the countries' governments. The following sections identify and examine barriers to Caribbean SIDS's strategic adoption. It will also explore potential facilitators to implementation of climate resilience and adaptation policies and practices, including learning from more recent catastrophic extreme events, such as Hurricanes Irma, Maria, and Dorian. This exploration will underscore SIDS needs that should frame the strategic development of Caribbean climate resilience and adaptation moving forward. Below, this article explores the values that must be incorporated into resilience formulations in order to address societal needs, as well as the barriers inhibiting more effective RBD that could better support the SIDS in the face of growing climatic risks.

What societal values are necessary in Caribbean resilience formulations?

New frameworks for planning and disaster responses value the ability to address broader societal needs and values including equity, well-being, and sustainability (see the Sendai Framework and the United Nations' sustainable development goals). The concepts are themselves interrelated (Figure 2).

Below, we explore each in turn and identify how synergistic governance can prioritize societal needs by designing their systems to be climate resilient. These values are relevant both to bouncing back and to bouncing forward and can assist in the formulation of RBI and RBD policies under various scenarios of emergency.

Public safety and social welfare. A functioning government should be able to safeguard its people. Disasters are hugely disruptive to society in many areas, including economic, political, educational, health, innovation, arts, and others. As such, decision-makers allocating resources must weigh competing needs as they prioritize the short-term responses amidst longer-term societal planning. During disruptions, it is vital that the physical, psychological, and social well-being for broader society is prioritized to assure the continued functioning of society. Public safety matters most and efforts should plan for and enact emergency lifesaving initiatives as a key facet of resilience planning. Bouncing back after a disaster can include structuring the physical environment and policy environment to mitigate effects of the next disaster when it occurs. Ensuring not only the physical safety of communities but also their contentment and well-being implies greater satisfaction with the lives they live, which in turn could be a good predictor of societal stability and sustainability.

Distributional equity and procedural justice. After a disaster, decision-makers must prioritize responses to recover many different facets of society. While a traditional cost–benefit analysis might emphasize the importance of hotels and the tourism industry, an equitable response takes a more holistic view that considers factors like historical disadvantage, differences in resource access, vulnerable

FIGURE 2 Societal values for Caribbean Small Island Developing States resilience

members of society, and need. As such, equity weights can expand cost–benefit analysis to distribute resources more fairly through a re-evaluation of the fundamental proportionate impact of the distributed resources. Prioritizing responses and recovery using a distributional equity lens will address pre-existing imbalances and ensure that all parties' endpoints after the recovery are on more equal footing than before the disaster occurred. Likewise, communities should collaboratively determine these weights and impacts in the distribution of resources to ensure procedural justice at multiple scales and levels of decision-making. Ensuring equitable responses can be challenging, as it requires planners to identify barriers, some of which may be invisible, and some of which may have been intentionally constructed under a legacy of prioritizing other goals in development or disaster recovery. The existence of inequity may also reflect pre-existing biases of society, and thus efforts to correct them may not be well understood or valued by a broader audience. However, providing for equity in disaster responses assures better resilience for the communities that most need it, and can also build better capacity for resilience in the future.

Environmental sustainability. When allocating resources for resilience, decision-makers can create decarbonized systems that are environmentally sustainable. They can similarly encourage investments, including disaster relief funds from external actors, that support environmental resilience, which in turn can support the resilience of the SIDS populations.

Prioritizing these broader societal needs as a necessary overlay on other resilience requirements can further enable SIDS to achieve climate resilience and should be considered early and throughout the planning process.

What are the capacity barriers to RBD in the Caribbean?

- While existing research is limited, it has highlighted some barriers to building climate resilience and adaptative capacities (Kuruppu & Willie, 2015). According to an interview-based study by Robinson (2018), Caribbean SIDS policymakers reported that climate resilience policy and adaptive capacity were limited nonexclusively by finances, budgetary restrictions, and income.
- Technical capacity and resources.
- Data and records.
- Natural resources and features.
- Human resources, manpower, and turnover.
- Knowledge and understanding of climate effects, especially (to be) gained through research.
- The focus or scope of national policies, legislation, and regulations.
- Monitoring and evaluation, and enforcement capacity.

In the Caribbean, where resilience planning measures are developed, their implementation tends to stall. Thus, each new disaster requires reactionary responses and cannot rely upon proactive measures that would have otherwise reduced operational burdens on individuals and institutions. As represented in Figure 3, three key elements comprise current barriers that must be overcome to enable the implementation of RBD. This includes the translation of community experience and knowledge into the culture of higher-order institutions and the necessity to design flexible policies. These elements reflect a need for a culture of transformation in order to provide institutions with practical activities to craft and implement climate resilience and adaptation policies that are both flexible enough to account for shifting demands but also sufficiently mainstreamed to ensure accountability among stakeholders. There is a necessity for tools and analytics to provide and evaluate key performance measures. These can support evidence-based decision-making to guide response and recovery to climate-driven disruptions and to ensure the implementation of critical elements of resilience and adaptation planning principles and policies (Scobie, 2018). Providing these components and overcoming these barriers within the Caribbean SIDS context will support resilience.

Linking local community resilience culture to institutions. Caribbean island residents have strong awareness of the need for resilience and adaptation; indeed, residents are already adapting and building resilience in countless ways. The islands' geologic and geographic vulnerability to natural disasters requires residents to confront increasing regularized disruptions to daily life (Jerez Columbié & Morrissey, 2023). The challenge is to link local and scientific knowledge to organize and diffuse resilience and adaptation practices (Beckford, 2018). Capacity exists, by necessity, on personal and private scales, but needs to similarly manifest within planning and public institutions.

The significant frequency and scale of disruptions have ingrained a singular mindset of "recovery" as a common frame for many island communities. In 2022, the head of the International Monetary Fund praised "the exceptional

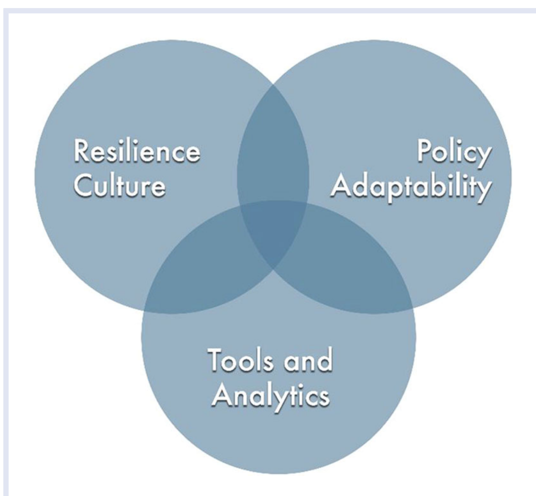

FIGURE 3 Barriers to overcome for resilience-by-design in the Caribbean Small Island Developing States

resilience that the people of the Caribbean and their economies have shown over the past couple of years." (Madden, 2022). At the local scale, measures of community resilience are well represented in the perseverance and adaptation of residents. This common culture is grounded in aspects of community resilience, a source of communal pride in overcoming adversity stemming from historic patterns of isolation and environmental fragility, as well as today's climate-attributed impacts. This local knowledge of resilience practices is critical for investing in and diffusing RBD, given the endogenous origins of these cultural capacities.

Given the islands' inherent vulnerabilities, there will always be a need to foster resilience culture within the local community. However, local community resilience capacities do not always translate in cultural terms to public institutions (Rapaport et al., 2018). This is an arguably necessary translation for the latent scale capacity of RBD. Here, the term institution refers to organizations or societal structures that serve the needs of the broader public, including those providing public infrastructure. As a practical consideration, efforts of community resilience at the household level following a disaster are inversely proportional to efforts by institutions to ensure that services like electricity, trash delivery, water, and sewage are restored as quickly as possible in areas where they had existed prior to the disruption. The resilience of institutions and infrastructure can reduce the burden for individuals, households, and communities (Cantelmi et al., 2021). Indeed, a failure to develop resilience culture for institutions can lead to individuals and local communities experiencing burnout and marginalization as circumstances repeatedly require resilience (Vercio et al., 2021). Current efforts to address inequity in the Caribbean islands, including low-cost housing, national health insurance, and employment opportunities, can be expanded and adapted to cater specifically to the needs of residents as they recover from climate-related shocks and stresses. Island institutions can leverage individual and local manifestations of community resilience (i.e., "resilience culture") to establish planning measures that cross various scales of society.

The success of resilience measures builds over periods that tend to be longer than expected returns for policy initiatives. This can be difficult to justify in a policy environment that emphasizes immediate challenges like sheltering, unemployment, and tourism development. Caribbean policies often rely on initiatives that address short-term needs, which sometimes counterproductively affect long-term sustainable solutions. For example, there are costs to protecting a mangrove that provides flood protection and ecological resilience, and those costs can be particularly hard to justify when tax revenues and economic growth can be stimulated within a shorter timeframe through hotel construction and tourism infrastructure recovery (Sheller, 2021). Furthermore, the mangrove's environmental performance and ecosystem services are uncertain because they depend partially on the weather and ongoing management strategies (Atkinson et al., 2016).

Resilience planning entails investing in managing in contingent benefits for an uncertain disaster, sometimes instead of investing in a clearly defined short-term and certain economic benefit. The latter are generally more attractive to policymakers and the private sector alike. Because governments make their investment plans in 3–5 year time horizons, large-scale resilience and adaptation benefits may not have enough time to accrue economic and political benefits for the government that implemented them. Investments in long-term adaptation that seek to bounce forward are even more economically constrained because the costs of transformative adaptation are often spread—in disruptive terms—to a narrow section of the economy that bears the burden of the transition (Keenan et al., 2021). The lack of mainstreaming resilience and adaptation into institutional context, particularly from local experiences, is a fundamental limitation for resourcing both RBI and RBD. This pattern has continued for decades, such that solutions that were viewed favorably decades ago remain in draft form today—long after their benefits would have accrued.

There are inconsistent incentives to unify public, private, and community stakeholders in adopting climate resilience policies and practices and a lack of effective intersectoral collaboration around mainstreaming. The economic dominance of certain sectors in the Caribbean, like tourism, requires government projects to have commitments from the private sector, as well as the labor force more broadly. Despite sophisticated planning, including global expertise captured in consultants' recommendations, proposed actions and policies can remain unimplemented partially due to insufficient participation from the private sector and/or support of the public.

For organic success in developing RBD, there is a need for private sector engagement in the policymaking process. Governments should seek opportunities to demonstrate that resilience and adaptation planning will positively impact not only the private sector's profitability but also their viability going forward. Engaging the private sector is critical for mobilizing latent structural capacities inherent in RBD approaches that are more flexible and responsive to changing conditions. For instance, private capital may be able to finance and develop critical risk mitigating infrastructure in a public–private partnership faster than the public sector alone (Queyranne et al., 2019).

Despite the challenges in implementing resilience projects, this region's planners have many advantages over planners in other parts of the world in terms of understanding the value of resilience. The contingency of "if" a disaster strikes is replaced by the inevitability of "when," which is a more suitable foundation for reducing investment uncertainty. Because disasters arise frequently around the Caribbean, most residents have personal experience and true expertise in a variety of different forms of resilience, including engineering resilience, ecological resilience, and community resilience (Meerow et al., 2016). Such experiences can also demonstrate the limits of risk management because no risk mitigation efforts are able to fully insulate the inhabitants from the increasingly large scale of the disaster's impacts. Resilience culture exists in the Caribbean; now it needs to be extended to institutions and to be monitored and evaluated over time.

Dominica provides an example of planning policies that enshrine the various values of resilience, even though rebuilding to climate-resilient building and engineering standards costs 25% more (Dorst, 2021). The benefits have already been demonstrated by infrastructure that is able to come online faster after storms and requires lower levels of capital investment following a disruption event. The planning also represents a complicated interrelationship between resilience and risk management concepts in Dominica's framework. For instance, the policies focus on buildings that may stand up to Category 5 hurricanes. Dominica's policy prescriptions have elements of both engineering resilience and disaster risk mitigation, but they lack connection points to broader user clusters to support community resilience (National Institutes of Standards and Technology, 2015). Building bridges higher to avoid debris overflow is similarly focused on engineering resilience, but it is not well connected to community resilience to the extent that strategic bridges shape population deployment and settlement patterns. In this sense, infrastructural capacities are not well aligned with spatial planning, particularly spatial planning that is consistent with sustainability goals (i.e., transformative adaptation in the built environment) (Zuniga-Teran et al., 2020). Nonetheless, the institutional investments being made in health, education, and food security may prove to enhance Dominica's community resilience over time, though the total effects will take years to measurably manifest.

Crafting and implementing flexible resilience and adaptation policies. Like much of the world, policy development in the Caribbean islands can be a lengthy process with bureaucratic or political hurdles. New and amended policies may not be implemented consistently, if at all. Policies that are implemented may not be consistently enforced or regulated, particularly for the private sector, which contributes to the gap between policy development and policy implementation. Climate resilience policies must be balanced with practical, on-the-ground solutions. Resilience efforts currently exist in silos for specific project sites (e.g., marine restoration sites) or quickly lose momentum if political actors disengage (Kentish, 2019) or if clear goals and indicators related to progress in achieving those goals are not transparent.

There are financial implications for developing and implementing resilience policies. Credit rating agencies that evaluate public debt and the issuers of that debt are increasingly active in evaluating not only the resilience-centered policies of issuers but more fundamentally, they are investigating the institutional capacity of issuers to learn and adapt from changing conditions and their capacity to adopt consistent policies over time that reduce the risk of their investments (Keenan, 2019). In this sense, issuers of public debt who have a strong institutional capacity to flexibly and consistent adapt their policies are rewarded with a lower credit risk assessment. Indeed, this may be understood as a situation where RBD capacities support the long-term resourcing of RBI investments. Comparing the cost-effectiveness and infrastructural integrity of investments within short- or long-term timeframes may also help clarify the benefits of climate-resilient investments to philanthropic donors and public finance investors, particularly in the context of RBI. Communicating benefits to internal and external stakeholders will be vital to developing and implementing climate-resilient policies that embrace both RBI-centered recovery and RBD strategic planning and climate adaptation. This requires a well-established framework for indicating, monitoring, and communicating results effectively to multiple stakeholders.

Climate resilience policies must be developed that are scalable to multiple sectors and jurisdictions. Project implementation may require the harmonization of multiple decision-making scales, including the subregional and regional scale that encompasses many island governments. However, the national governments may be best suited to support these types of projects, though governments need collaboration from other scales, including at the individual and household levels. In addition to long-term planning, adaptation, and developing actionable policy goals, individuals' behavioral choices are also vital to both effective and flexible policies. For individuals, their support of projects could be galvanized by a publicity campaign that emphasizes a policy's intended benefits, even if they are uncertain and may only arise in the long term. The benefits should be clearly communicated, especially when people see the projects as representing an imposition such as a behavioral change or a trade-off for a more immediately tangible benefit.

Tools, analytics, and evidence-based decision-making. Developing policies for resilience and adaptation requires information and decision-making to shape the design, prioritization, and execution of resource allocation priorities. However, these key priorities can only be as successful as the information- and knowledge-based data upon which all resilience and adaptation decisions rely, and such information can be impaired with multiple levels of uncertainty. In a changing and complexly connected world, governance and business leadership and practice are informed through robust evidence-based decision-making to guide resilience and adaptation planning, response, and recovery to climate-driven disruptions. The next generation of policymakers must learn to translate science to policy, even in the face of uncertainty.

Sustaining knowledgeable workforces and collaborations

Evidence-based decision-making requires a skilled public and private sector workforce capable of filling the booming demand for reliable and valid information about future conditions. Climate resilience planning, response, and recovery draw from a variety of disciplines including climatology and environmental science, environmental and civil engineering, economics, risk analysis and risk management, public health, and risk communication. Meeting the climate resilience data demands of tomorrow requires investment in interdisciplinary and transdisciplinary education and training programs.

Caribbean states should identify opportunities for strategic education partnerships to train the data workforce of tomorrow for the interdisciplinary work to support leadership information needs. Private and public investment is needed for state-of-the-science curriculum across all education levels (kindergarten through higher education) that centers the SIDS and Caribbean context. These can invigorate teaching and learning about climate issues and infuse authentic inquiry of pressing societal issues into existing education rubrics. However, barriers include sparse access to funding for curriculum development and equipment, a lack of technical prowess and content specialization among educators, and inadequate time to prepare and present interdisciplinary lesson plans (World Bank, 2021). Such barriers to success manifest as decreased self-confidence among educators to teach interdisciplinary science and further entrench student disinterest in pursuing science and technology training as they mature through the school system.

Novel education programs may be necessary to break this cycle and to foster a prepared workforce with the training and desire to tackle grand challenges. Such revolutionary education developments are occurring in other fields like applied biotechnology education, where the use of mobile science labs and tailored interdisciplinary curricula are more equitably reaching diverse student populations across geographies to sustain growth and innovation while developing the next generation of the workforce. At the end of the day, the execution of RBD investments is going to require generations of Caribbean residents who must have the expertise to design, build, manage, and adapt their environment.

Data needs, comparative forecasting tools, and real-time data analytics

Effective climate risk management warrants data collection about status and needs as well as the capacity to synthesize data into knowledge and insight to inform decisions. However, using data during a crisis or a disaster is particularly difficult because a community's status and needs are uncertain and evolve rapidly. Emergency responders need many options to use multiscale platforms to collect data and assess on-the-ground conditions—including in real time as events unfold. For instance, US Army Corps of Engineers presently deploys hundreds of responders to collect data and inform the operating picture for command decisions. Data collection technologies can dramatically improve emergency response and recovery efficiency. Data infrastructure and research platforms, especially platforms featuring open data, can be tailored to address three key questions for climate resilience planners, as outlined in Table 2.

Intelligence and data gathering are central to the capacity of institutions to learn and adapt, particularly in the context of RDB approaches. These guiding questions can serve as the basis for the development of a suite of tools to collect data at appropriate scales in rapid timelines to inform climate resilience decision-making. All tools should also be integrated into data management structures and workflows that align and synthesize nested data sets across scales. Well-designed data structures, especially those with open data, provide common operating frameworks to facilitate visualization, analysis, and coordination. These will support on-the-ground missions as well as after-the-fact study, simulation, and comparative forecasting of future issues.

TABLE 2 Key questions for climate resilience and adaptation planning

Question	Methodology to answer question
What can we learn from prior events?	Reviewing the historical record can help identify vulnerable areas and estimate data parameters and needs for future decisions.
What climate-based disruptions are expected?	Desktop analyses may be used to proactively assemble local data and historical data to project consequences of disruptions, especially for identified vulnerable communities. Web-based tools can help emergency managers rapidly access community data, such as information shared on social networks, and summary metrics during unfolding crises and disasters.
What conditions exist after a disruption that might affect emergency responses?	Improved data collection infrastructure may benefit from deploying at large, mid-, and small scales (e.g., remote sensing, Unmanned Aircraft Systems, and mobile phone apps or other field collection devices). Such data can better support disaster response professionals by reducing labor and travel needs for large-scale response teams and overcoming common logistical challenges in disaster zones (e.g., road blockages, power outages, absent homeowners). Field data collection platforms including smartphone applications can provide a strong foundation for sets of on-the-ground tools that fill data gaps not observable at larger scales. These tools also provide important validation for information gathered via remote sensing.

Methods to examine cascading climate events

Traditional risk assessment and management considers individual threats using historic data or model predictions, while all-hazards frameworks can examine multiple threats. However, this approach neglects the interconnections of real systems (e.g., urban environments and climate disruption), and the cascading and nonlinear nature of certain threats (e.g., hurricanes). Future data usages should therefore seek to incorporate real-time decision evaluation and synthesis of trade-offs in policy targets, considering possibilities for cascading threats and climate disruptions. The development of novel, flexible, and dynamic evaluation tools capable of adjusting inputs and outputs on a case-by-case basis is warranted. Evidence-based decision frameworks specific to the Caribbean context should prioritize how affected populations and infrastructure stability may be impacted by cascading and nonlinear climate disruptions.

The tools and analytics needed for climate resilience thus demonstrate propensities to support bouncing back and bouncing forward. Such tools and analytics are needed to complement the institutional value of resilience and implementable resilience planning to overcome the barriers to resilience, especially RBD, in the Caribbean. Together, these factors form the first triad of resilience needs for the Caribbean.

These foundational concepts of cultivating a resilience culture, prioritizing policy adaptability, and developing adequate tools and analytics function are connected by the future that they together enable. This future is supported by a climate-resilient workforce, evidence-based decision-making, and tool and methodology standardization that allows for continual improvement. We envision these concepts as complementing the societal values profiled above. Together, they provide the foundation for climate resilience (Figure 4).

FIGURE 4 Resilience as related to social values and capacity barriers in the Caribbean Small Island Developing States

Such RBD will help to foster systems that enable SIDS to bounce forward amidst climate disruptions. These features support communities to bounce back from disruptions that inevitably occur by providing both preparation and the ability to react quickly to changing circumstances with decisions that can best support the objectives of the community.

Conclusions: Resilience and adaptation opportunities and resources

Caribbean SIDS understand the value of resilience and the co-benefits that can be made available to their populace. This article conceptualized resilience based on two triads. Implementing it will require parsing the different types of resilience according to their inputs and outcomes. Developing these institutional capacities is critical for resourcing both RBI and RBD investments.

The short-term demands of recovery and response are well understood in today's climate. The more difficult challenge is the advancement of resilience and adaptation investments that connect with not only short-term demands but also the long-term co-benefits derived from a socially and environmentally sustainable future. Short-term disaster responses and RBI approaches should incorporate broader societal needs and values including social welfare and environmental sustainability.

Resilience-by-design investments and capacities can fill a gap as external resources underwriting RBI become more constrained over time in the global competition for resilience and adaptation resources. Investing in RBD means acknowledging and partnering with local stakeholders and the private sector to scale up local community resilience knowledge at a national level. Thereafter, the governance institutions must recognize that their flexibility to develop and implement consistent resilience and adaptation policies is a strong signal to the private sector, including foreign investors and domestic economic stakeholders. It signals the priorities that will shape resource allocations in the future. To develop and deploy these policies, policymakers need to invest in everything from workforce training to intelligence systems that can support evidence-based decision-making. Collectively, these institutional capacity-building investments will allow Caribbean SIDS to move away from one-off RBI projects to achieve a broader strategic deployment of RBD investments. Ultimately, when allocating resources for resilience and adaptation, decision-makers can create decarbonized systems that are socially and environmentally sustainable. This simultaneous prioritization of governance of societal needs can best foster climate resilience and usher in a new era of Caribbean prosperity.

DATA AVAILABILITY STATEMENT

This study does not rely upon external data.

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14. ABSTRACT
Although the Caribbean's Small Island Developing States (SIDS) minimally contribute to global greenhouse gas emissions, they face disproportionate climate risks and are particularly susceptible to systemic economic threats posed by climate change and subsequent increases in climate variability. Historically, strategic programs and investments have sought to develop more robust and adaptive engineered systems to absorb climate threats. However, such initiatives are limited and under-resourced in the SIDS' context. This article reviews existing climate strategies in the Caribbean and then critically examines current gaps and barriers relating to climate impact knowledge, needs, and implementation. This examination can assist Caribbean SIDS leadership to identify opportunities to transition from a vulnerability-reducing mindset to one of resilience and transformative adaptation to improve long-term economic outlooks, social welfare, and environmental stewardship despite recurring and escalating climate risks.

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