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360° Resilience

A Guide to Prepare the Caribbean for a New Generation of Shocks

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Table of Contents

Acknowledgements vii
Abbreviations viii

360° Resilience: A Guide to Prepare the Caribbean to a New Generation of Shocks 1
Finding 1 3
Finding 2 9
Three recommendations for building resilience to a new generation of shocks 18
Recommendation 1. Increase government efficiency 18
Recommendation 2. Empower households and the private sector 20
Recommendation 3. Reduce future physical risk 22
Conclusion 28

Part 1: A diagnosis 31

Part 1 Introduction 32
Overview of Part 1 34

Chapter 1: Asset losses from natural hazards and sea level rise 40
Global databases and resources: a first screening 41
Country risk profiles: informing disaster risk financing 46
Satellite imagery: looking at trends in exposure 48
Modeling sea level rise and sandy beach erosion: exploring future risks 54
Summary 58

Chapter 2: Lifeline infrastructure 60
Assets 61
Network effects 64
Impact of infrastructure disruptions on users 69
Summary 75

Chapter 3: Private sector vulnerabilities and losses 76
Economic structures of Caribbean countries 77
Impact of shocks on tourism 80
Impact of shocks on agriculture and fisheries 86
Impact of shocks on the financial sector 92
Summary 94

Chapter 4: Macroeconomic and fiscal vulnerabilities and losses 97
Macroeconomic vulnerabilities 98
Limited government capacity to respond to shocks 100
Impact of natural hazards on GDP and public finances 102
Impact of other shocks on GDP and debt 106
Forward-looking assessments usingmacroeconomic models 108
Summary 111

Chapter 5: Human capital and well-being 114
Impact of shocks on poverty and well-being 115
Impact of shocks on education 119
Impact of shocks on health and health systems 123
Impact of shocks on displacement and migration 128
Summary 129

Chapter 6: Summary and conclusions 132

Part 2: A progress assessment 135

Part 2 Introduction 136

Chapter 7: Foundations for rapid, robust, and inclusive growth 140
Economic opportunity and growth 141
Inclusion and access to basic services 143

Chapter 8: Facilitate risk reduction decisions by firms and households 155
Assess disaster and climate change risks, and make this information available 156
Develop and implement technical solutions for resilience 167
Diversify economic sectors 171
Make finance for resilience accessible and provide direct support to the poorest and most vulnerable 173
Build skills for resilience through public works and training programs 176

Chapter 9: Design resilient infrastructure systems, urban and coastal plans 185
Lifeline infrastructure: a governmentwide strategy 186
Risk-informed land use and urban planning 199
Coastal management plans and nature-based solutions 204

Chapter 10: Build resilient health and education systems 211
Resilient health systems: a government-wide strategy 212
Resilient education systems: a governmentwide strategy 221

Chapter 11: Help firms and people manage residual risks and natural disasters 231
Emergency preparedness and early warning systems 232
Insurance and other financial instruments 244
Shock-responsive social protection systems 247
Business continuity plans and financial preparedness 255
Building back better 255

Chapter 12: Anticipate and manage macrofiscal and financial issues 260
Monetary policy 261
Fiscal policy, debt, and fiscal space 263
Disaster risk financing strategies 267
Macroprudential policies and financial development 273

Part 3: A way forward 280

Part 3 Introduction 281

Recommendation 1: Increase government efficiency 286
Invest in digitalization for key government services 287
Improve postdisaster spending processes 288
Reduce budget variability and fiscal risks by improving public asset management 289
Build fiscal resilience 289
Improve debt management 289
Assess direct and indirect liabilities and improve the transparency of budget allocation 290
Roll out the development of DRF strategies that cover the entire spectrum of risk 290
Regional coordination, and skills and resource sharing 291

Recommendation 2: Empower households and the private sector 293
Help firms and households plan ahead by making good quality risk data publicly available 294
Help households diversify their income and bounce back after disasters 294
Help firms (including MSMEs) and households invest in resilience and rebuild after disasters 296

Support farmers and fisherfolk with access to data, technological solutions, and finance 298
Invest in digital infrastructure and build digital skills to strengthen businesses and increase human capital 298
Improve continuity of learning during and after shocks 299
Reduce economic vulnerability through diversification 299

Recommendation 3: Reduce future physical risk 301
Develop and implement risk-informed building codes 302
Develop risk-informed coastal and land use plans that consider future climate change impacts 303
Take advantage of natural capital 308
Identify and strengthen critical infrastructure assets, including schools and health centers 310
Develop water resources management strategies 312
Be prepared to build back better, possibly in different places 312

Appendix A 314
Antigua and Barbuda 315
Bahamas, The 316
Barbados 317
Belize 318
Dominica 319
Dominican Republic 320
Grenada 321
Guyana 322
Haiti 323
Jamaica 324
Sint Maarten 325
St. Kitts and Nevis 326
St. Lucia 327
St. Vincent and the Grenadines 328
Suriname 329
Trinidad and Tobago 330
Turks and Caicos 331
Annex A 332

Appendix B 333
Antigua and Barbuda 334
Bahamas, The 337
Barbados 340
Belize 343
Dominica 346
Dominican Republic 349
Grenada 352
Guyana 355
Haiti 358
Jamaica 361
Sint Maarten 364
St. Kitts and Nevis 367
St. Lucia 370
St. Vincent andthe Grenadines 373
Suriname 376
Trinidad and Tobago 379
Turks and Caicos 382
Annex B 385

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Abbreviations

AR5	Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change
AAL	average annual losses
ACB	ASEAN Centre for Biodiversity
ASEAN	Association of Southeast Asian Nations
ASP	adaptive social protection
ASPIRE	Atlas of Social Protection Indicators of Resilience and Equity
ATM	automatic teller machine
BOOST	Building Opportunities for Our Social Transformation (Belize)
CAFF	Climate Adaptation Financing Facility
CAP	Common Alerting Protocol
CARICOM	Caribbean Community
CARPHA	Caribbean Public Health Agency
CAT-DDO	Catastrophe-Deferred Drawdown Option
CBD	Caribbean Development Bank
CC	contingent credit
CCCCC	Caribbean Community Climate Change Center
CCRIF SPC	Caribbean Catastrophe Risks Insurance Facility
CCT	conditional cash transfer
CDEMA	Caribbean Disaster Emergency Management Agency
CDB	Caribbean Development Bank
CDM	Comprehensive Disaster Management
CERC	Contingent Emergency Response Component
CHaRIM	Caribbean Handbook for Risk Information Management
CIF	Climate Investment Fund
CIMH	Caribbean Institute of Meteorology and Hydrology
CMO	Caribbean Meteorological Organization
CRIS	Caribbean Risk Information System
CR-FELTP	Caribbean Regional Field Epidemiology and Laboratory Training Programme
CROSQ	CARICOM Regional Organisation for Standards and Quality
CSA	climate-smart agriculture
CVQ	Caribbean Vocational Qualifications
DaLA	Damage and Loss Assessment
DPRCA	Disaster Preparedness & Response Capacity Assessment
DRF	disaster risk financing
DRM	disaster risk management
DRR	disaster risk reduction
DTM	Digital Terrain Model
EC$	Eastern Caribbean dollars
ECCU	Eastern Caribbean Currency Union
EM-DAT	Emergency Events Database
EMIS	Education Management Information System
EOC	Emergency Operations Center
EP&R	emergency preparedness and response
EWS	early warning system

FAO	Food and Agriculture Organization
FR	fiscal rule
GDP	gross domestic product
GeoCRIS	Geospatial component of CRIS
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	geographic information systems
HAC	Humanitarian Assistance Committee
HDX	Humanitarian Data Exchange
HGEM	Hadley Centre Global Environment Model
HIS	Health Safety Index
IDB	Inter-American Development Bank
IATA	International Air Transport Association
IBF	impact-based forecasting
ICT	information and communications technology
IDMC	Internal Displacement Monitoring Centre
IHR	International Health Regulations
ILO	International Labour Organization
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPSL	Institut Pierre Simon Laplace
ITU	International Telecommunication Union
LFS	labor force survey
LiDAR	light detection and ranging
MFMOD	macroeconomic and fiscal model
MHEWS	Multi-Hazard Early Warning System
MHLW	Ministry of Health Labor and Welfare
MOE	Ministry of Education
MOU	memorandum of understanding
MRIO	Multi-Regional Input-Output (database)
MSME	micro, small and medium-sized enterprises
NAP	national adaptation plan
NCD	noncommunicable disease
NDMO	National Disaster Management Office
NEMO	National Emergency Management Organization
NERGIST	National Emergency Response Geographic Information System Team
NGFS	Network for Greening the Financial Sector
NGO	nongovernmental organization
NMHS	National Meteorological and Hydrological Services
NMS	national meteorological service
NOAA	National Oceanic and Atmospheric Administration
NPL	nonperforming loans
NSO	national statistics office
NVQ	national vocational qualification
OCT	overseas countries and territories
OECD	Organisation for Economic Co-operation and Development
OECS	Organization of the Eastern Caribbean States

PAHO	Pan American Health Organization
PATH	Program of Advancement Through Health and Education (Jamaica)
PFM	public financial management
PGA	Peak ground acceleration
PISA	Programme for International Student Assessment
PML	probable maximum loss
PPE	personal protective equipment
PPP	purchasing power parity
PPS	Pharmaceutical Procurement Service
RCP	representative concentration pathways
SABLE	Sustainable Agribusiness for Laborie and Environs
SAR	synthetic aperture radar
SDG	Sustainable Development Goal
SFC	stock-flow consistent
SIDS	Small Island Developing States
SLC	survey of living conditions
SLDB	St. Lucia Development Bank
SLMS	School Learning Management System
SOE	state-owned enterprise
SRTM	Shuttle Radar Topography Mission
SSPs	shared socioeconomic pathways
STEM	science, technology, engineering, and mathematics
TLS	traffic light system
UCT	unconditional cash transfer
UKHO	United Kingdom Hydrographic Office
UN	United Nations
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UNISDR	former name for UNDRR
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNOPS	United Nations Office for Project Services
UNWTO	United Nations World Tourism Organization
UWI	University of the West Indies
VCA	Vulnerability and Capacity Assessment
WDI	World Development Indicators
WGI	Worldwide Governance Indicators
WHO	World Health Organization
WMO	World Meteorological Organization
WSC	Water and Sewerage Corporation
WTTC	World Travel and Tourism Council

All dollar amounts are U.S. dollars unless otherwise indicated (eg EC$)

S

A SUMMARY >>

360° Resilience: A Guide to Prepare the Caribbean to a New Generation of Shocks

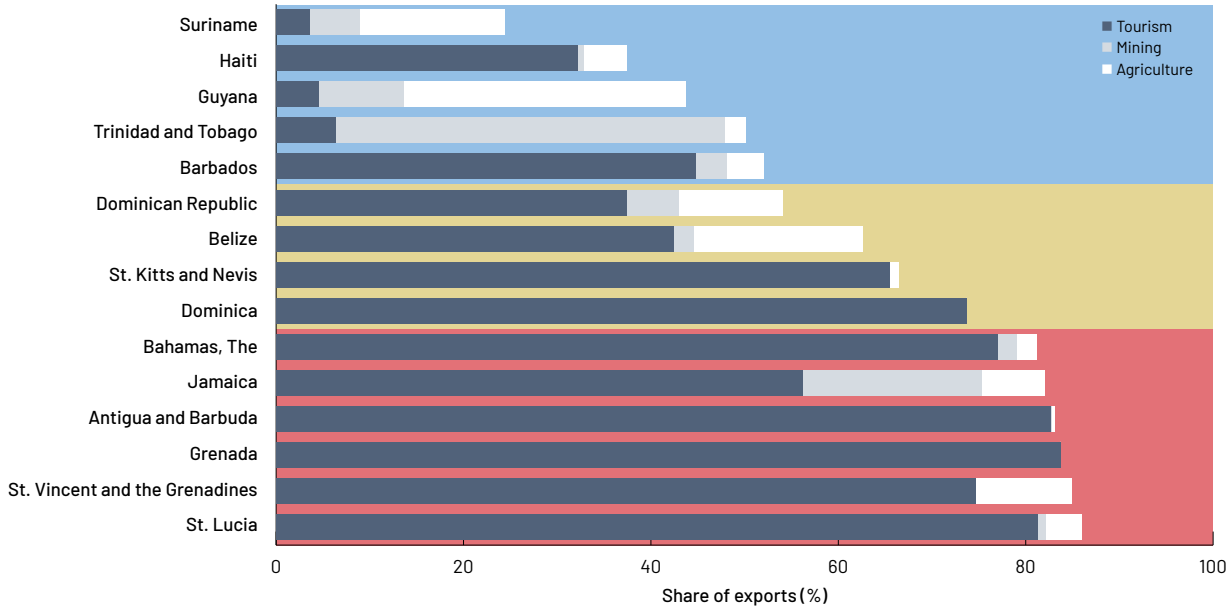
Caribbean countries, a set of mostly Small Island Developing States (SIDS), have a history of dealing with large shocks. The region is threatened by both economic and natural hazards.

Nations have specialized in tourism and commodity exports (*figure S1*), disproportionally exposing them to global economic cycles through changes in tourism demand and commodity prices. They are also located in a region that is highly exposed to a range of natural hazards—from volcanic eruptions to earthquakes and hurricanes—which damage their infrastructure stock, reduce tourism demand, and destroy agricultural production. Hazards have often caused severe damage to economies and livelihoods in the region.

Despite their varying national capacities and exposure to natural hazards and economic volatility, the countries of the Caribbean have sustained long-term development progress. Their specialization in sectors where they have a comparative advantage (tourism and commodities) has led to relatively high income levels. Antigua and Barbuda, The Bahamas, Barbados, Sint Maarten, St. Kitts and Nevis, Trinidad and Tobago, and Turks and Caicos are high-income countries; and Belize, Dominica, the Dominican Republic, Guyana, Jamaica, St. Lucia, St. Vincent and the Grenadines, and Suriname are upper-middle-income countries. Haiti is the region's only low-income country.

FIGURE S1 >>

Share of agriculture, tourism, and commodities in Caribbean exports (2016–18)



Source: Based on data from World Development Indicators (WDI)[1] (accessed February 2021)

Note: Countries in blue are in the bottom third; those in yellow are in the middle third; and those in red are in the top third of Caribbean countries that are most reliant on the three sectors.

But high income levels have also come, historically, with high exposure to global business cycles and natural hazards, which has resulted in high economic volatility, high unemployment, and persistent inequality and poverty. Economic growth has slowed over the past 10 years, and more recently, the COVID-19 pandemic has demonstrated that, although the region was prepared to handle shocks, it is vulnerable to and dependent on changes in global tourism demand.

Taking a holistic approach to resilience, this report assesses the historical and future impacts of shocks in the Caribbean, policy responses to those shocks, and gaps in resilience building. It offers two main findings and a series of recommendations for policy makers.

Finding 1: Caribbean countries have achieved resilience levels that have allowed them to support economic development despite large recurring damages and losses from multiple hazards and shocks. But this relies to a large extent on informal mechanisms that neither systematically protect the poor and most vulnerable groups nor prevent the loss of human capital. Businesses in the region have invested in disaster preparedness, staff training, and backup infrastructure like water tanks and electric generators. Remittances from abroad have blunted declines in consumption after disasters. In many cases, governments have prepared adeptly for extreme events, also benefiting from regional collaboration mechanisms to monitor and forecast hurricanes and organize a coordinated response when the impact exceeds individual countries' response capacity. Past efforts have, however, left some people behind. One in five people in the region still lives in poverty and past shocks have contributed to pushing people into and keeping them in poverty.

Finding 2: Caribbean countries are not prepared for the new challenges posed by climate change, compounded by uncertainty on future tourism markets and a lack of fiscal space. The strategies that have worked in the past will not be enough in the future. Climate change threatens to intensify natural hazards and brings new sources of volatility though impacts on health, agriculture yields, and coastal

landscapes. The post-COVID-19 world brings more uncertainty on prospects for tourism. Many countries have also depleted their fiscal space and coping capacity while dealing with past crises.

These new challenges call for more consistent approaches to resilience, building on stronger institutions, robust analytics, and more transparent prioritization. To boost resilience and better prepare for the shocks and stresses of the future, this report recommends that Caribbean governments focus on three main areas:

- **Increasing government efficiency** by improving investment management and infrastructure maintenance, clarifying procurement rules for emergency situations, allocating budgets transparently, ensuring fiscal rules are robust, and layering risk financing strategies
- **Empowering households and the private sector** by increasing both the coverage and adequacy of social protection, strengthening worker skills for resilience, improving access to finance, and facilitating access to risk information
- **Reducing future physical risk** by investing in critical infrastructure, better enforcing building codes and standards, systematically considering emerging and changing risks, and planning to build back better after shocks.

Finding 1. Caribbean countries have achieved resilience levels that have allowed them to support economic development despite large recurring damages and losses from shocks. But this relies to a large extent on informal mechanisms that neither systematically protect the poor and most vulnerable groups nor prevent the loss of human capital.

This report reviews existing assessments of past losses from natural and economic shocks in the Caribbean, looking at impacts on physical capital, private sector activity (especially tourism and agriculture), economic growth, poverty, and well-being. It concludes that, despite the damage to physical capital experienced by countries due to natural hazards (especially in housing and transport infrastructure), the impacts on growth are short-lived, possibly because many mechanisms are in place to help economies bounce back rapidly. However, natural hazards have a high impact on poverty and human capital and threaten the sustainability of economic growth.

Natural hazards are costly in terms of infrastructure damages

An analysis of infrastructure assets exposure carried out for this report reveals that a large proportion of the region's assets is exposed to hurricane wind and landslides, and a smaller but significant share is also exposed to floods and earthquakes (Schweikert et al. 2021). While data on infrastructure vulnerability are missing, the absence of construction standards and maintenance—and the often high age of assets in many countries—suggest that most would be severely damaged in case of shock.

A review of historical damage caused by tropical storms, hurricanes, earthquakes, and floods shows that, in terms of assets, the housing and infrastructure sectors are by far the most impacted (71–81 percent of total damages in Dominica and 67 percent in Sint Maarten from Tropical Storm Erika and Hurricane Maria; 71 percent in Haiti from the 2010 earthquake; 87 percent in St. Lucia and 96 percent in St. Vincent and the Grenadines from the 2013 floods). Within the infrastructure sector, transport assets often suffer the costliest damage (66–84 percent of infrastructure damage in Dominica, 97 percent in St. Lucia, and 89 percent in St. Vincent and the Grenadines). Given that transport infrastructure—particularly roads and bridges—is almost always managed by the public sector, these damages represent significant liabilities for governments.

Lessons from past disasters indicate that governments are slow to rebuild infrastructure systems, particularly when compared to the high frequency of shocks experienced by these countries. When Hurricane Maria struck Dominica in 2017, the country was still recovering from damages and losses from Tropical Storm Erika in 2015. At least three long bridges destroyed in previous events had not yet been replaced and temporary bailey bridges were still in use. The longer it takes to rehabilitate critical infrastructure, the higher the impact on the population and the economy.

Despite high infrastructure damage, at the macroeconomic level, Caribbean countries show relatively high levels of resilience to natural shocks

Empirical studies on the macroeconomic impacts of disasters in the Caribbean find that, on average, natural disasters have a negative impact on gross domestic product (GDP) growth in the Caribbean, but the effect is relatively short-lived, lasting a few years at most (Strobl 2021). The empirical literature also finds a short-lived increase in public debt, stemming from a combination of reduced tax revenues and increased spending for the recovery (Strobl 2021). This can be surprising, given the amount of capital destroyed by past hurricanes. Between 2000 and 2019, Caribbean countries lost the equivalent of 3.6 percent of aggregate GDP per year to damages and losses related to natural hazards, compared to 0.3 percent in all emerging market and developing economies (World Bank 2021). Indeed, in a single day in 2017, some countries, such as Dominica and Sint Maarten, saw storms destroy capital value equivalent to or higher than their annual GDP.

There are methodological limitations to empirical studies that could explain these results. These are linked to the way hurricane damages are modeled (leading to attenuation bias), the way statistical offices measure GDP (in particular, the value of housing and transport services), and the way they focus on the marginal effects of natural disasters (looking at growth), rather than their impacts on average productivity.

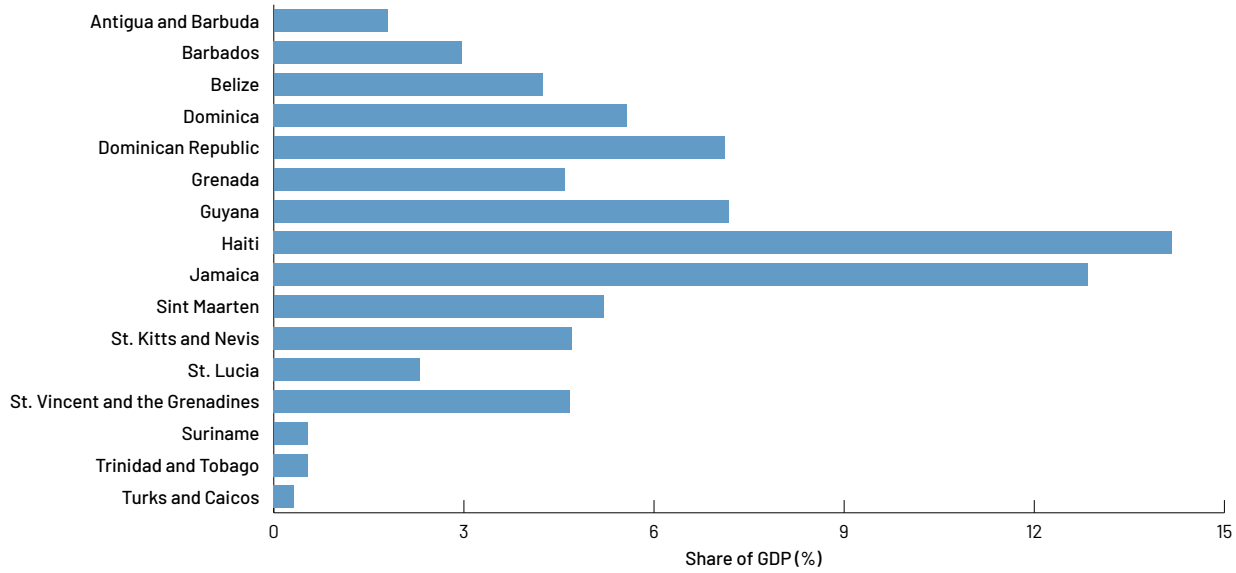
However, there are many real explanations for the quick postdisaster economic rebounds. First, not all sectors are impacted equally. A study conducted for this report on the impact of hurricanes on sector value added finds that, in the year of a storm event, gross value added declines significantly in the agriculture (-14 percent), hotel and restaurant (-12 percent), mining and quarrying (-28 percent), and trade (-7 percent) sectors, whereas other sectors do not experience significant impact (Masetti 2021). One year on, the storm's impact continues to depress growth in the agriculture and hotel and restaurant sectors, while construction rebounds, typically due to enhanced rebuilding. The trade sector also recovers its contemporaneous losses after a year.

Second, Caribbean countries have a large diaspora and rely heavily on remittances. Data are incomplete and underestimate total flows (a significant proportion of remittances received in the Caribbean is in kind, through shipments of goods). But they show that, on average, Caribbean countries receive the equivalent of several percent of GDP in remittances every year (up to 12 and 14 percent respectively in Haiti and Jamaica) (*figure S2*). And as this income is unaffected by hazards, it acts as a buffering mechanism. For example, Henry et al. (2020) show that remittances can reduce the fall in consumption expenditure in Jamaica after a hurricane by about 75 percent. It is also possible that they increase after a disaster, but the quality of data does not allow for finding a statistically significant relationship between natural hazards and regional-level remittance flows. In addition, external aid can explain the limited impact on public debts, although data on external aid transfers after shocks is incomplete.

Third, having experienced more than 400 natural disasters since 1950, Caribbean countries have built some mechanisms to prepare and cope with natural hazards. The next sections present evidence gathered through a survey in the tourism industry and through lessons learnt from recent disasters and the COVID-19 pandemic that countries have built good levels of disaster management capacity, including through regional coordination.

FIGURE S2 >>

Remittances in Caribbean countries (average over 1990–2019)



Source: Based on data from WDI (last accessed September 2021)[1]

A firm survey and lessons learned from past disasters show good levels of preparedness to quickly restore economic activity

A survey for the Caribbean tourism industry carried out between March and October 2020 and covering all island countries with high dependence on the tourism sector (Erman et al. 2021) shows that businesses perceive high levels of risk from natural hazards and, as a result, have invested in preparedness.

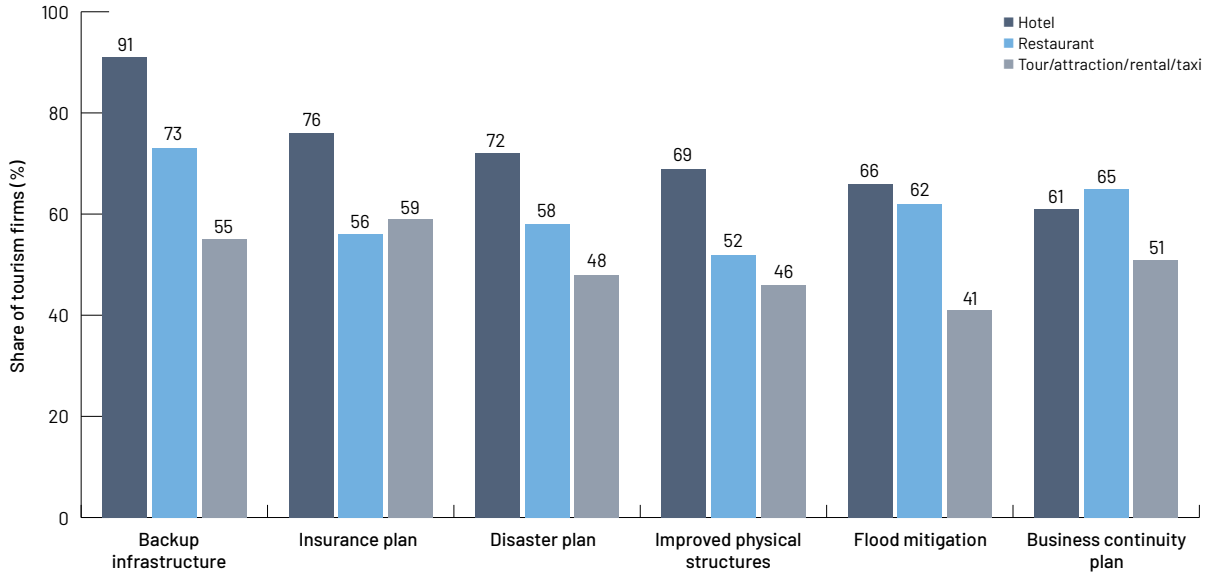
Approximately 82 percent of respondents feel at least somewhat prepared to cope with a natural disaster and 97 percent of firms have taken some preparedness action, including insurance (63 percent), a business continuity plan (60 percent), or investing in backup infrastructure (75 percent) (*figure S3*). Backup infrastructure can help firms overcome periods of shortage, but only if shocks are brief. Water tanks and generators are common: 72 percent of firms own a water tank and 57 percent a generator. Solar power is present in the region, but only 10 percent of firms rely on it as a form of energy. Solar power is most common in the hotel sector, while water tanks and generators are common in the three examined sectors: hotel, restaurant, and touring/attraction/taxi/rental.

Other preparedness actions include improved physical structures, such as storm shutters or hurricane straps (56 percent), and flood mitigation measures such as sandbags and drainage (59 percent). About 61 percent of businesses have a disaster preparedness plan in place. This usually means that they have a plan for what to do in case of an emergency and a dedicated staff member who oversees the emergency response. Of the firms in the survey with a disaster preparedness plan, 75 percent have a dedicated staff member. About 80 percent provide staff members with disaster planning/response training.

Interviews with technocrats involved in the immediate response to recent natural disasters in The Bahamas (Hurricane Dorian), Dominica (Hurricane Maria), St. Lucia (Hurricane Tomas and the 2013 Christmas flood), and Sint Maarten (Hurricanes Irma and Maria) also confirm some governments' good levels of preparedness to quickly restore critical infrastructure.

FIGURE S3 >>

Disaster preparedness in tourism industry firms across the Caribbean



Source: Erman et al. 2021

For example, to prepare for Hurricane Maria, engineers in Dominica pre-positioned heavy machinery on terrain and in areas where road closures were likely to occur. Anticipating bridge collapses, the government also procured, ex ante, bailey bridges that could be used as replacements. These types of preparation allow for speedy road clearing, enable continued mobility between locations, and help get systems operational as soon as possible. As a result of efficient government programs that hired contractors with heavy equipment to remove debris and reinstate access, and community labor to clear light debris, roads across Dominica were reopened within two weeks (Government of the Commonwealth of Dominica 2017). In Sint Maarten, where the airport terminal suffered major damage, the landing strip was cleared of debris immediately after the hurricane to allow for emergency use. Basic, but severely compromised, commercial operations were restored in October 2017, about a month after the event (World Bank 2018).

The COVID-19 pandemic highlighted the good functioning of regional coordination and social protection programs to respond to crises

Caribbean countries' early response to the COVID-19 pandemic has been swift and commendable, as most islands experienced a less steep disease outbreak growth compared to their Central and South American counterparts. Strong responses from national leadership and regional and international bodies have played integral roles in supporting the region's responses to the pandemic. The Caribbean Community (CARICOM) coordinated the procurement of necessary equipment; the Caribbean Disaster Emergency Management Agency (CDEMA) and the Caribbean Public Health Agency (CARPHA) supported outbreak response logistics and strengthening regional testing capacity; and the Organization of the Eastern Caribbean States (OECS) scaled up activities under their Pharmaceutical Procurement Service model to swiftly purchase and distribute critical medical supplies across the region. The Pan American Health Organization (PAHO) worked to increase testing capacity and surveillance within the region by providing equipment, reagents, and training, while the United Nations Children's Fund (UNICEF) supported the development of an online portal to deliver virtual mental health and psychosocial services to frontline workers and caregivers in the Eastern Caribbean. The World Bank shifted its program focus to support the region's response and recovery through financing from the COVID-19 fast track facility and activating

contingent emergency financing components in several countries to support vaccination strategies and measures to protect the poor and vulnerable, safeguard jobs and micro, small and medium-sized enterprises (MSMEs), stimulate the economy, and enable medium-term reforms for a resilient recovery.

Indeed, the COVID-19 pandemic led to a remarkable use of social protection systems in the Caribbean. Existing cash transfer programs have expanded vertically (increasing the benefit value) and horizontally (expanding the number of beneficiaries). Barbados, Belize, Cayman Islands, the Dominican Republic, Jamaica, and Trinidad and Tobago topped up benefit values, while programs in St. Kitts and Nevis, Sint Maarten, and St. Lucia have included more beneficiaries in their programs. The Bahamas, Belize, the Dominican Republic, Haiti, Jamaica, St. Lucia, Trinidad and Tobago, and St. Vincent and the Grenadines launched new cash transfer programs, offering unemployment assistance and targeting badly hit sectors like tourism or poor and vulnerable households that are excluded from safety nets.

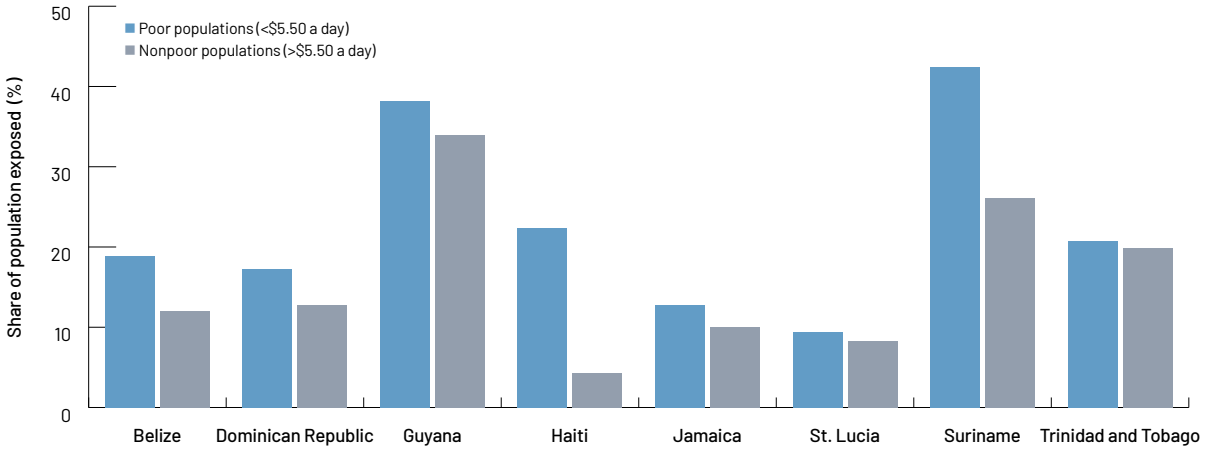
School closures meant countries had to adapt their school feeding programs. New approaches include providing take-home rations (Belize and the Dominican Republic), food vouchers (Cayman Islands), and cash or food assistance through other programs (Jamaica and Trinidad and Tobago). Almost all countries have also delivered food packages to vulnerable households. School nutrition programs are integral components of national social protection systems and provide a platform to scale up and reorganize the distribution of meals during disasters and pandemics. The system for distributing hygiene kits after a disaster is well established in the Caribbean through CDEMA, national disaster offices, and nongovernmental organizations, which may explain the high level of preparedness in areas with existing school nutrition, hygiene kit and public health campaigns.

But despite social protection programs, shocks increase poverty and reduce human capital

Despite relatively high income levels in all Caribbean countries except Haiti, one in five people in the region still lives in poverty, and past shocks have contributed to pushing people into or keeping them in poverty. Poor people are relatively more exposed to floods than the rest of the population (***figure S4***), living in vulnerable houses, due to the lack of adherence to building codes and the use of substandard materials for informal construction.

FIGURE S4 >>

Exposure of poor and nonpoor populations in Caribbean countries to >15cm flooding



Source: Based on data from Rentschler and Salha 2020
Note: Figure shows exposure to 1-in-100-year pluvial, fluvial, and coastal floods

Poor people also have access to fewer coping mechanisms. In Jamaica, fewer than 5 percent of those in the poorest quintile have home insurance, compared to 60 percent in the richest. In St. Lucia, only 30 percent of the poorest quintile have bank accounts, compared to 80 percent of the wealthiest. In Dominica, a postdisaster needs assessment after Hurricane Maria estimated a 14 percentage point increase in poverty—some 2,800 individuals—if consumption impacts were left unaddressed (Government of the Commonwealth of Dominica 2017). The 2010 earthquake in Haiti is estimated to have wiped out 10 years of progress in poverty reduction (Government of the Republic of Haiti 2010). Finally, in Caribbean countries, the COVID-19 crisis is estimated to have increased poverty by 10–25 percent (World Bank 2020).[2]

Hallegatte, Rentschler and Walsh (2018) find that well-being impacts of disasters are much higher in the Caribbean than in other countries with similar income levels, far exceeding asset losses as high poverty levels and limited access to coping strategies lead to prolonged deprivation. An extension of this work finds that households just above the poverty line in St. Lucia are several times more likely than wealthier households to experience poverty for at least six months when their homes are affected by an earthquake (Walsh and Jagdeo, forthcoming). Severely affected households may never recover, meaning natural hazards create long-lasting consequences for human and economic development, reinforcing and perpetuating intergenerational cycles of poverty.

Disasters also lead to future earning loss when school buildings are damaged or used as emergency shelters (Bellony and Powers 2021). A review of recent disasters finds that many school buildings were damaged by hurricanes and earthquakes, leading to forced school closures lasting a few weeks to several months. Months after Hurricane Dorian hit The Bahamas in 2019 and Hurricane Maria hit Dominica in 2017, some schools were still being used as temporary shelters for displaced residents. A month after Hurricane Maria, 95 percent of Dominican students still had no access to schooling (Government of the Commonwealth of Dominica 2017), while in Haiti, half of all students were left without access to education after the 2010 earthquake, with some schools taking more than a year to reopen (Government of Haiti 2020). Lifetime earning losses due to school closures have not been quantified for disasters, but they have been quantified for the COVID-19 pandemic and associated interruptions in face-to-face learning. Estimates range from $100 per year in Haiti to $902 in Jamaica for a five-month closure scenario, which represents a 3.5 and 6.2 percent loss in yearly earnings per student in Haiti and Jamaica, respectively. A more pessimistic scenario with seven months of school closures would cost students between $147 (Haiti) and $1,422 (Jamaica) in yearly earnings (5.2 percent and 9.7 percent loss in yearly earnings, respectively).

Disasters impact people's health through direct death and injury and by diverting health system services to respond to the shock. This can impact routine health services, such as immunizations and cancer screenings, negatively impacting short or long-term health outcomes (Harnam and Khan 2021). In their study of the health impacts of the 2017 Atlantic Basin hurricane season, Shultz et al. (2019) find that almost all SIDS populations that were exposed to hurricanes in 2017 experienced psychological distress and predict an increase in the onset of posttraumatic stress disorder and depression. Some water treatment and sewage systems in SIDS were disabled due to damage to infrastructure or power outages after the 2017 hurricanes, and water supplies were contaminated with wastewater and other pollutants. Health impacts caused by contaminated water also reduce lifetime earnings and long-term growth prospects.

Finally, Caribbean countries have lost 10–40 percent of their labor force—particularly high-skilled workers—due to emigration to Organisation for Economic Co-operation and Development (OECD) member countries (Mishra 2006). Many have lost more than 70 percent of their labor force with more than 12 years of completed schooling. This is among the highest emigration rates in the world. Several studies find that hurricanes increase migration from Central America and the Caribbean to the United States by 6–16 percent (Andrade Afonso 2011; Mahajan and Yang 2017).

Despite Caribbean countries' significant progress in developing social protection systems (especially in response to the COVID-19 pandemic), gaps remain in terms of coverage and adequacy (Beazley and Williams 2021). Most have in place a mix of programs that aim to support the main social protection objectives of equity, opportunity, and resilience. Social insurance coverage in the region remains low and biased towards the upper income level, due to predominantly high levels of informality. Approximately 60 percent of Jamaica's poorest quintile and up to 80 percent of St. Lucia's have no access to social insurance. Social assistance is pro-poor, but there is substantial room for improvement in terms of reaching the poorest: 36 percent of Jamaica's poorest quintile and 47 percent of St. Lucia's are excluded from social assistance.

Although countries have demonstrated their ability to react quickly to shocks with emergency social protection responses, these have often been ad hoc, reactionary, and designed during the emergency and not proactively, resulting in delays and inefficiencies. In many Caribbean systems, key operational processes and delivery mechanisms for foundational social protection remain rudimentary, limiting their ability to adapt to post-shock contexts and needs (Beazley and Williams 2021).

These results suggest that natural disasters threaten the long-term sustainability of growth by reducing human capital, and its inclusiveness by heavily affecting the poor and vulnerable, despite progress in social protection.

Finding 2. Looking ahead, countries are not prepared for the new challenges posed by climate change, compounded by uncertainty on future tourism markets. At the same time, the lack of fiscal space in some countries reduces future coping capacity.

This report proposes new analysis of the impact of sea level rise on coastal flooding and sandy beach erosion, highlighting the scale of future challenges for Caribbean countries. It also warns that the impact of past shocks (including the COVID-19 pandemic) on public debt have deteriorated the capacity and available buffers of many governments to adapt to these changes and respond to future shocks.

Caribbean countries face difficult trade-offs for food security

The World Food Programme estimates that 2.9 million people in the Caribbean were food insecure in July 2020, compared to 1.2 million in April (WFP 2020). Most Caribbean countries depend on food imports to satisfy domestic demand, making them vulnerable to disruptions in the food chain caused by the COVID-19 pandemic (FAO 2020). And since they export perishable, labor-intensive foods, they are also vulnerable to disruptions in logistics and customs delays (FAO 2020). A survey by the Food and Agriculture Organization (FAO) national offices in the Caribbean found that food availability issues in supermarkets and informal markets at the start of the crisis were down to supply problems. As a result of disrupted food supply chains in the early COVID-19 pandemic, some Caribbean countries like Trinidad and Tobago have rethought their agriculture production strategy to reduce dependency on imports and increase production for domestic consumption.

Agriculture accounts for 23 percent of employment in the Caribbean (62 percent in Haiti) and has always been an integral part of the Caribbean economy. The sector is characterized by a dual system: large-scale, export-oriented traditional plantation crops such as sugarcane and bananas juxtaposed by small-scale farming of staple local crops (Beckford and Campbell 2013). Most of the poor rely on agriculture for their livelihoods (Ramasamy 2013)—for example, 9 of Jamaica's 14 parishes are over 70 percent rural and 65 percent of the population depends on agriculture as a major source of livelihood (Campbell, Barker and McGregor 2011).

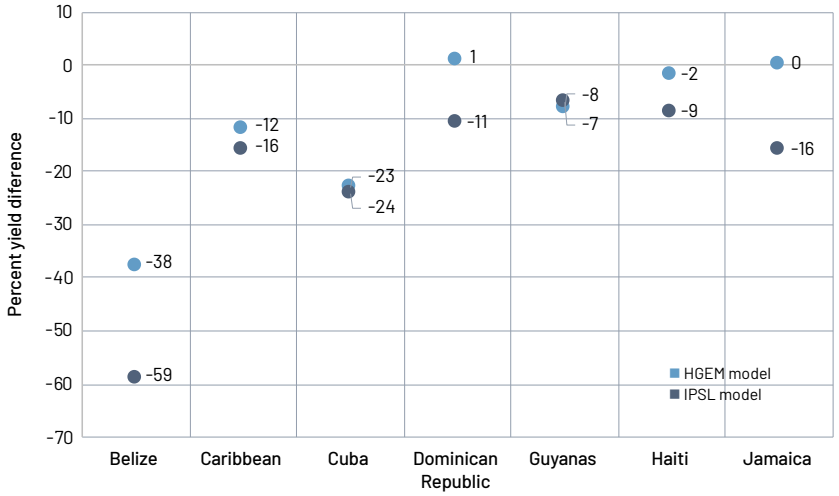
Climate change will severely impact the Caribbean agriculture sector, which will need to adapt. It already suffers regularly from severe hurricane and drought damage and, as temperatures rise, several crops will experience heat stress and lack the ideal climate conditions for maximizing yields. Recent modeling results show that the largest negative impact of climate change in Latin America and the Caribbean will be on sugar cane, followed by maize and cotton (Piñeiro et al. 2020). The study finds that, compared to a scenario without climate change, maize yield losses due to climate change through 2030 in the Caribbean will be roughly 16.5 percent. ***Figure S5*** shows the agriculture yield in 2050 with climate change impacts relative to a counterfactual without climate change, using several climate models. Except for one model projection for the Dominican Republic, all countries and subregions experience a yield loss due to climate change. Belize has a projected agriculture yield loss of 38 to 59 percent, depending on the model used.

FIGURE S5 >>

Agriculture yield difference in 2050 due to climate change (RCP 4.5)

Source: Based on data from Rosegrant et al. 2017

Notes: A negative number indicates a lower expected yield in 2050 compared to a situation without climate change while a positive number implies a higher expected yield. *Caribbean* refers to 25 Caribbean SIDS; *Guyanas* includes Guyana, Suriname, and French Guiana. IPSL and HGEM are two global climate models. RCP 4.5 (or Representative Concentration Pathway) refers to a climate scenario corresponding to a decline in global emissions after 2040.



The **fisheries** sector could offer an avenue for growth and food security in the region but is also challenged by climate change impacts. Within the CARICOM region, it employs 200,000 fishers and 100,000 people in fish processing, marketing, and other supporting roles. Fish supplies 7 percent of protein intake in the Caribbean, and the sector supplies 1 percent of all Latin American fish production and about 0.2 percent of total world fishery production. The **aquaculture** sector is a promising source of growth and jobs, but its development in the Caribbean has been slower than the global average. As of 2014, the Caribbean only constituted about 0.05 percent of world total aquaculture production (Makara 2021).

The fisheries sector is already affected by overfishing, habitat alteration, poor management, and other challenges, which are only compounded by the effects of climate change. Sea level rise, rising sea surface temperatures, ocean acidification, and increasing storm intensification have the most widespread impacts on fisheries in the Caribbean (Pérez-Ramírez 2017). Sea level rise has already caused beach erosion and the relocation of housing and fishery landing sites. Recent storms and hurricanes have also caused significant damage—for example, in Jamaica, Hurricane Gustav caused $14 million in damages to the marine fisheries sector, mainly through the loss of fishing gear, while in Dominica, Tropical Storm Erika caused over $2 million in damages, 95 percent of which was to boats and engines (Monnereau and Oxenford 2017).

Climate change impacts can also directly affect—and even alter—the physiology, behavior, growth, distribution, reproductive capacity, and mortality of fish. Sea surface temperature extremes caused

repeated mass bleaching events on the Mesoamerican Barrier Reef System in Belize, Honduras, and Guatemala in 1993, 1998, 2005, and 2010. Coral bleaching damages critical fish habitats, decreases fish production, and impacts the protection of beaches and landing sites. Productivity in fisheries is predicted to decrease in tropical and temperate regions and increase closer to the poles because marine organisms are expected to shift geographical distributions to maintain their appropriate thermal environments. Under current climate conditions and policies, these impacts will be unequally distributed, with tropical developing countries and SIDS experiencing the greatest impacts (Free et al. 2020).

Tourism is suffering from both the COVID-19 crisis and longer-term climate change

COVID-19 was no ordinary shock to global tourism, of a kind not seen since the mass expansion of international tourism began in the 1950s (Gössling, Scott and Hall 2020). At the time of this report, the total impact of the pandemic on Caribbean economies remains unknown, but early evidence points to devastating effects. According to Tourism Analytics (2021), regional stopover arrivals for January and February 2021 dropped by 68 percent compared to 2020, while arrivals declined by 66 percent from January to December 2020 compared to 2019. The Caribbean Tourism Organization made a preliminary projection that the 50 percent reduction in regional stayover arrivals in 2020 would take the Caribbean back to 1995/96 tourism levels, reversing 25 years of growth (CTO 2020). Erman et al. (2021) find that during March to November 2020, Caribbean hotels and restaurants lost 90 and 77 percent of their sales, respectively.

The COVID-19 vaccine rollout is expected to gradually increase consumer confidence and contribute to an ease in travel restrictions. However, the International Air Transport Association (IATA) has warned that international passenger demand may not recover to pre-pandemic levels until 2024 (IATA 2020). The United Nations World Tourism Organization's (UNWTO) extended scenarios for 2021–24 point to a rebound in international tourism by the second half of 2021, with the rebound expected to continue into 2022 as travel conditions normalize and the pandemic is globally contained. However, a return to 2019 levels in terms of international arrivals could take anywhere between two and a half to four years (UNWTO 2020).

As the Caribbean tourism sector prepares for the post-COVID era, which brings more uncertainty around future global demand for air travel and tourism, it also needs to prepare for climate change impacts.

Climate change is expected to increase the severity, and maybe the frequency, of hurricanes in the Caribbean, with severe impacts on the tourism sector. Several studies looking at the average impact of hurricanes on tourism in the region concluded that an average hurricane strike causes tourism arrivals to drop by only 2 percent in the 12 months afterwards the storm, while the largest event—Hurricane Ivan in 2004—was estimated to have reduced arrivals by 20 percent. An analysis conducted for this report, however, finds that the impact was much higher for 2008–18. After accounting for fluctuations in global economic trends, disease epidemics, institutional capacity, and adaptation investment, Scott et al. (2020) find that high-damage hurricanes reduce tourist arrivals by 11 percent during the following 12 months, compared to a year with low-damage or no hurricanes. When looking at monthly impacts, they find that hurricanes initially reduce tourism arrivals by over 30 percent, recovering to the season average in the following three months.

Erman et al. (2021) provide more detailed information. As expected, the tourism firm survey found that natural disasters force businesses to close, resulting in immediate losses in sales. But losses may also continue after firms reopen, as prolonged reconstruction of vital infrastructure and tourist attractions often limit travel, making tourists less willing to return to a country after a disaster. Survey respondents indicated that the five main contributing factors to sales reductions were:

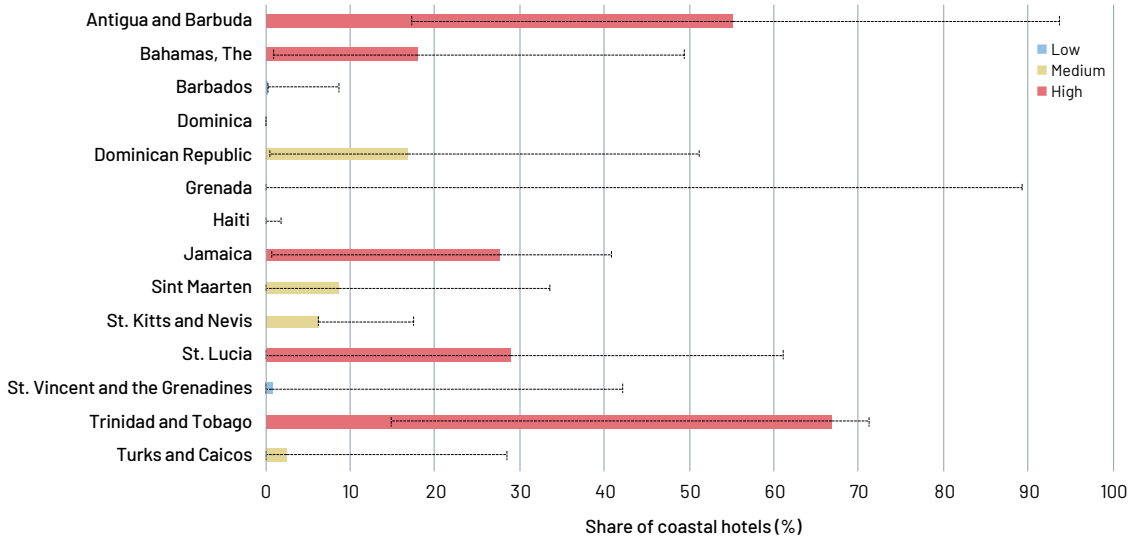
» Halted international air transport (44.8 percent)
» Negative perception of the country due to disaster (37.6 percent)
» Cruise ships rerouted or stopped coming (26.1 percent)
» Travel agencies rerouted or stopped sending tourists (25.5 percent)
» Damage to touristic attractions (24.4 percent)

The study estimates that, six months after the disasters hit, the average loss across the Caribbean ranges from 9 to 14 percent. Losses were more salient after Hurricane Irma, when firms lost 18–25 percent on average. Interestingly, some of these impacts are mitigated at the regional level because, when a Caribbean country is affected by a disaster, tourists are often rerouted to nearby countries. Apart from firms in Jamaica, survey respondents reported an increase in demand because of a natural shock in a neighboring country. The countries where most firms have experienced this effect are St. Kitts and Nevis (70 percent) and Antigua and Barbuda (64 percent).

As well as increasing sales losses from hurricanes, climate change will damage the assets that tourism relies on, namely coastal infrastructure and sandy beaches. Sea level rise is expected to increase coastal flooding and accelerate coastline erosion. A new analysis carried out for this report finds that, across all Caribbean countries, a 35-meter shoreline retreat of sandy beaches is projected under a high climate change scenario by 2050, increasing to 98 meters by 2100 (Giardino et al. 2021). The largest average projected shoreline retreats by 2050 under high climate change impacts are in Suriname (71 meters), Guyana (65 meters), Trinidad and Tobago (53 meters), and Belize (46 meters). While absolute retreat is large, in countries such as Belize and Trinidad and Tobago, where only relatively small parts of the coastlines are sandy, the risk of sandy area land loss is lower. Note that the magnitude of impacts could be lower if there is a significant reduction in greenhouse gas emissions in the next decades. Reducing global greenhouse gas emissions following an average impact climate change scenario (RCP 4.5) can decrease projected land loss by almost 20 percent in 2050 and almost 40 percent in 2100, relative to the high-impact (RCP 8.5) scenario.

FIGURE S6 >>

Hotels in Caribbean countries experiencing beach loss by 2050 under a moderate climate change scenario



Source: Based on data from Campbell, Spencer and Strobl 2021

Notes: Coastal hotels are those that are located within 1km (Euclidean distance) from the beach. The bars show the mean share of hotels experiencing beach loss; the error bar represents the 95 percent confidence interval. Countries are categorized according to the mean amount of projected beach loss. Countries with low beach loss are in the bottom third; those with medium beach loss are in the middle third; and those with high beach loss are in the top third.

Sandy beach erosion directly affects the profitability of the tourism sector (Thinh et al. 2019). Even under a moderate (RCP 4.5) CO2 emissions pathway, 13 (30) percent of nearshore hotels will experience beach loss resulting in a 17 (38) percent decrease in tourism revenue for the region by 2050 (2100) (Campbell, Spencer and Strobl 2021). In the absence of adaptation, by 2050, countries like Trinidad and Tobago, Antigua and Barbuda, St. Lucia, and The Bahamas will see a large proportion of hotels unable to profit from proximity to a sandy beach (*figure S6*). However, the level of uncertainty is large for longer time horizons—for the 2100 estimate, the regional share of hotels affected varies between 2 and 35 percent, with 95 percent confidence. Sea currents will also lead to beach accretion (sediment build-up) in some areas, benefiting some hotels. The priority for adaptation should therefore focus on areas that are threatened by both increased coastal flooding and sandy beach erosion.

Recent economic and financial crises have deteriorated governments' capacity to respond to future shocks

Governments play a central role in helping populations and economies cope with natural and economic shocks. This is particularly so in the Caribbean, where insurance markets are not always well developed and the financial sector is not resilient, limiting post-shock risk sharing and resource mobilization for private actors.

Financial sector assets in the region stand at almost 170 percent of GDP and financial crises in the past have had devastating impacts on the Caribbean economy. Masetti (2021) assesses the resilience of the sector by measuring its exposure to economic sectors that are vulnerable to disasters (that is, the number of assets financial institutions own in vulnerable sectors) and looking at the financial sector's soundness to gauge its shock-absorbing capacity. Results show that banks—the dominant type of financial institution in most Caribbean countries, which own more than 50 percent of total assets—are particularly exposed through personal loans, so any shock that impacts the household sector's debt repayment capacity would be particularly severe. Results highlight that banking sectors in countries like Grenada and Trinidad and Tobago, which have high lending exposure to both the hotel and restaurant and mining sectors, are particularly vulnerable. In many countries, risks are compounded by weaknesses in bank asset quality that are likely to be exacerbated by the COVID-19 pandemic. Masetti (2021) also suggests that existing financial sector safety nets are not enough to protect the most vulnerable and mitigate the economic costs of financial sector turmoil. These vulnerabilities of the financial sector to climate shocks mean that sector risks amplify—rather than mitigate—the impact of future disasters.

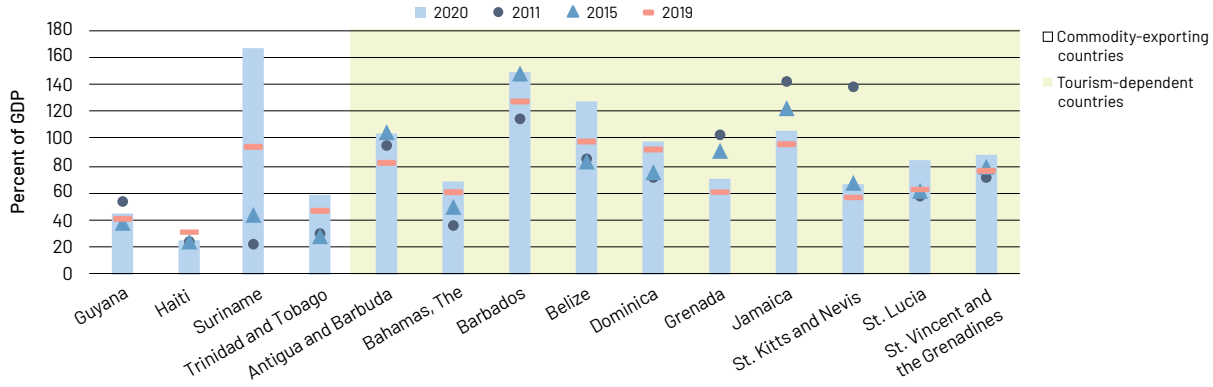
Insurance penetration in the Caribbean, while varying substantially across countries, is generally low. Premiums written account for 8 percent of GDP in Barbados, 6 percent in The Bahamas and Grenada, only around 1.5 percent in Guyana and the Dominican Republic, and less than 1 percent in Haiti and Suriname. In some countries, insurance penetration is affected by the reinsurance and captive companies that underwrite mostly overseas business rather than protect the local economy, implying that insurance protection of the private sector is lower still. Most of the insurance coverage relates to nonlife instruments—often dominated by motor insurance—while property insurance or other instruments that offer more suitable protection against disasters are scarce. Erman et al. (2021) find that, while 63 percent of firms report having an insurance plan with disaster coverage, only 23 percent of those affected by disasters in recent years could rely on insurance recovery. This suggests that many Caribbean countries still use antiquated insurance wording with exclusions and defensive clauses that favor the insurer.

The weakness of the insurance and financial markets increases the need for governments to react to shocks by implementing countercyclical policies. Most Caribbean countries are limited in their use of monetary policy as a response to external shocks because export-oriented economies require a relatively stable exchange rate environment, which leaves little room for monetary policy to react to factors other than

exchange rate changes. Fiscal policy is therefore an essential tool for governments to respond to shocks. However, countercyclical fiscal policy requires building fiscal space, which in many countries is limited and gets crowded out by high levels of public debt and debt servicing costs. High debt levels compromise a country's creditworthiness and constrain its ability to borrow.

FIGURE S7 >>

General government gross debt in Caribbean countries



Source: Based on data from IMF's World Economic Outlook database (accessed April 2021)[3]

Unfortunately, financial shocks in the Caribbean have had a negative impact on countries' debt levels. While the impact of natural disasters on public debt has been limited (Strobl 2021), the 2008 global financial crisis and the COVID-19 pandemic have had devastating effects. The financial crisis has had long-term effects on public debt in the region, with debt-to-GDP ratios increasing by approximately 15 percentage points between 2008 and 2010 (IMF 2013). The pandemic's impact on debt-to-GDP ratio has also been adverse: apart from Guyana, which started producing oil in 2020, all countries with available data saw an increase in debt-to-GDP ratio between 2019 and 2020 (*figure S7*).

Rising debt is due to a combination of increased social protection spending and a drop in fiscal revenues. A study on St. Lucia estimated that the drop in air and cruise arrivals in 2020 led to a 55 and 17 percent drop in government revenues, respectively, bringing a total 72 percent reduction in fiscal revenues in 2020.

These high debt levels risk reducing government access to debt markets, including concessional financing, which is important after a disaster. They also prevent governments from responding countercyclically and aggressively to future recessions or financial crises by reducing tax collections or increasing spending.

Outdated technologies and limited data availability create bottlenecks for facing old and new challenges

New technologies offer great opportunities for public and private actors in the Caribbean to better manage climate and disaster risk (Fontes de Meira and Bello, 2020), but the region is lagging on access to these. Since the 1980s, there have been efforts to address technology gaps with bodies and frameworks to align efforts regionally and increase cooperation. However, the process remains fragmented, constrained by policy shifts, inadequately resourced, and unable to retain capable staff.

Low levels of use and acceptance of digital payments across the region prevents individuals and businesses from transacting online. High costs for opening and maintaining bank accounts, transaction

fees for "traditional" digital payment methods such as credit and debit cards, and steep automatic teller machine withdrawal fees drive a preference for cash transactions and avoiding interaction with the formal banking system.

Limited digitalization also impedes access to education and health services. When social distancing measures imposed during the COVID-19 pandemic forced many schools to close and switch to remote learning, disparity in access to technology led to inequitable access to education. In the Caribbean, 1 in 10 households with school-aged children—mostly low-income households—lacks access to the tools and equipment they need for remote learning (Bellony and Powers 2021).

There are also challenges around availability, interoperability, and critical data sharing to help strengthen resilience across sectors. Limitations include:

- Outdated information, with most countries only collecting census data every 10 years
- Paper-based data collection, as in the case of postdisaster household assessments or shelter evaluations
- A lack of hazard, risk, and other data sharing across government and with the private sector
- The lack of interoperability of data from different sources and databases
- Limited use of data in decision making, which means there is little risk-informed land use planning.

While most countries have made significant progress around data collection, these limitations—particularly around data sharing—prevent them from reaping the expected resilience benefits.

Against this backdrop, Caribbean countries must design new resilience strategies, based on robust analytics and prioritization processes. Using the evidence gathered for this report (*box S1*), the recommendations section outlines three priorities for Caribbean countries.[4]

BOX S1 >>

The traffic light system used in this report

The traffic light system (TLS) is based on the conceptual framework proposed by Hallegatte, Rentschler and Rozenberg (2020) and is organized around actors and responsibilities within governments, grouping actions under "foundations" for rapid and inclusive development, which offers protection against shocks, and five priority areas[a] to build resilience and adapt to shocks (*figure BI2.1.1*). The TLS conceptual framework covers the five pillars outlined in the *Caribbean Pathway for Building Resilience*,[b] namely (i) Social protection for the marginal and most vulnerable, (ii) Safeguarding infrastructure, (iii) Enhancing economic opportunity, (iv) Environmental protection, and (v) Operational readiness, but it also covers more extensively the role of the Ministry of Finance through macro-fiscal policy and financial sector regulation for resilience. The goal is to identify gaps, facilitate target setting, and monitor progress across all sectors and aspects of resilience.

Under each priority area lie several actions with indicators to monitor progress towards implementing these actions. According to criteria defined by World Bank experts, the framework defines three maturity levels and classifies the indicator as:

- **Nascent** (red) when the country does not meet the standard or includes areas that are only starting to or do not address the standard at all
- **Emerging** (yellow) when the country partly meets the standard and has progressed beyond the initiation point but has not reached the final point
- **Established** (blue) when the country meets the standard

The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. It is intended to serve as a starting point for discussion, and the indicators and ratings can be modified, based on additional country-level information. The TLS can also be used as a complement to other resilience tools already available in the region, such as CDEMA's Comprehensive Disaster Management (CDM) Audit Tool.[c] While the CDM Audit Tool provides more depth when analyzing the traditional disaster risk management (DRM) cycle, the TLS proposed here is broader and includes actions that are the responsibility of the Ministries of Finance or Economy, Health, Education, or Social Protection. As such, the TLS can first be used to identify areas that require attention, while CDEMA's framework can be used to identify and monitor more specific actions.

Figure BS1.2 summarizes the TLS results and shows that few countries score "established" on most priority actions. The actions with the highest number of "established" countries are under foundations, existence and availability of risk information, and coastal management plans. Actions with almost no "established" countries include making building codes and urban plans risk-informed, developing and making the social protection systems responsive to shocks, and being prepared to build back better. The TLS also helps identify data gaps. For example, data are missing for most indicators on actions related to access to technologies for resilience, clarifying responsibilities between the public and private sector, and anticipating the long-term macroeconomic impacts of climate change.

[a] In this report, the *Adaptation Principles'* priority area 2—*Adapt land use plans and protect critical public assets and services*—has been split into two: *Design resilient infrastructure systems, urban and coastal plans* and *Build resilient health and education systems*. *The Adaptation Principles'* framework also proposes a sixth priority area for institutions, legal frameworks, planning and monitoring. In this report, the actions in this area are included in each of the five presented priority areas.

[b] https://www.cdema.org/Building_A_Caribbean_Pathway_For_Disaster_Resilience_In_The_Caribbean_Community_(CARICOM).pdf

[c] https://www.cdema.org/cdm

FIGURE BS1.1 >>

Conceptual framework applied to the TLS and used in Part 2 of this report

PRIORITY AREA 1	PRIORITY AREA 2	PRIORITY AREA 3	PRIORITY AREA 4	PRIORITY AREA 5
Facilitate risk reduction decisions by firms and households	Design resilient infrastructure systems, urban and coastal plans	Build resilient health and education systems	Help people and firms manage residual risks and natural disasters	Anticipate and manage macrofiscal and financial issues

FOUNDATIONS

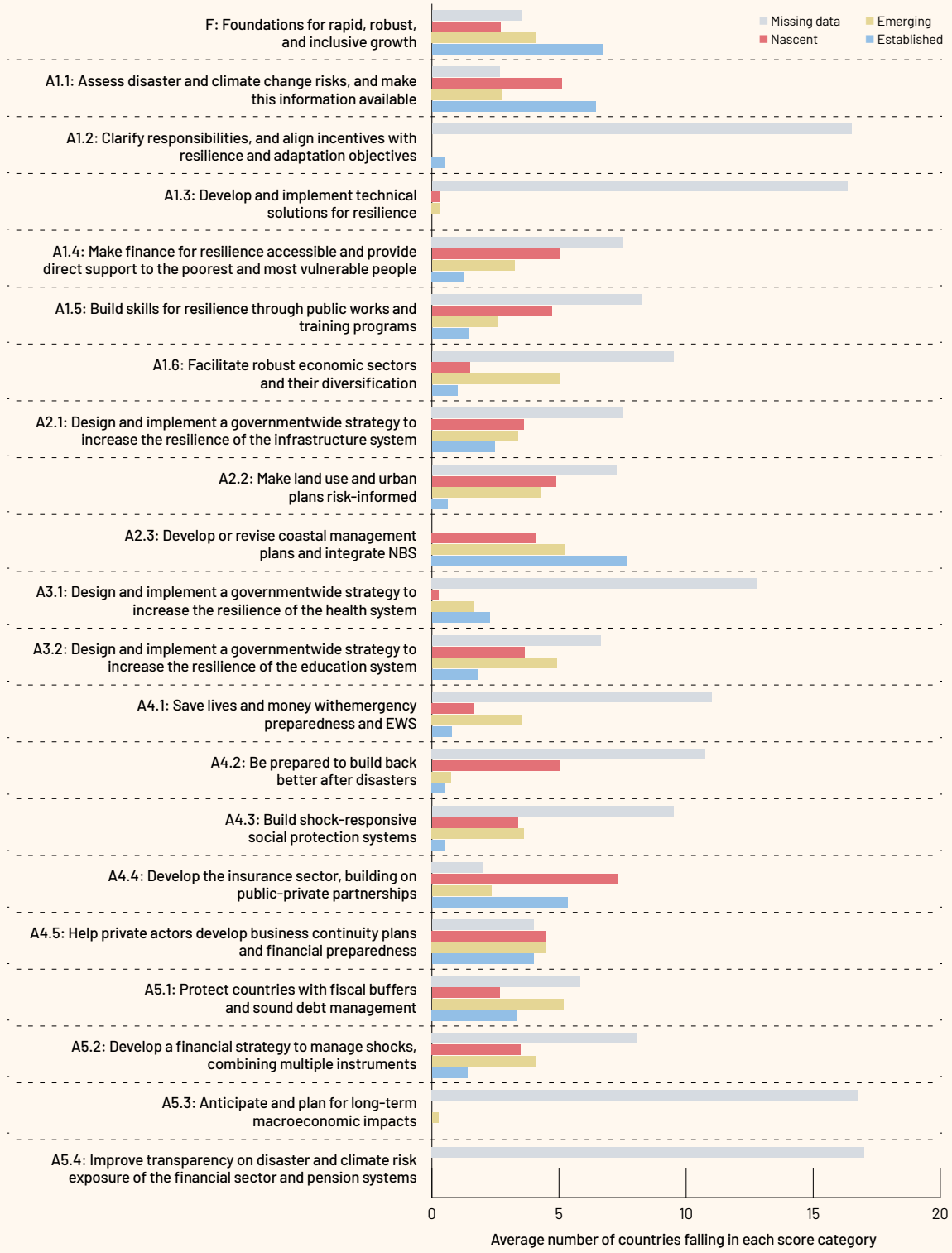
Rapid, robust, and inclusive development

Source: Adapted from Hallegatte, Rentschler and Rozenberg 2020

Note: Foundations are the actions, systems and processes that enable rapid, robust, and inclusive development and form the basis of the conceptual framework, while the five priority areas identify actions governments can take to strengthen resilience.

FIGURE BS1.2 >>

Summary of the TLS results, by priority action



Note: The red score (Nascent) indicates that the country does not meet the standard or includes areas that are only starting to or do not address the standard at all; the yellow score (emerging) indicates that the country partly meets the standard and has progressed beyond the initiation point but has not reached the final point; and the blue score (established) indicates that the country meets the standard. Grey indicates that there was no or insufficient data available to assign a score. Individual results for each country are presented in Appendix B.

Three recommendations for building resilience to a new generation of shocks

This analysis of resilience in Caribbean countries demonstrates that all countries have made progress on some aspects of resilience building, but there is room for improvement. The report proposes a country-level TLS to help identify gaps, facilitate target setting, and monitor progress (*box S1*). The TLS is a first screening; and going forward, prioritizing actions would benefit from a participatory process and high-level client engagement at country level. The recommendations drawn in this summary are more general and apply to many countries in the Caribbean.

Recommendation 1. Increase government efficiency

Governments have many responsibilities for building resilience, from investing in more robust infrastructure systems to organizing disaster response and supporting firms and households after shocks. Given their limited capacity and public budgets, governments need to focus on being more efficient and transparent in the way they manage public budgets and deliver these services.

Invest in digitalization for key government services. Digital development is a key building block for publicly sharing risk information, enabling interoperable and interagency information systems—between disaster management agencies, health authorities, and education authorities—that are crucial for responding effectively to shocks and for more efficient and transparent government services, such as land management (through electronic cadastral systems and an efficient land registration process) and social protection (Beazley and Williams 2021; Bellony and Powers 2021; Harnam and Khan 2021; Johnson, Caroca Fernandez and Restrepo Cadavid 2021). Many Caribbean countries' social protection systems, for example, still rely on rudimentary Excel- or paper-based registries. The first steps towards interoperability and integration would require establishing a system for nationwide unique identity management and digital registries. Next, countries would need to develop protocols and mechanisms for sharing and protecting data within and between the social protection and DRM sectors, to make program designs and operations more risk-informed and enhance coordination. Finally, they would need to establish mechanisms for frequent updates, to ensure that the data are current, relevant, and of good quality. No country in the region has such a mechanism (Beazley and Williams 2021). Continued leadership by regional organizations like CARICOM and OECS can facilitate the process at national levels.

Improve processes for postdisaster spending. Fiscal response to disasters in the Caribbean is not always strategic or efficient, and emergency finance procedures are often undocumented, ad hoc, coincidental, and sometimes inefficient. And while there have been some achievements in disaster finance planning and fiscal impact mitigation, given the frequency of natural disasters in the Caribbean, national authorities should provide more guidance on how to manage public finances, procurement, and investments to swiftly respond to—or rebuild after—disasters. Governments do not systematically track public assets, which are also financially underprotected, making it difficult to quickly carry out accurate postdisaster needs assessments or replace destroyed assets.

Reduce budget variability and fiscal risks by improving public asset management. One avenue of improvement is increasing the transparency and accountability of state-owned enterprises. Transport authorities and water utilities need asset management systems and preemptive maintenance budgets. But, while most Caribbean countries have some type of asset registry, they have yet to expand this to a comprehensive inventory of all assets, covering both their condition and the strategic, financial, and

technical aspects of infrastructure management. Most countries make reactive decisions, based on experience, rather than ex ante decisions driven by data. Without appropriate succession planning and business continuity practices, such decisions are susceptible to staff turnover. State-owned water utilities could largely improve their efficiency by reducing their high nonrevenue water levels—that is, water lost through pipes in bad condition. In the Caribbean, 24–63 percent of potable water never reaches the customer after leaving the point of production (Medina et al. 2021).

Build fiscal resilience. In response to external shocks, fiscal policy is the most important instrument for Caribbean governments. However, the fiscal fragilities accumulated over the past decades have left the region with limited fiscal space and unable to respond to volatilities. This is further aggravated by inefficiencies in public sector governance. The region has been operating significantly procyclical fiscal policies over the past decades, accumulating high public debt. In the current environment, fiscal policy not only fails to accumulate enough fiscal cushion to mitigate external shocks; it also amplifies external shocks to the overall economy via fiscal spending. To rebuild and strengthen fiscal resilience, countries must establish fiscal responsibility frameworks to discipline fiscal policies and build credibility in normal times, thereby ensuring financing cushions in the event of an external shock.

Adopting and strengthening the design and effectiveness of appropriate fiscal rules should be a priority for all Caribbean governments. Countries have made significant progress in adopting fiscal rules with the required enforcement, escape clauses, and oversight. The benefits of following the rules are also prominent—for example, after implementing the 2015 Fiscal Responsibility Law, Grenada saw its debt-to-GDP ratio reduced by 48 percentage points to less than 60 percent of GDP in 2019. Other countries adopting rules-based fiscal responsibility frameworks include The Bahamas, which adopted the Fiscal Responsibility Act in 2018; St. Vincent and the Grenadines, which approved the Fiscal Responsibility Resolution in 2019; and St. Lucia and Belize, which are both preparing to adopt fiscal rules.

Assess direct and indirect liabilities and improve the transparency of budget allocation for emergency social protection and health expenditures. Many Caribbean governments have started assessing direct contingent liabilities for disaster risk financing strategy design. To complement these assessments, governments should also evaluate indirect liabilities from reduced fiscal revenues and increased expenditure for adaptive social protection and health emergency services due to a shock. Most countries do not have such ex ante quantification of indirect contingent liabilities. But these are fundamental for establishing adequate financing mechanisms to manage the financial risk of the entire frequency and severity spectrum and linking with adaptive social protection and health emergency financing mechanisms to ensure an effective and sustainable response to shocks. While most Caribbean countries are party to risk financing arrangements—notably through the Caribbean Catastrophe Risks Insurance Facility (CCRIF SPC)—they lack strategies for comprehensive disaster risk financing and a systematic link to adaptive social protection and health emergency financing.

Roll out the development of disaster risk financing strategies that cover the entire spectrum of risk from small, frequent events to rare, extreme events. The region has been actively building layers of disaster risk financing with support from international organizations, including the World Bank. Most countries are also part of the CCRIF SPC.[5] But a more comprehensive approach to disaster risk financing is crucial to adequately cover the spectrum of frequencies and severity of shocks. Such an approach is based on disaster risk profiles that provide an understanding of direct liabilities from infrastructure and indirect liabilities from reduced fiscal revenues and increased expenditure for adaptive social protection and health emergency services. St. Lucia's National Strategy for Disaster Risk Financing (2018) is a well-established legal and institutional framework for managing disaster and climate risks that strengthens the government's ability to assess, reduce, and manage fiscal risks from natural disasters. This is a model

worth replicating across countries to enable governments to adequately budget and prepare for the financial impact of disasters and ensure immediate liquidity without jeopardizing medium- to long-term development goals.

Recommendation 2. Empower households and the private sector

As well as improving the efficiency of government support for resilience, governments need to empower private actors (households and businesses) to help them diversify their income sources, make more resilient choices, and bounce back after disasters.

Help firms and households plan ahead by making good quality risk data publicly available in a format that can be used and analyzed and reflects the (uncertain) future impacts of climate change. While all countries in the Caribbean have made significant progress in producing data needed for hazard and risk assessments and carrying out hazard and risk analytics (as reflected in their relatively high TLS scores), few have up-to-date risk information in a geospatial data format, at the right scale, that considers the future impacts of climate change. Geospatial data require local technical staff and computer systems to produce timely analytics and information for specific projects or plans. This capacity, however, is limited in most Caribbean countries.

Data must also be useful for DRM, with hazard maps, exposure datasets, vulnerability information, and risk analytics made publicly available on websites or other public information platforms. While sensitive data, such as household surveys, can only be shared within government, the public availability of hazard and risk information is important even when urban and coastal planning is weak, as it can inform private actors' decision making about where and how to build. So, in the absence of planning, risk maps may still shape development if they are publicly available. This also reinforces the need to educate practitioners and the public about risk analytics, and to clearly communicate uncertainty about future risk and the range of changes that climate change can bring (to coastal flooding, for example).

In the Caribbean, the foundational policy framework for data governance has gaps. Not all countries have passed freedom of information legislation into law—it is lacking, for example, in Barbados, St. Lucia, Grenada, Dominica, Suriname, and Haiti. Similarly, the existence of open data and data management policies is inconsistent, while the lack of legislation for cybersecurity creates a propensity to restrict all access to all data in the name of security.

Help households diversify their income and bounce back after disasters by building a social protection system that has high coverage, comprehensively addresses risks, and provides adequate benefits. The fastest available response to poor households in post-shock contexts is often through vertical expansion of existing social protection benefits. So, if countries' foundational social protection programs—particularly their flagship cash transfer program—have limited coverage, it can be difficult to scale them up quickly and effectively to help the poor cope with emergencies or shocks.

Central to effective coverage expansion is improving targeting systems for foundational social protection programs, particularly to identify and enroll those who are most in need. Optimally, these systems should be informed by updated household survey data, but these are lacking in several countries. An important complement to this is ensuring that they provide adequate benefits to help programs meet their objectives, and by extension, foster meaningful resilience. Primary among this is guaranteeing that benefits for any flagship poverty-targeted safety nets are enough to ensure consumption smoothing among beneficiary

households. It is also important to recognize that countries face difficult trade-offs between expanding coverage and increasing benefits. Programs with small coverage that provide adequate benefits and include deliberate measures to facilitate economic inclusion and poverty reduction could help pave the way for new rounds of beneficiaries through graduation.

Help firms (including MSMEs) and households invest in resilience and rebuild after disasters by developing the financial and insurance sectors, including regulation on risk disclosure and strengthening financial sector safety nets. Financial development plays a key role in promoting competitiveness and diversification. It also relieves some fiscal pressure by transferring risks to the private sector, and helps countries better manage the impact of terms of trade volatility, especially in the case of small, open economies as in the Caribbean. In the face of external shocks, a less developed financial market is not only unable to give firms timely and needed liquidity; its high vulnerability and significant systemic risk exposure also amplifies the shocks. Strengthening financial regulation and improving financial access for MSMEs are the two key reforms for leveraging financial markets and helping offset external shocks.

Credit information, a key gap for developing the financial sector, could be addressed by establishing credit registries or bureaus. With the appropriate legal framework, these could be set up by the private sector; otherwise, central banks could offer them as a public good. Such registries would help mitigate information asymmetries and enhance access to credit for underserved segments, such as MSMEs. Improving the secured transaction and moveable collateral framework would also improve access to credit and facilitate liquidity—a much-needed service for postpandemic recovery. Governments should also consider specifically promoting access to credit for upfront investments in private sector resilience building.

For example, St. Lucia has advanced the Secured Transaction Act and Insolvency Act, which will promote credit access for MSMEs by enabling movable collaterals and encourage investors by addressing distressed loans and minimizing losses. These reforms will serve as an example for other countries to undertake similar steps in the region. The passage of the Banking Act in the eight OECS member states also provides a framework for improved supervision and resolution. As well as benchmarking the Caribbean to international sound practice, such financial sector reforms will help build crisis preparedness and resilience.

Financial sector supervisors should also focus on building financial sector resilience to climate and environmental risks through requirements for risk assessments, with authorities considering explicit guidelines for financial institutions on climate and environmental risk management, governance, and disclosure. To get further information and share experiences, central banks and supervisors could consider joining the Network for Greening the Financial Sector.[6]

Support farmers and fisherfolk with access to data, technological solutions, and finance. Solutions for adaptation must be based on local, historic climate knowledge; and the input and participation of local farmers and fisherfolk is crucial in creating and implementing said solutions. Farmers and fisherfolk also need to expand their knowledge and access climate-adaptive and risk management tools and strategies. To create an enabling environment, governments should make financing available and accessible, ensure that the necessary materials and equipment are available in local markets, provide advisory services to deliver technical guidance, and create policy and regulatory environments that incentivize farmers and fisherfolk to invest in climate-adaptive tools and strategies. They should also consider management reform and offshore mariculture as solutions for improving resilience in the fisheries sector.

Invest in digital infrastructure and build digital skills to strengthen businesses and build human capital. Digitalization can increase the efficiency of key economic sectors, such as tourism, by opening new ways for customer acquisition, improving online brand visibility, expanding international reach, and

improving the quality of service delivery and client satisfaction (Masetti 2021). Strong internet connection can attract "digital nomads"—remote workers, academics, or freelancers who are not geographically bound to their workplace and want to work from a Caribbean country for up to 18 months—either from the diaspora or other countries. While these newcomers would not be taxed in the short term, they can be a source of innovation and potentially future fiscal revenues if they decide to stay.

Access to innovative, low-cost digital financial services—transaction accounts, savings, credit, insurance, remittances, and so on—could also help vulnerable households, MSMEs, and farmers invest, smoothing consumption over time and mitigating the impact of climate and other shocks to their livelihoods. Modernized payment system regulation and infrastructure would also support the efficient transmission of social cash transfer funds to vulnerable households throughout the Caribbean (Masetti 2021).

Digital technologies contribute to continuity of learning during shocks, and children from disadvantaged households must be provided with the required tools. However, this needs to be combined with addressing the parental educational shortcomings where these exist. Parents and caregivers are main actors in supporting education continuity and based on recent evidence, and well-educated parents are better poised to protect children from learning loss after disasters (Andrabi, Daniels and Das 2020).

Digital development will require upgrades to physical information and communications technology infrastructure and legal and regulatory reforms in the telecommunications sector to increase the scope and reduce the costs of connectivity under clearly defined rules and responsibilities. Alongside these reforms, governments must help businesses adopt technology and empower individuals with digital skills. Eastern Caribbean countries continue to lag significantly across most of the digital economy foundations, compared to peers at similar levels of socioeconomic development. COVID-19 has further underlined these digital deficits, exposing the region's lack of preparedness to move government operations, education, communications, and commerce online.

Creating redundancy in infrastructure networks, ensuring backup power infrastructure is in place, and putting legislation in place for cybersecurity will create resilient digital systems (Sandhu and Raja 2019). But in the Caribbean, cybersecurity legislation and policies are often nonexistent. The International Telecommunication Union's 2018 Global Cybersecurity Index rates all countries in the region except Cuba, Jamaica, and the Dominican Republic in the lowest tier of commitment to cybersecurity due to a lack of legislation, policies, and trained personnel (ITU 2019).

Recommendation 3. Reduce future physical risk

Aging infrastructure stocks in the Caribbean are a constraint to future growth and resilience. The absence of land use plans also makes planning ahead for future sea level rise and changes in flood extents extremely challenging. While countries need to be pragmatic, given the high costs of infrastructure investments, they have many opportunities to reduce physical risk at reasonable costs.

Develop and implement risk-informed building codes that are relevant to the local context and ensure informal builders are equipped to build resiliently. Building and land use regulations are remarkably powerful and comparatively inexpensive tools for increasing people's safety and resilience to climate change and disaster risks. But achieving this requires a comprehensive and effective building regulatory framework—a system of interrelated legislation, codes, enforcement mechanisms, education and training requirements, product testing and certification, professional qualifications, and licensing schemes that

support a safe, sustainable, and resilient built environment. When this apparatus is functioning well, it enhances the legitimacy of the building code process and creates an enabling environment for greater compliance with these standards.

Building standards must be adapted to local circumstances and uniformly applied across the sector so that all buildings are built to the local code. However, to be effective, they must also consider how the poorest can afford to build, thus addressing the high levels of informal building that occur in the Caribbean. It is advisable for national building legislation to provide guidance or make provisions for national and local government management of informal sector builders. Jamaica is already doing this through its Building Act 2017, which establishes provisions for regulating a new category of "previously unregistered and unregulated (informal) builders". The Act gives building practitioners the opportunity to be registered formally and receive a license to construct residential and small commercial buildings. As most such buildings have not previously been subject to regulatory review or inspection, this provision extends the benefits of building standards to the informal building sector.

Risk-informed land use and building code implementation and enforcement are typically the weakest part of the building regulatory system due to a lack of human and financial resources allocated to this function. Since many Caribbean countries are quite small and lack an abundance of financial and human resources, pooling regional resources can offer economies of scale that cannot otherwise be achieved. For example, enhanced regional collaboration through a centralized platform could offer greater opportunities for building industry practitioners to network, share relevant experiences, lessons learned and best practices, and access training that would enable them to bring their expertise where it is needed in the region. Alternatively, technological solutions—such as bringing building permit approval processes online—can increase the efficiency of the permitting processes and enhance coordination among relevant agencies, enabling physical planning departments to focus their limited human resource capacity on ensuring the building codes are adequately implemented and enforced.

Develop risk-informed coastal and land use plans that consider future climate change impacts. Many Caribbean countries are not effectively using urban planning to strategically manage urban development to increase resilience. Although most countries have policies and documents that recognize the importance of urban planning and integrating disaster risk into the planning process, regulation and institutional frameworks continue to lag and have insufficient human capital and skills to support the planning process; when plans are in place, countries generally lack the resources to implement them (Johnson, Caroca Fernandez and Restrepo Cadavid 2021).

Land use plans need to consider future climate change impacts and the resources needed to protect coastal areas from sea level rise. A high-level assessment of coastal protection infrastructure investment needs shows that countries like Dominica, Guyana, and Suriname could have significant investment needs for coastal protection, driven by maintenance costs as much as new investments (*table S1*). In the absence of appropriate funding and asset management systems for adequately maintaining coastal protection infrastructure, governments should consider alternative strategies, including natural barriers and managed relocation. Making relocation a strategic option that leaves people, communities, and the environment better off poses significant challenges for coordinating scientific inputs and government support. Research is needed to identify vulnerable population groups and how to build communities' capacity to successfully navigate relocation. Incorporating local needs, knowledge, and preferences into planning processes is also crucial. And given the highly uncertain tradeoffs and consequences of managed relocation options, governments can work with scientists to explore what actions, policies, and support make people better off across many plausible futures.

TABLE S1 >>

Caribbean countries' coastal protection capital and maintenance investment needs (2020–2050) under RCP 4.5

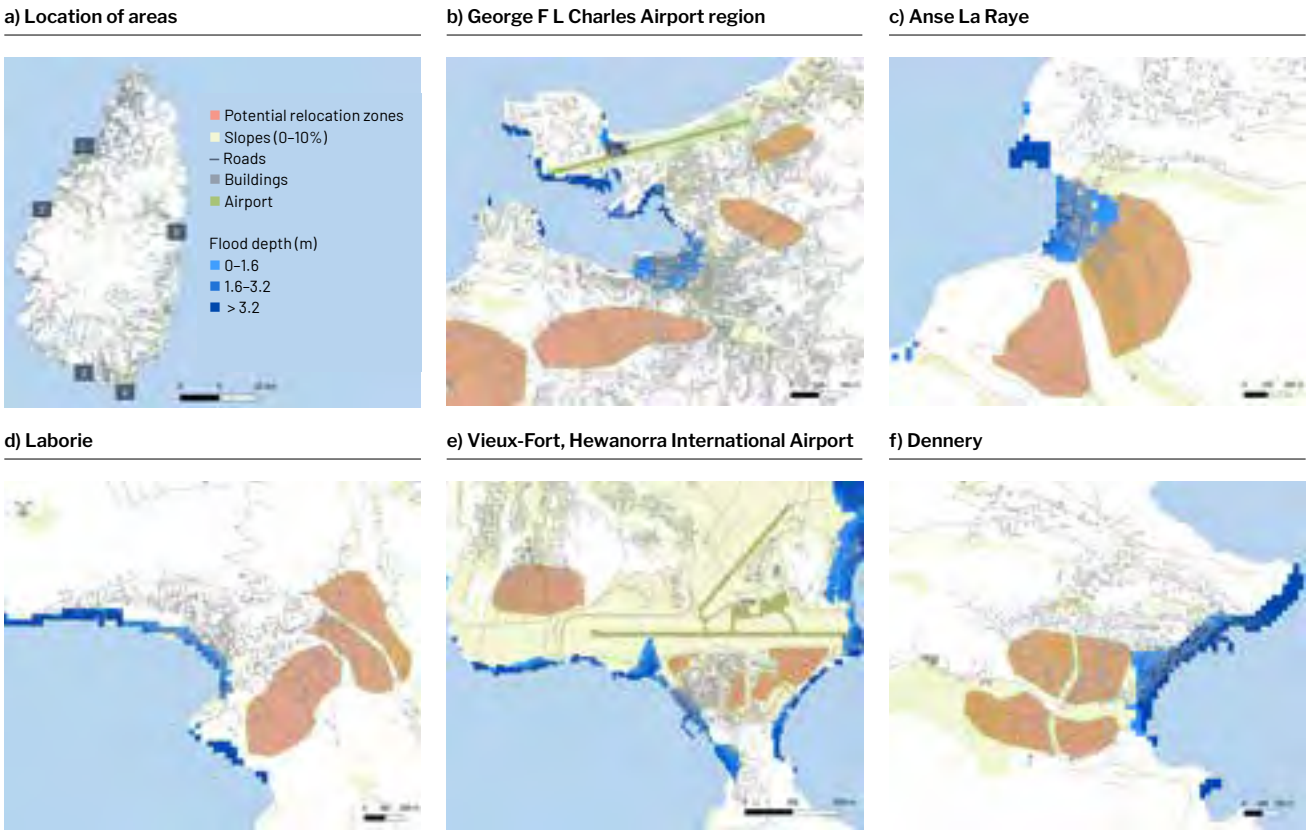
	Total coastal protection investment costs ($, millions)		Total coastal protection maintenance costs ($, millions)		Total cost per year (% of 2019 GDP)	
	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound
Antigua and Barbuda	53	138	94	256	0.3	0.8
Bahamas, The	1,828	1,711	2,275	4,779	1.0	1.6
Belize	194	508	244	660	0.8	2.1
Dominica	112	291	210	568	1.8	4.9
Dominican Republic	225	554	409	1,095	0.0	0.1
Guyana	5,095	10,869	2,431	5,178	4.8	10.3
Jamaica	128	280	256	561	0.1	0.2
St. Martin	59	153	103	282	0.4	1.0
St. Vincent and the Grenadines	18	47	33	90	0.2	0.6
Suriname	1,505	4,009	817	2,180	2.1	5.6
Turks and Caicos Islands	48	122	121	330	0.5	1.3
Total region	9,266	18,682	6,992	15,980	0.4	0.9

Source: Based on data from Nicholls et al. 2018

Notes: Costs are presented for an adaptation strategy based on a cost-benefit analysis. Other scenarios are available in Nicholls et al. (2018). Countries in red (nascent) are in the lowest third for that indicator; those in yellow (emerging) are in the middle third; and those blue (established) are in the top third.

FIGURE S8 >>

Identifying areas that are potentially suitable for future development in St. Lucia



Source: Giardino et al. 2021

Note: Areas in pink are potentially suitable for future development or relocations away from possible flood plains (in blue). Flooding is shown for sea level rise estimates by 2100 under RCP 8.5.

In the absence of land use plans, a first step can be using high-resolution elevation data and coastal flood maps (*figure S8*) to identify areas that are safe and underdeveloped. In this example from St. Lucia, such areas are identified in pink.

Take advantage of natural capital. Natural barriers are often cost-efficient, no-regret solutions for coastal protection and have many "co-benefits", from becoming tourism attractions to providing habitats for animals that are critical for the fisheries sector. Investing in coastal wetlands can stabilize coastlines by trapping sediment with their root systems and reducing wave height and velocity with their dense vegetation. For example, salt marshes, coral reefs, seagrass beds, and mangroves can reduce non-storm wave heights by an average of 72, 70, 36, and 31 percent, respectively; coral and oyster reef systems can control coastal erosion by reducing wave velocity; and seagrass can help stabilize sediment and regulate water currents that contribute to coastal erosion. A paper prepared for this report finds that the presence of mangrove helps mitigate hurricane damage, avoiding between 6–40 percent of total economic damage (Miranda et al. 2021). Restoring coastal wetlands can be two to five times cheaper than building submerged breakwaters to deal with wave heights of up to half a meter.

As well as being critical assets for tourism, sandy beaches and dunes can prevent waves and storm surge from reaching inland areas. Where sandy beaches are being eroded by sea level rise, they can be enhanced through artificial sand nourishment. However, sound environmental frameworks are necessary to ensure that dredging sand does not create environmental issues in other places.

TABLE S2 >>

Estimated beach nourishment costs in Caribbean countries, assuming no additional adaptation action

	Total beach nourishment cost (2020–2050, $ millions)		Total cost per year (% of 2019 GDP)	
	Lower bound	Upper bound	Lower bound	Upper bound
Antigua and Barbuda	111.2	556	0.22	1.12
Bahamas, The	4,158	20,790	1.02	5.10
Barbados	23.6	118	0.02	0.08
Belize	396	1,980	0.70	3.51
Dominican Republic	0	0	0	0
Dominica	256	1,280	1.47	7.33
Grenada	20.4	102	0.06	0.28
Guyana	164.4	822	0.11	0.53
Haiti	230.8	1,154	0.05	0.27
Jamaica	119.6	598	0.02	0.12
Sint Maarten	32	160	0.09	0.45
St. Kitts and Nevis	25.2	126	0.08	0.40
St. Lucia	26	130	0.04	0.20
St. Vincent and the Grenadines	19.2	96	0.08	0.39
Suriname	20.8	104	0.02	0.09
Trinidad and Tobago	127.2	636	0.02	0.09
Turks and Caicos	301.6	1,508	0.84	4.20
Total region	**6,032**	**30,160**	**0.11**	**0.55**

Source: Based on data from Giardino et al. 2021

Note: The lower-bound cost is based on $10 per cubic meter, while the upper-bound is based on $50 per cubic meter. Most of the cost is due to the need to dredge and transport the sand and thus depends on distance to the dredging site. Countries in red (nascent) are in the lowest third for that indicator; those in yellow (emerging) are in the middle third; and those blue (established) are in the top third.

Table S2 presents high-level estimates of the potential cost of beach nourishment in the Caribbean, assuming linear erosion between 2020 and 2050 and using current beach nourishment costs. It also compares annual beach nourishment costs to countries' 2019 GDP. These estimates show that beach nourishment can be an affordable solution to erosion in many countries. But in The Bahamas, Belize, Dominica, and Turks and Caicos, the cost is high, and countries will need a strategy to either select the beaches they want to protect or complement sand nourishment with other measures that reduce erosion, such as submerged breakwaters or vegetation on the beach, assuming there is no infrastructure. Where sand nourishment is too expensive, countries might need to organize managed retreat away from the coast to allow vegetation to protect the dunes and the beach.

Identify and strengthen critical infrastructure assets, including schools and health centers. Most countries would probably aspire to very low-risk infrastructure systems. Indeed, given their small size, this may seem achievable for most Caribbean countries. However, the severity and frequency of extreme events, the degree of uncertainty around the intensity and complexity of future events, and the financial and implementation capacity limitations these countries face advise a strategic approach based on prioritization instead. *Table S3* presents an estimation of the costs of retrofitting existing exposed infrastructure. Although it does not cover all assets, these calculations suggest that the cost is relatively limited in most Caribbean countries and could be spread over several years. For example, Belize, Guyana, Haiti, the Dominican Republic, and Trinidad and Tobago spent on average 1.95 percent of GDP on infrastructure between 2008 and 2019. Belize spends the most, with an average of 4.2 percent, and Haiti the least, at 0.39 percent (Infralatam 2021). There are, however, several caveats. First, these estimates assume that infrastructure is well maintained, while many of the assets could be in bad condition. If this is the case, retrofitting would become reconstruction, which costs two to three times more. Second, the estimates assume that authorities know which assets are exposed to hazards and can prioritize investments based on exposure. Third, although retrofitting would reduce vulnerability by 30 to 80 percent depending on the assets, it would not offer much protection against high-intensity events like Category 5 hurricanes, so there is still a need for preparedness (Miyamoto International 2021).

Increasing the resilience of infrastructure systems at an acceptable cost begins by identifying its most critical parts that are also particularly exposed and vulnerable. Criticality analyses can help identify which parts of a networked system play particularly important roles for the functioning of the whole system, making it possible to prioritize the interventions that will give the largest benefits. Since criticality analyses include the functional aspect of systems, they can also help inform preparedness and response activities for the assets identified as critical but where interventions to increase resilience have yet to take place. In this way, the focus shifts from an asset-based to a resilience-based perspective, which goes beyond the robustness of a system to address flexibility and adaptability (Fisher and Gamper 2017). Given budget constraints in the Caribbean, using criticality analyses can help prioritize across sectors.

When identifying critical facilities in the education sector, it is necessary to reflect on the role of learning spaces in the community. Schools function as social spaces for communities and, in times of disaster, as emergency shelters. If housing infrastructure is significantly damaged or destroyed, the return of schools to educational use is often delayed. Recent experiences in the Dominican Republic have proved school facilities are central to community well-being. The country is using school facilities to implement public policies to overcome health, nutrition, and recreational challenges at community level. Developing operational guidelines for different school uses—including as emergency shelters—is essential to the resilience of the education system.

After identifying critical infrastructure assets and systems, governments need to redefine acceptable and intolerable risk levels, which infrastructure sectors can then use to design their own regulations and measures, ensuring consistency across systems. For health facilities, they can use PAHO's Smart Hospital

Initiative[7] and the *WHO Guidance for Climate Resilient and Environmentally Sustainable Health Care Facilities* (WHO 2020) to guide and support national infrastructure improvements.

TABLE S3 >>

Costs of retrofitting existing infrastructure assets exposed to hazards in Caribbean countries

	Low retrofit cost (% of 2019 GDP)	High retrofit cost (% of 2019 GDP)	Roads	Bridges	Power plants	Hospitals	Airports	Water treatment plants
Antigua and Barbuda	1.4	3.9	✓	✓	✓	✓		
Bahamas, The	4	9.5	✓	✓	✓	✓	✓	
Barbados	0.3	1.1	✓	✓	✓	✓		
Belize	4.6	21.2	✓	✓	✓	✓	✓	
Dominica	3	14	✓	✓	✓	✓	✓	
Dominican Republic	2	5.2	✓	✓	✓	✓	✓	✓
Grenada	0.3	1	✓	✓	✓	✓		✓
Haiti	1.2	3.7	✓	✓	✓	✓	✓	
Jamaica	1.5	6	✓	✓	✓	✓		✓
St. Kitts and Nevis	0.4	1.2	✓	✓	✓	✓		
St. Lucia	0	0.4	✓	✓		✓		
St. Vincent and the Grenadines	1.3	2.4	✓	✓	✓	✓		
Suriname	15.9	27.1	✓	✓	✓	✓	✓	
Trinidad and Tobago	2.8	4.9	✓	✓	✓	✓		

Source: Based on data from Miyamoto International 2021; Schweikert et al. 2021

Notes: Only the assets for which publicly available localization data are available are considered. The improvement considered would reduce vulnerability by 30–80 percent, depending on the asset and hazard. Calculations assume that assets are in good condition; however, if assets need to be rebuilt rather than improved, costs will double or triple.

Be prepared to build back better, possibly in different places. It can take many years for Caribbean countries to recover from a disaster, and the process is often interrupted by yet another impact. When Hurricane Maria struck Dominica in 2017, the commerce and microbusiness sector was only beginning to regain its strength after Tropical Storm Erika in 2015, and housing reconstruction had not been finalized. An efficient recovery has the potential to reduce the impact not only of future disasters but also of the disaster that caused the damage in the first place, by helping the economy bounce back more quickly. However, the often high level of urgency to reconstruct leaves little time and human resources are stretched. To be truly able to build back better, governments need to prepare for a faster and stronger recovery and reconstruction.

Faster recovery refers to speedier reestablishment of connectivity and access to services, which shortens impacts on well-being. To achieve this, materials, machinery, replacements, and people need to be pre-positioned before an event so they can efficiently access and address issues. Many countries in the region already use this practice, but can strengthen it further through risk analytics and by prioritizing critical

infrastructure. Faster recovery also requires quick procurement of goods and services while ensuring accountability, transparency, and overall value for money, considering quality, cost, and delivery time. Apart from Jamaica, procurement planning for emergencies and emergency procurement procedures are relatively weak in the region. Strengthening disaster-resilient and responsive procurement through market research, preparing procurement plans and developing sourcing strategies is critical for speeding up recovery in the region so that, when a disaster occurs, agencies already have information on adequate suppliers and can use transparent expenditure procedures that were put in place before disaster struck. According to Hallegatte, Rentschler and Walsh (2018), faster recovery could lower average well-being losses by 46 percent in Belize and St. Lucia, 50 percent in Trinidad and Tobago, and 54 percent in Dominica.

Reconstruction that does not consider risk-informed land use plans and follows outdated building codes—or fails to enforce building codes—will miss the opportunity to increase resilience with a forward-looking perspective that takes climate change effects into account. Preparing for recovery requires obtaining the necessary political commitment for developing recovery policies and programs that strengthen public and private sector institutional and technical capacities to ensure individual builders, carpenters, contractors, and building officials at all levels of government have the capacity for design, construction, and quality assurance required for postdisaster situations. According to Hallegatte, Rentschler and Walsh (2018), stronger reconstruction would reduce overall well-being losses due to natural disasters by more than 40 percent in Antigua and Barbuda, Dominica, and Trinidad and Tobago.

While political commitment may be limited before a disaster, extreme events often open a window of opportunity to pass previously prepared legislation, enact specific guidelines, or enable the use of supporting information. Housing is one of the fields where preparation is particularly critical, especially if resettlement is involved. In the absence of land use plans, it is impossible to relocate people quickly in safe areas. Besides, with sea level rise, current resettlement approaches are likely to be inadequate. Making resettlement a strategic option that leaves people, communities, and the environment better off requires much higher coordination between stakeholders and continuous planning processes. Given the uncertainty around future climate impacts, key issues are how to best incorporate local needs, knowledge, and preferences into planning processes, and ensuring choices are flexible.

Conclusion

This report takes a 360-degree approach to resilience in the Caribbean, assessing progress and gaps across all sectors and countries. While this summary draws general conclusions that are applicable to many countries, ***Appendices A*** and ***B*** of the full report contain much more detailed, country-specific analyses. Planners can use the traffic light tool presented in ***Appendix B*** to discuss resilience strategies, set targets, and monitor progress at country level. The tool can be tailored to each country's context.

Continued actions to strengthen regional coordination will be key for resilience. As explained in this summary, regional coordination has been instrumental during the COVID-19 response. Given some countries' capacity constraints, pulling together resources at regional level will also be vital. Areas where strengthened collaboration is needed include data gathering and sharing, digitalizing national data, integrating regional data management and support, allocating health resources during crises, enforcing building codes, sustainable fiscal policy reforms with a central oversight committee, a central contingency fund for major external shocks, coordinated tax incentives, building financial sector resilience, and more coordinated strategies to attract foreign direct investment and tourism, avoiding a "race to the bottom" and high fiscal costs.

Endnotes

1. https://databank.worldbank.org/source/world-development-indicators.
2. A World Bank High Frequency Phone Survey in May 2020 found that over 70 percent of households in St. Lucia saw incomes decrease since the beginning of the pandemic. The poverty rate was expected to increase to 22.8 percent in 2020, implying that 8,000 St. Lucians could fall into poverty. Moreover, the impact will be long lasting due to limited safety nets.
3. https://www.imf.org/en/Publications/WEO/weo-database/2021/April.
4. For a complete overview of all recommendations see Part 3 of the full report and the respective background notes prepared for this report.
5. For detailed information on payouts from the CCRIF SPC, see: https://www.ccrif.org/about-us.
6. https://www.ngfs.net/en.
7. https://www.paho.org/en/health-emergencies/smart-hospitals.

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Chapter 1 >>
Asset losses from natural hazards and sea level rise

Chapter 2 >>
Lifeline infrastructure

Chapter 3 >>
Private sector vulnerabilities and losses

Chapter 4 >>
Macroeconomic and fiscal vulnerabilities and losses

Chapter 5 >>
Human capital and well-being

Chapter 6 >>
Summary and conclusions

I.1

INTRODUCTION TO PART 1 >>

A diagnosis: an overview of current and future impacts of shocks on the Caribbean

Caribbean countries are highly exposed and vulnerable to a large range of external shocks.

Exposed implies that, if a country were hit by a shock, a large proportion of its population, assets, and economic activity would be affected. *Vulnerable* means that, when hit by a shock, the exposed people, assets, and sector incur significant losses—that is, a large portion of consumption or assets are destroyed, and many jobs disappear. This high exposure is due to their small territories and populations, and the concentration of economic activity and exports in a few sectors, including tourism, agriculture and fisheries, and oil. The small size of the countries and their populations contributes to their high vulnerability, by limiting their capacity to prepare for shocks. High sovereign debt levels also reduce the fiscal space for undertaking the costly investments required to resist shocks, while relatively high poverty levels limit people's ability to invest in their own protection (*table I.1*).

TABLE I1.1 >>

Selected indicators for the Caribbean countries covered by this study

	Surface area (sq. km)	Total population	GDP per capita ($)	Agriculture, forestry, and fishing, value added (% of GDP)	Services, value added (% of GDP)	Debt (% of GDP)	Poverty rate
Antigua and Barbuda	440	97,118	17,113	1.8	66.3	90.1	18.3
Bahamas, The	13,880	389,482	34,864	0.6	71.2	55.5	12.8
Barbados	430	287,025	18,148	1.6	71.9	145.4	17.2
Belize	22,970	390,353	4,815	9.6	65.5	96.3	41.3
Dominican Republic	48,670	10,738,958	8,282	5.2	58.3	48.6	20.9
Dominica	750	71,808	8,111	13.0	53.3	96.3	28.8
Grenada	340	112,003	10,809	4.9	66.6	72.0	37.7
Guyana	214,970	782,766	6,610	17.6	44.7	51.7	
Haiti	27,750	11,263,077	1,272	19.4	54.1	39.3	58.5
Jamaica	10,990	2,948,279	5,582	6.6	59.3	104.7	12.6
Sint Maarten	34	40,733	29,160	0.1	69.1		
St. Kitts and Nevis	260	52,834	19,935	1.4	67.4	60.1	21.8
St. Lucia	620	182,790	11,611	2.0	75.2	60.9	25.0
St. Vincent and the Grenadines	390	110,589	7,458	7.2	62.8	77.6	30.2
Suriname	163,820	581,363	6,360	9.7	52.6	74.3	
Trinidad and Tobago	5,130	1,394,973	17,398	1.1	53.4	40.6	17.1
Turks and Caicos Islands	950	38,191	31,353	0.4	75.4		

Source: Based on data from World Bank, World Development Indicators (accessed April 2021). [1] The debt levels are averages over 2016-2018.

Finally, the region frequently experiences hydrometeorological, seismic, and geological hazards, including hurricanes, flooding, landslides, storm surge, and volcanic eruptions, and is likely to experience several different shocks and dangerous gradual changes due to external conditions (*table I1.2*). Since 1950, more than 400 disasters[2] have occurred in the Caribbean due to natural phenomena, mostly caused by severe storms and flooding.[3] Climate change is expected to exacerbate some of these events. The frequency and intensity of droughts and excess precipitation are expected to increase, while sea level rise will bring storm surges further inland (IPCC 2013). The availability of fresh water will also be impacted by the changes to seasonal rain patterns and sea water intrusion into aquifers. While it is difficult to know if climate change will increase the frequency of hurricanes, it will most likely increase their intensity. Climate change can

TABLE I1.2 >>

Examples of future external events that could affect Caribbean economies and well-being

Type of event	One-off events	Gradual change
Economic	» External supply and demand shocks, such as commodity price shocks, changes in terms of trade, a global economic crisis or pandemic » External financial shocks, such as interest rate shocks	» External supply and demand shocks, such as reduced demand for tourism due to the COVID-19 pandemic, increased air transport cost, or increased food prices due to climate change mitigation policies
Natural	» Natural hazards such as hurricanes, floods, droughts, or earthquakes » Disease outbreak	» Temperature increase » Land degradation and salinization » Sea level rise

also bring new mosquito-borne diseases and will impact agriculture as mean temperatures are expected to increase over the suitable levels for most crops (IPCC 2013). The region has been—and will likely continue to be—affected by commodity price shocks and global (or regional) economic and financial crises, which have been regular events over the past 60 years.[4] Finally, the COVID-19 pandemic has heavily impacted this tourism-reliant region and long-term changes to global demand for tourism could further affect Caribbean countries.

Combined with exposure and vulnerability, the *likelihood* of being hit by a shock allows a *risk* to be quantified. In practice, however, while it is possible to quantify the likelihood of hurricanes and earthquakes with some confidence based on catastrophe modeling and historical data, it is not possible to quantify the likelihood of economic shocks. Climate change is also changing the probability of hydrometeorological events—such as hurricanes, floods, and storms—making it more difficult to quantify future disaster risk. When it is impossible to quantify the probability of events occurring, they are often referred to as *uncertain* or *deeply uncertain* (*box I1.1*).

In this report, the word *risk* is often used even when referring to deeply uncertain events. In these cases, risk refers to the combination of exposure and vulnerability to some shocks, knowing that these shocks will happen in the future but with no reliable quantified information on the annual probability of occurrence.

Overview of Part 1

Part 1 of this report focuses on the different channels through which the shocks that hit the Caribbean create social and economic losses, and the tools that exist to assess the past, current, and future impacts of shocks (*table I1.3*). While postdisaster damage and loss assessments (DaLAs) give a picture of the impact of past disasters on some parts of the economy (*box I1.2*), additional econometric analyses and forward-looking modeling exercises are needed to capture the full impact of shocks on Caribbean economies and guide decision makers. In this first part, all the analyses of the impacts of the COVID-19 pandemic on Caribbean economies are identified in colored boxes and pages.

Chapter 1 describes the impact of natural hazards and climate change on physical capital (for example, buildings, machinery, and infrastructure) and natural capital, which includes wetlands, mangroves, and agriculture land. These are the most tangible losses and often the easiest to quantify. The chapter uses a series of probabilistic risk modeling exercises to quantify current asset risk. It also presents modeling exercises on the future impact of sea level rise on coastal flood risk and land loss.

Chapter 2 describes how damage to transport, energy, and water assets can lead to bigger losses for infrastructure services and users, through network effects. It builds on DaLAs for the impact of past disasters on infrastructure, and on modeling exercises to identify critical infrastructure assets and how damage to these can impact users. It is important to consider network effects because even small damages to critical infrastructure can lead to important losses for households and the private sector.

Chapter 3 looks at how different productive sectors are affected by shocks, offering an in-depth review of impacts on the tourism, agriculture, and financial sectors. As well as natural hazards, this chapter assesses the impact of economic, financial, health-related shocks, building on DaLAs for the impact of past disasters on some sectors, on econometric analyses that quantify the impact of storms on the value added of different sectors, and on a firm survey for impacts on the tourism industry. This chapter highlights that relying heavily on one or two sectors can make an economy very vulnerable to shocks.

BOX I1.1 >>

Climate change and uncertainty

Climate change impacts are deeply uncertain,[a] making it impossible to agree on a set of probabilities that accurately describes future impacts. The range of uncertainty, however, varies from one type of impact to the next, and while projections of future sea level rise at the global level are robust, climate change impacts on future hurricanes or agriculture yields are much more uncertain, and there is disagreement on the direction of change (Chambwera et al. 2014). In addition, given the small size of Caribbean countries, downscaling global climate change impacts to the level of Caribbean countries brings even more uncertainty.

On the global impact of sea level rise over the course of the current century, many studies have brought consensus on the likely range of impacts that can be expected (Hallegatte et al. 2013; Hinkel et al. 2014; Tiggeloven et al. 2019; Vousdoukas et al. 2016; Vousdoukas et al. 2018). The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) states that global sea levels will rise by a likely range (representing at least 66 percent probability) of 0.26–0.98 meters (compared to 1986–2005) by 2100 (IPCC 2013). Available information suggests that sea level rise trends in the Caribbean have been broadly similar to global trends over the last 60 years (Nicholls and Cazenave 2010; Palanisamy et al. 2012). Similarly, regional future projections show trends that are comparable to global projections (Church et al. 2013). There is also a small yet not negligible probability that sea level rise may be higher than the above-mentioned predictions due to accelerated ice sheet melting (DeConto and Pollard 2016). To adapt to these possible rapid and highly uncertain changes, it will be necessary to take decisions on how to adapt sooner and/or to implement different solutions (Haasnoot et al. 2019).

The impact of climate change on hurricanes and other extreme events is much more uncertain. Some studies predict a near doubling of the frequency of Category 4 and 5 storms by the end of the 21st century, despite a decrease in the overall frequency of hurricanes, but there is no consensus on these projections (Bender et al. 2010). Similarly, there is an absence of consensus on the impacts of climate change on agriculture yields (see ***chapter 4*** for a range of impacts from Piñeiro et al. 2020).

Finally, it is important to keep in mind that exposure and vulnerability will be different in the future, and that future socioeconomic change is also deeply uncertain. To capture the uncertainty of both future climate and socioeconomic changes, the scientific community has produced a set of scenarios called Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) (Riahi et al. 2017; van Vuuren et al. 2011), which this report uses throughout. For example, ***chapter 1*** uses RCP 4.5, which represents a scenario in which emissions decline after 2040, and RCP 8.5, a high-emissions scenario in which emissions continue to rise throughout the 21st century (Vousdoukas et al. 2018). While it can be argued that recent climate commitments make the RCP 8.5 emissions scenario unlikely, the resulting sea level rise is still possible due to other uncertainties linked to the climate system. So this report uses it as an upper-bound scenario.

a. *Deep uncertainty* occurs when parties to a decision do not know or cannot agree on models that relate to the key forces that shape the future, probability distributions of key variables and parameters in these models, and/or the value of alternative outcomes (Lempert, Popper and Bankes 2003).

Chapter 4 focuses on macroeconomic and fiscal impacts. Shocks affect GDP through both damages to capital and interruptions to business. However, complexities linked to restructuring, relief, government borrowing, and investment to replace destroyed capital make the impact on GDP much more complex. As such, it is important to measure GDP losses as well as capital and private sector losses. This chapter is mostly a literature review of econometric exercises that try to capture the impact on GDP, fiscal revenues, and debt. It also reviews two forward-looking modeling exercises using macroeconomic models.

Chapter 5 reviews broader human capital, well-being, and social impacts. It builds on case studies that quantify the impact of shocks on poverty, years of schooling, health, and migration as well as two modeling exercises—one that uses household data to translate asset losses into well-being losses, and another that quantifies future climate change impacts on poverty. While those impacts are the most important for understanding and increasing the resilience of populations, they are also the hardest to quantify in the absence of frequent household surveys.

Finally, *chapter 6* closes Part 1 by summarizing and drawing conclusions from these chapters.

Part 1 is the basis for the *risk tables* that have been prepared for all countries covered by this report and that are available in *Appendix A*. These risk tables summarize the information gathered through different background notes prepared for this report into simple indicators, and then rank countries in the Caribbean for each indicator before assigning them three levels: low, medium, or high. For the probability of being hit by a natural hazard, levels are based on the World Bank ThinkHazard! website.[5] For all other indicators, levels are assigned related to peers in the Caribbean, meaning that a low level for an indicator means that the country is in the lower third of all countries in the region for this indicator.

TABLE I1.3 >>

Summary of the assessment methods presented in Part 1

Parts of the economy affected	Historical losses	Current risk (modeled)	Future risk (modeled)
Physical and natural capital	» DaLAs (*introduction*)	» Probabilistic risk modeling for assessing contingent liabilities and planning disaster risk reduction » Flood exposure of urban areas (*chapter 1*)	» Sea level rise modeling to assess land loss and future flood risk to assets (*chapter 1*)
Infrastructure assets and services	» DaLAs (*introduction*)	» Criticality analysis to identify vulnerabilities in networks » Network modeling to assess sector linkages and consumer surplus losses (*chapter 2*)	n.a.
Productive sector	» DaLAs (*introduction*) » Econometric analysis of private sector losses due to storms » Firm surveys (*chapter 3*)	» GIS analysis of exposure of agriculture land to floods (*chapter 3*)	» Modeling of future climate change impacts on agriculture yields (*chapter 3*)
GDP and fiscal revenues	» Econometric analysis of past GDP and fiscal losses due to storms » Econometric analysis of COVID-19 impact on fiscal revenues (*chapter 4*)	» Macrofiscal modeling with two different macroeconomic models (*chapter 4*)	
Human capital and well-being	» Impacts of past shocks on poverty, years of schooling, health, migration (*chapter 5*)	» Probabilistic risk modeling combined with household surveys to assess well-being losses (*chapter 5*)	» Impacts of climate change on poverty using microsimulation (*chapter 5*)

BOX I1.2 >>

Damage and Loss Assessments (DaLAs)

The DaLA methodology, developed in 1972 by the UN Economic Commission for Latin America and the Caribbean, has been improved through close collaboration with the World Health Organization (WHO), Pan American Health Organization (PAHO), World Bank, Inter-American Development Bank (IDB), United Nations Educational, Scientific and Cultural Organization (UNESCO) and International Labour Organization (ILO). A DaLA is a flexible tool that provides government agencies with technical assistance regarding impacted communities and is a basis for defining recovery and reconstruction needs. Caribbean governments use DaLAs to assess the macro socioeconomic and environmental impacts of natural disasters on the overall economy and individual livelihoods and incomes. After an event—usually 4–6 weeks after impact—a team of persons with technical knowledge of specific sectors conducts assessments on the damages and losses to that sector. By estimating and including the replacement value of totally or partially destroyed physical assets, losses in the flows of the economy that arise from the temporary absence of damaged assets, and the resulting impact on postdisaster economic performance, DaLAs offer an overview of damages and losses incurred after selected extreme events that hit Caribbean economies to analyze the level of impact and the principal affected sectors.

Table BI1.2.1 summarizes the damages and losses caused by Tropical Storm Erika and Hurricane Maria Dominica, the 2010 earthquake in Haiti, the 2013 floods in St. Lucia and St. Vincent and the Grenadines, and Hurricanes Maria and Irma in Sint Maarten.

Overall, the scale of damages and losses varies greatly per country and event. While the value of capital destroyed in Dominica by both Tropical Storm Erika and Hurricane Maria and in Sint Maarten by Hurricanes Irma and Maria are equivalent to three-quarters or even exceed GDP for the year of the event (75 and 162 percent respectively for Dominica and 73 percent for Sint Maarten), capital damage from the floods in St. Lucia and St. Vincent and the Grenadines is equivalent to just a few percent of GDP.

In terms of assets, the housing and infrastructure sectors are most impacted by far for all events (71–81 percent of total damages in Dominica, 71 percent in Haiti, 87 percent in St. Lucia, 67 percent in Sint Maarten, and 96 percent in St. Vincent and the Grenadines). Within the infrastructure sector, transport assets often suffer the costliest damages (66–84 percent of infrastructure damages in Dominica, 97 percent in St. Lucia, and 89 percent in St. Vincent and the Grenadines). Given that transport infrastructure (particularly roads and bridges) is almost always managed by the public sector, these damages represent significant liabilities for governments. Within productive sectors, the largest damages to assets are often experienced by the primary sector—that is, agriculture, fisheries, and forestry.

When looking at economic losses, the impact is better distributed among the sectors. The infrastructure sector still represents a large share of losses, but with more variation between countries and events—for example, 86 percent of economic losses in St. Vincent and the Grenadines but only 8 percent in Sint Maarten. With the caveat that the DaLAs do not all report losses for the same sectors, in general, the productive sectors experience 30–65 percent of all reported losses. The exception is St. Vincent and the Grenadines, where they were barely affected by the 2013 flood. Within the productive sectors, losses are generally higher for the secondary and tertiary sectors, although the primary sector experienced higher losses in Dominica with Hurricane Maria, and in St. Lucia with the 2013 floods.

Direct damages and losses to the health and education sectors have historically been low compared to the rest of the economy. The exception is Haiti in 2010, where education infrastructure was damaged, and the health sector experienced significant losses.

The human and social impacts of storm events are also dire. Hurricane Maria had direct negative impacts on employment, livelihoods, and by extension poverty, in Dominica. Following the passage of the hurricane, an estimated EC$94.9 million in

income and 3.1 million workdays were lost. Restoring livelihoods in critical employment sectors such as agriculture and tourism faced significant time constraints, which were estimated to cause a 25 percent reduction in overall consumption. This would increase the poverty head count from 28.8 to 42.8 percent, double the number of indigent individuals from 2,253 to 4,731, and push about 2,800 individuals considered vulnerable before the disaster below the poverty line (Government of the Commonwealth of Dominica 2017).

TABLE BI1.2.1 >>

Summary of damages and losses caused by select natural disasters ($, millions)

	Dominica				Haiti		St. Lucia		Sint Maarten		St. Vincent and Grenadines	
	Tropical Storm Erika 2015		Hurricane Maria 2017		2010 earthquake		2013 flood		Hurricanes Irma and Maria 2017		2013 flood	
	Damages	Losses	Damages	Losses	Damages	Losses	Damages	Losses	Damages	Losses	Damages	Losses
PRODUCTIVE SECTOR	71	17	178	202	397	933	10	6	368	883	1	0
Tourism/Industry/ Commerce/Retail	28.61	12.26	90.55	77.62	245.90	837.30	0.40	2.11	367.75	740.47	0.12	0.059
Agriculture/Fisheries/ Forestry	42.46	4.87	87.40	124.87	53.0	96.0	9.21	3.71	–	–	1.37	0
Finance/Banking	–	–	–	–	98.20	0	–	–	–	143.0	–	–
SOCIAL SECTOR	49	11	444	42	3,259	1,091	3	2	507	117	9	3
Education/Culture/ Youth/Sport	3.55	0.45	79.05	6.12	434.0	43.20	0.80	0.19	60.23	1.71	0	0.02
Health	0.64	1.30	10.90	6.95	196.40	273.70	0.24	0.13	4.27	1.92	1.83	0.22
Food and safety nutrition	–	–	–	–	2,950	35.0	–	–	–	–	–	–
Housing	44.53	9.61	353.96	28.50	2,333.20	738.70	2.15	2.05	442.0	22.10	6.80	2.34
Employment/ Livelihoods/Social protection	–	–	–	–	–	–	–	–	–	91.0	–	–
INFRASTRUCTURE SECTOR	283	51	306	137	868	758	71	8	446	114	76	19
Urban and community infrastructure	–	–	–	–	411.60	183.80	–	–	–	–	–	–
Transport	–	–	182.15	52.62	307.10	289.10	68.80	3.10	–	–	67.87	14.73
Energy/Electricity	2.19	0.33	33.18	32.94	20.80	37.23	–	–	5.92	24.58	5.21	3.35
Telecommunications/ Information and Communications Technology	10.0	0	47.74	8.31	94.0	46.0	0.12	0.41	50.66	–	–	–
Air and sea ports	14.90	0.08	18.89	3.26	–	–	–	–	382.10	79.50	–	–
Roads and bridges/ Drainage	239.25	48.28	–	–	–	–	–	–	0.10	–	–	–
Water and sanitation/ Solid waste management	17.14	2.38	24.0	39.73	34.0	201.40	2.30	4.10	7.13	9.90	3.15	1.32
CROSS-CUTTING	0	0	3	1	3	496	0	0	51	236	0	0
Environment/Disaster risk management	–	–	3.0	0.8	3.0	496.40	–	–	2.02	5.52	–	–
Governance/Public financial management	–	–	–	–	–	–	–	–	3.0	230.0	–	–
Additional public buildings	–	–	–	–	–	–	–	–	45.5	–	–	–
Total ($, millions)	403	80	931	382	4,526	3,278	84	16	1,371	1,350	86	22
Total (% of GDP)	75	15	162	66	40	29	5	1	73	68	12	3

Sources: Based on data from Government of the Commonwealth of Dominica 2015 and 2017; Government of the Republic of Haiti 2010; Government of Saint Lucia and World Bank 2014; World Bank 2018; Government of St. Vincent and the Grenadines 2014.

Endnotes

1. https://databank.worldbank.org/source/world-development-indicators.
2. This analysis uses EM-DAT's definition of *disaster* as a situation or event that overwhelms local capacity, necessitating a request to national or international level for external assistance. In this report, *natural disaster* refers to a disaster that was caused by a natural hazard.
3. EM-DAT: The Emergency Events Database. Université catholique de Louvain, Belgium. https://www.emdat.be/.
4. Since 1950, the world economy has experienced four global recessions: in 1975, 1982, 1991, and 2009. These episodes were highly synchronized internationally and involved severe economic and financial disruptions in many countries around the globe. The 2009 global financial crisis was by far the deepest and most synchronized of the four (Kose, Sugawara and Terrones 2020).
5. https://thinkhazard.org/en/.

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CHAPTER 1 >>

Asset losses from natural hazards and sea level rise

The Caribbean region is highly exposed to different types of natural shocks, including tropical storms and hurricanes, volcanic eruptions, earthquakes, floods, and landslides. Tropical storms and hurricanes regularly bring strong winds and heavy rainfall, damaging buildings, destroying crops, and wreaking havoc on people's livelihoods through floods, landslides, and storm surge.

The easiest way to measure or model the impact of these disasters is by assessing their impact on physical capital, or assets such as buildings, roads, and machinery. The DaLAs (*box I1.2*) show that damages to buildings (particularly housing) and infrastructure assets (particularly transport) have been the costliest reported impacts of natural hazards in the region. By one modeling estimate, all hazards combined—earthquakes, hurricanes, tsunamis, and floods—cause annual average damages of $12.6 billion to assets in the Caribbean[1] (UNISDR 2015).

This chapter presents analyses on potential asset damages from natural disasters in Caribbean countries, historical exposure of urban land and people to flooding, and the potential impact of future sea level rise and sandy beach erosion. The analyses all use modeled events representing possible future shocks to guide risk reduction and adaptation planning.

Global databases and resources: a first screening

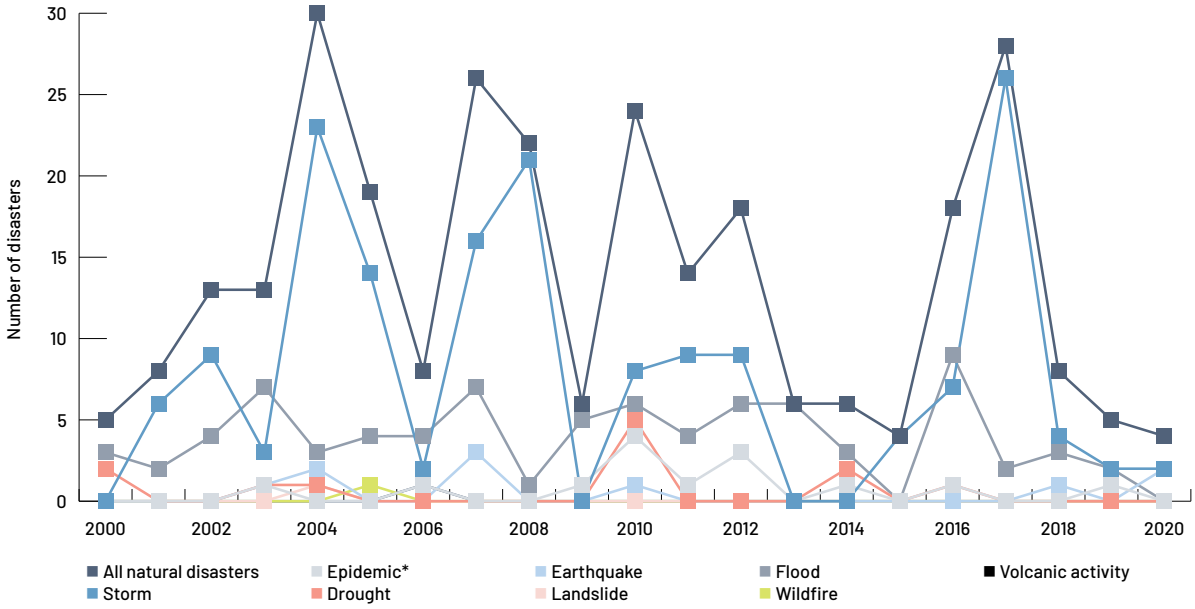
Many global resources are available to provide a first screening of a country's major natural risks. While these resources cannot directly inform project design or policy, they can be used to identify the main issues and compare risks across countries.

Historical records

The most widely used database recording past disasters is EM-DAT,[2] curated by the Centre for Research on the Epidemiology of Disasters at Belgium's Université catholique de Louvain (*figure 1.1*). Other institutions have created similar datasets, including the United Nations Office for Disaster Risk Reduction's (UNDRR's) DesInventar, and reinsurers MunichRe's NatCatSERVICE and SwissRe's Sigma.

FIGURE 1.1 >>

Annual occurrence of selected shocks in the Caribbean (2000–2020)



Source: Based on data from EM-DAT 2021[2]

Notes: Epidemics include cholera, dengue, typhoid fever, and chikungunya. Figure includes: Anguilla, Antigua and Barbuda, The Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Dominica, the Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Puerto Rico, St. Barthélemy, St. Kitts and Nevis, St. Lucia, St. Martin, Sint Maarten, St. Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos, and U.S. Virgin Islands.

According to EM-DAT,[2] the most frequent disasters[3] in the Caribbean are storms and floods, and the territories most affected in the last two decades are: Haiti (83 recorded disasters), the Dominican Republic (54), Cuba (35), Jamaica (21), Puerto Rico (18) and The Bahamas (15).

Historical data records can shed light on a country's risk level but do not provide precise estimates of future risks. They tend to be incomplete, especially in low-income countries, for both low-frequency, high-severity disasters—such as tsunamis, major earthquakes, or hurricanes—due to their low probability of occurrence, and high-frequency, low-impact events, which are often not recorded but add up over time in terms of economic impact. Different databases use different definitions and thresholds (for example, for what they consider a disaster), methodologies, and scopes. Socioeconomic and climate trends also make

natural hazards non-stationary, so relying solely on historical data will not provide accurate estimates for future events (McCarl, Villavicencio and Wu 2008).

Hazard and risk modeling

Simulation modeling is required to assess the probability of hazards and their economic implications (*box 1.1*). Hazard and risk models use deterministic or probabilistic approaches to calculate intensities, probabilities, and anticipated losses. Historical recorded disaster losses can be used to calibrate probabilistic models and provide loss statistics for high-frequency, low-severity events, which are often inadequately captured by these models (GFDRR 2016b).

Several global tools or assessments present the results of such modeling. The World Bank's ThinkHazard! tool,[4] for example, uses global hazard models to assess probability and exposure to 11 different threats (from floods to wildfires) at country and subnational levels. *Table 1.1* shows that individual Caribbean different countries face different probabilities of occurrence for the major events that threaten the region.

TABLE 1.1 >>

Probability of occurrence for different hazards in the Caribbean

	River flood	Urban flood	Coastal flood	Hurricane	Landslide	Earthquake	Tsunami	Wildfire	Volcano	Extreme heat	Water
Antigua and Barbuda	Low	High	Medium	High	Medium	Medium	Medium	Low	Medium	Medium	High
Bahamas, The	Low	Low	High	High	Low	Low	Medium	Low	No data	Medium	Medium
Barbados	Low	Low	Medium	Medium	Medium	Medium	Medium	Low	No data	Low	High
Belize	High	High	Medium	High	Medium	Medium	Low	High	No data	High	Low
Dominica	Low	High	Medium	Medium	High	Medium	Medium	Low	High	Low	Low
Dominican Republic	High	High	High	High	High	Medium	Low	High	No data	Medium	Low
Grenada	Low	Low	Medium	Medium	High	Medium	Medium	Low	Low	Low	Low
Guyana	High	High	High	Low	Low	Low	Medium	High	No data	Medium	Low
Haiti	High	High	Medium	High	High	Medium	Low	High	No data	Medium	Medium
Jamaica	High	High	High	High	High	Medium	Low	High	No data	Medium	Low
St. Kitts and Nevis	Low	Low	Medium	Medium	Medium	Medium	Low	Low	High	Medium	High
St. Lucia	Low	Low	Medium	Medium	Medium	Medium	Medium	Low	Medium	Medium	Medium
St. Vincent and the Grenadines	Low	Low	Medium	Medium	High	Medium	Medium	Low	No data	Low	High
Sint Maarten	No data	No data	No data	Medium	No data	No data	No data	No data	No data	No data	No data
Suriname	High	High	High	Low	Low	Low	Medium	High	No data	Medium	Low
Trinidad and Tobago	High	High	Medium	Medium	High	High	Medium	High	No data	Medium	Low
Turks and Caicos	Low	Low	Medium	High	Low	Low	Low	Low	No data	Medium	No data

High: Users should be highly aware of potentially severe damage from this hazard for the project location. Without taking measures to mitigate the hazard and risk, high levels of damage can be expected to occur within the project or human lifetime (and potentially frequently in that timeframe, for hydrometeorological hazards, e.g., floods, extreme heat).

Medium: Users should be aware of potentially damaging effects of this hazard for the project location. Potentially damaging events can be expected to occur within the project or human lifetime and measures to mitigate the hazard and risk should be considered. For hydrometeorological hazards, damaging effects could occur frequently in that timeframe.

Low: Potentially damaging events are less likely or unlikely to occur within the project or human lifetime but are still possible. Measures to mitigate the hazard and risk would be prudent at critical locations. Hazard has been classified based on long-term averages, and there is still potential that damaging events could occur in this timeframe.

No data: No dataset covering the chosen location is currently available in ThinkHazard!

Source: Based on data from ThinkHazard![4]

Notes: Some hazard maps do not cover the entire country—please refer to https://thinkhazard.org/en/ for more details on data limitations. Although ThinkHazard! distinguishes between low and very low risk, these are combined here as "low" to arrive to three scales.

BOX 1.1 >>

Modeling asset losses from natural disasters

Annual average damages (or annual expected asset losses) are assessed through the traditional disaster risk management framework (***figure B1.1.1***), which includes:

1. **Hazard:** the type, intensity, and probability of the shock
2. **Exposure:** the assets (or sometimes people) affected by the shock
3. **Vulnerability:** the damage or value lost when hit by the shock

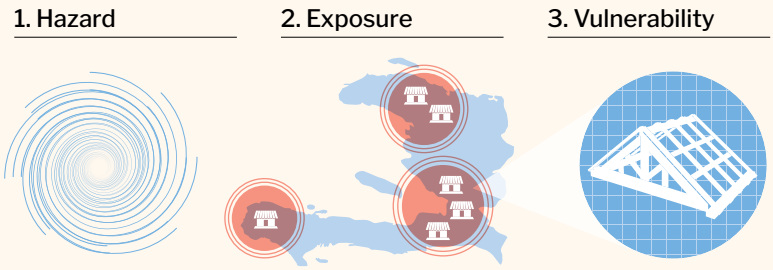
Natural hazards are geophysical, hydrological, meteorological, or climatological events that are often described in terms of their probability of occurrence—the inverse is also called a *return period*—and associated severity in terms of flood depth, wind speed, magnitude of impact, and so on. In the Caribbean, the most common hazards are storms, floods, epidemics, earthquakes, and volcanic activity.[a] For risk assessments, events of different intensity and probability are modeled. These modeled hazards do not intend to predict when a specific event will occur; rather, they provide insight on the *probability of occurrence* of a given hazard intensity. For example, a storm with a 250-year return period (also known as a 1-in-250-year storm) has a 0.4 percent chance of occurring in every given year and corresponds to a specific wind speed. *Exposure* refers to the population and assets at risk for a given event and recognizes, for example, the difference between a half-meter flood in an empty plain and in a busy village. Lastly, *vulnerability* describes how certain types of building or infrastructure asset get damaged by events of different intensities—for example, ground shaking will have a different effect on a small wooden house than a tall concrete building.

Together, these elements provide insight into the potential impact of certain shocks and estimate the risk to assets in monetary terms. This is the average damage natural disasters inflict on assets and is often measured in terms of their repair or replacement value. Governments can use several approaches for estimating risk to assets, including the following:

- Global modeled estimates of disaster losses, such as the United Nations (UN) Global Assessment Report on Disaster Risk Reduction (UNISDR 2015)
- Simple risk assessments, such as the Global Facility for Disaster Reduction and Recovery's (GFDRR's) country risk profiles[b]
- Full catastrophe models, which are more accurate but require a longer and more expensive exercise

FIGURE B1.1.1 >>

Framework for modeling asset losses from disasters in the Caribbean



Source: Adapted from Hallegatte et al. 2017

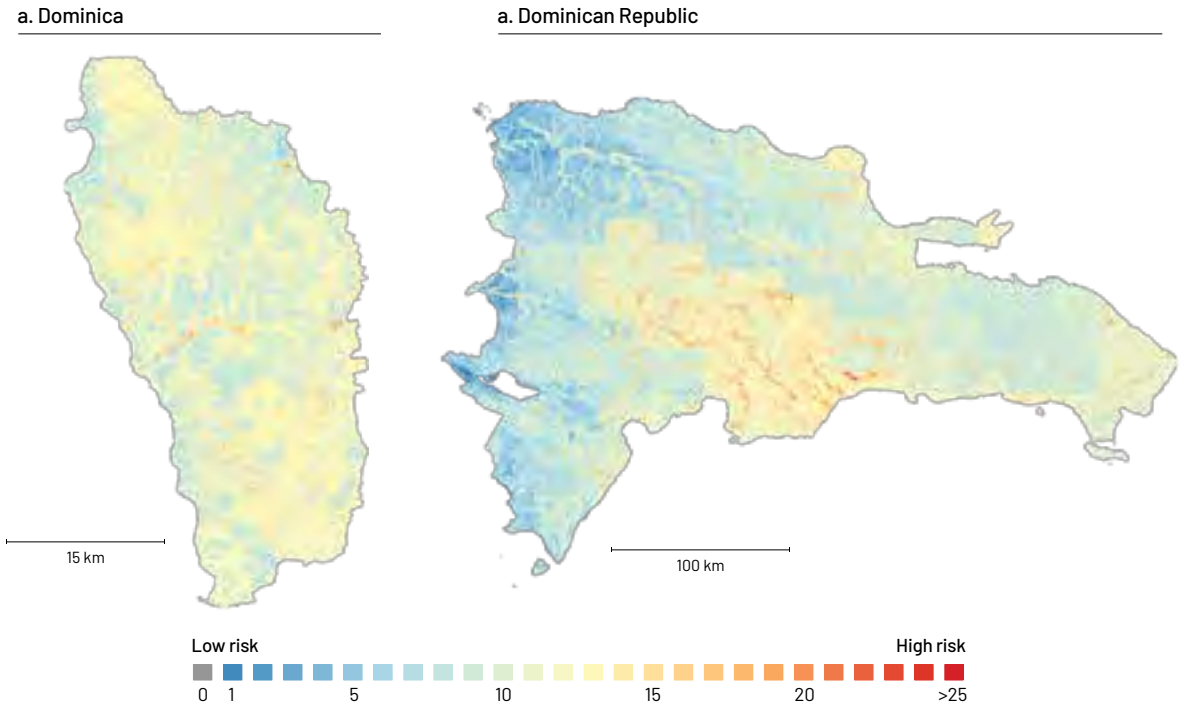
a. www.emdat.be
b. https://www.gfdrr.org/en/disaster-risk-country-profiles

For example, while many islands face a high probability of being hit by a hurricane, a few countries have a low or very low probability of being hit (Guyana, Suriname). Unsurprisingly, all countries in the Caribbean face medium to high probability of being affected by coastal floods.

As well as probability, it is important to know the geographical location of hazards for decision making. It is possible to overlay asset maps with modeled hazard maps for different events with different probabilities to assess the exposure of assets—that is, the quantity and value of assets that would be affected by a hazard if it occurred. Using data from ThinkHazard! and other global hazard databases, Schweikert et al. (2021) performed a multi-hazard exposure assessment of infrastructure assets to identify areas that are relatively more exposed to multiple hazards. ***Figure 1.2*** details their findings for Dominica and the Dominican Republic. Red and orange colors indicate areas where high levels of hazard intensity for multiple hazards intersect and are generally along rivers and coastlines due to the combined risk of flooding, landslides, and other hazards. Blue shows low or no exposure for all hazards. It should be noted, however, that these assessments rely solely on the geographical overlap in hazard occurrence and do not consider possible dependence between hazards—for example, that seismic activity may also lead to landslides. Results for all countries can be found in Schweikert et al. (2021). The uniqueness of Caribbean countries (and small island states in general) is that almost 100 percent of their territory is exposed to some natural hazard.

FIGURE 1.2 >>

Multi-hazard map for Dominica and the Dominican Republic



Source: Schweikert et al. 2021

Notes: Areas in orange and red indicate exposure to high-intensity hazards for multiple hazards. For each hazard, intensity is classified from 0 (none) to 5 (extremely high risk). By overlaying each hazard risk layer in each location, a single map is generated with a scoring matrix of 0–30, where 0 is no/unknown risk and 30 is extremely high risk for all hazards assessed.

The probability of occurrence of different hazards and the exposure of assets are not enough to assess the potential asset damages that could occur due to these hazards. To go further, the UN Global Assessment Report on Disaster Risk Reduction (UNISDR 2015) combines hazard and exposure data with assumptions on asset vulnerability to propose a measure of risk by country. *Table 1.2* shows that countries like Antigua and Barbuda, The Bahamas, and Dominica face a much higher risk to their assets (as a percentage of GDP) than the Dominican Republic or Jamaica. This higher risk is a combination of higher exposure relative to the size of the country and higher vulnerability of assets.

TABLE 1.2 >>

Average annual damages for different hazards in the Caribbean

	Earthquake		Hurricane		Tsunami		Flood		Total	
	AAL ($, millions)	% of GDP	AAL ($, millions)	% of GDP	AAL ($, millions)	% of GDP	AAL ($, millions)	% of GDP	AAL ($, millions)	% of GDP
Antigua and Barbuda	30.9	0.49	238.3	3.81	0.1	0.00	0.0	0.00	269.3	4.30
Bahamas, The	0.0	0.00	2,190.0	4.79	0.0	0.00	0.0	0.00	2,190.0	4.79
Barbados	22.8	0.16	80.7	0.58	0.0	0.00	0.0	0.00	103.5	0.74
Belize	3.0	0.05	43.5	0.73	0.0	0.00	36.9	0.61	83.3	1.39
Dominica	13.1	0.64	55.5	2.73	0.0	0.00	0.0	0.00	68.5	3.38
Dominican Republic	363.9	0.18	549.4	0.27	0.0	0.00	87.1	0.04	1,000.3	0.49
Grenada	8.6	0.19	21.1	0.46	0.0	0.00	0.0	0.00	29.7	0.65
Guyana	0.1	0.001	0.0	0.00	0.0	0.00	33.8	0.42	33.8	0.42
Haiti	119.5	0.42	51.2	0.18	0.0	0.00	27.9	0.10	198.6	0.70
Jamaica	48.8	0.07	402.9	0.57	0.0	0.00	9.8	0.01	461.4	0.65
Sint Maarten	-	-	-	-	-	-	-	-	-	-
St. Kitts and Nevis	26.7	0.65	55.4	1.35	0.0	0.00	0.0	0.00	82.0	2.00
St. Lucia	5.1	0.15	41.7	1.24	0.0	0.00	0.0	0.00	46.7	1.39
St. Vincent and the Grenadines	2.8	0.11	21.7	0.82	0.0	0.00	0.0	0.00	24.5	0.93
Suriname	0.0	0.00	0.0	0.00	0.0	0.00	52.8	0.55	52.8	0.55
Trinidad and Tobago	596.1	0.87	24.0	0.03	0.0	0.00	0.4	0.001	620.5	0.90
Turks and Caicos	0.1	0.01	20.6	1.96	0.01	0.001	0.0	0.00	20.7	1.97

Source: Based on data from UNISDR 2015

Notes: AAL = annual average losses. The countries in red are in the top third of average annual losses for the hazard type; those in blue are in the lowest third; and those in yellow are in the middle third. The gray cells show that there are not enough data available to make a rating.

Limitations

Although these assessments are useful for screening risk and comparing countries, there are limitations that need to be considered. First, the scale defines the level of detail a model can provide. For example, global flood models typically rely on low resolution topography data and do not incorporate geo-referenced information on existing flood protection systems. The resulting flood maps can therefore help identify areas that are potentially at risk but cannot be used for infrastructure planning. Second, it requires a significant effort to develop or adjust vulnerability curves that accurately reflect the spatial distribution of assets and how buildings or different asset classes will react to different types and intensities of natural hazard. Furthermore, estimating the probability of different hazards relies on extensive historical data, and records for low-frequency, high-impact events tend to be absent, while high-frequency, low-impact events are often not recorded at all. Climate change also makes natural hazards non-stationary,

as it changes their probability distributions with time, while socioeconomic and land use trends change exposure and vulnerability. Therefore, it is important to regularly update hazard probabilities, exposure layers, and vulnerability curves to monitor how risk is changing.

Country risk profiles: informing disaster risk financing

GFDRR's country risk profiles go a step further, providing risk assessments that estimate the direct damages to buildings caused by hurricanes[5] and earthquakes based on more reliable country-level data (*box 1.2*). These assessments are intended to develop key baseline data, evaluate the impact of disasters, promote and inform risk reduction, and help devise a cost-effective disaster risk financing strategy by quantifying governments' direct contingent liabilities—that is, the amount they will need to pay to repair public assets like roads or hospitals (*chapter 12*). They can also be used to measure the wider benefits of disaster risk reduction investments, such as improved drainage systems, higher standard bridges, or different materials for buildings.

BOX 1.2 >>

Quantifying governments' contingent liabilities

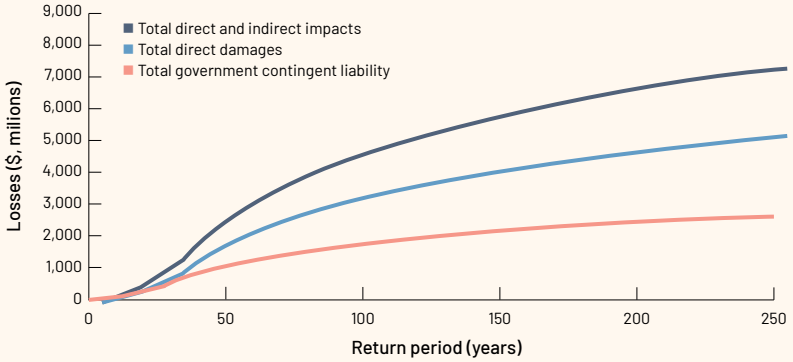
The risk assessments presented in the World Bank country risk profiles follow the traditional disaster risk management framework (*box 1.1*) to model asset losses, combining modeled catalogs of hazards or potential natural catastrophe events that could occur in a region, exposure layers of assets at risk, and vulnerability curves (*figure B1.2.1*). The exposure layers typically contain a database of buildings and may also include other assets, capturing important spatial and construction attributes such as geographical location, type of occupancy (residential, commercial, industrial, or agricultural), construction material (wood, steel, masonry, and so on), age, number of stories, and replacement value. The profiles then calibrate the probabilistic models using historical records on disaster losses, complementing the loss estimates from more frequent, lower-intensity events, and the risk or expected losses. These are typically presented as average annual losses (AAL) or probable maximum loss (PML) from natural hazards. The AAL is the average yearly expected loss for the respective hazard, while the PML describes the largest losses that might be expected to occur for a given return period, or the likelihood that a specific economic loss will be exceeded. This is also described in loss exceedance probability curves.

FIGURE B1.2.1 >>

Indicative loss exceedance probability curves for floods and wind-related events (Jamaica)

Source: World Bank 2018a

Notes: A return period describes how much time is expected to pass before a natural shock of the same intensity occurs again. Using historic data and based on the statistical frequency of a shock of a certain intensity, it describes the inverse of the probability of such an event. A 1-in-25-year flood has a 1/25 or 0.04 annual probability of occurring. In other words, each year there is a 4 percent chance of such an event occurring, regardless of when the last such event took place.



The World Bank has developed country- and department-level earthquake and hurricane risk profiles for four Caribbean countries: Jamaica, Grenada, St. Lucia, and Belize (GFDRR 2016a–d). In all four countries, hurricane risk constitutes a larger threat than earthquakes, yet estimated losses are significant for both (*table 1.3*). These risk assessments also show significant differences in exposure and vulnerability between countries. For example, in Jamaica, hurricanes cause AAL of $67 million and earthquakes $36 million. In Grenada, where the building stock value is 17 times lower, losses are only 8 times lower for hurricanes but 20 times lower for earthquakes. When expressed as a percentage of GDP, however, country losses are of the same order of magnitude (0.5–1 percent for hurricane risk and 0.08–0.3 for earthquake risk). In Jamaica and St. Lucia, there is a 0.4 percent chance each year of direct losses due to hurricanes exceeding 25.3 and 27.2 percent of GDP respectively, while in Grenada and Belize, this goes up to 43.6 and 46.6 percent. In all examined countries, vulnerable single-family buildings make up a large share of AAL—20 percent in Belize and Grenada, 23 percent in Jamaica, and 30 percent in St. Lucia.

TABLE 1.3 >>

Risk to assets in selected Caribbean countries

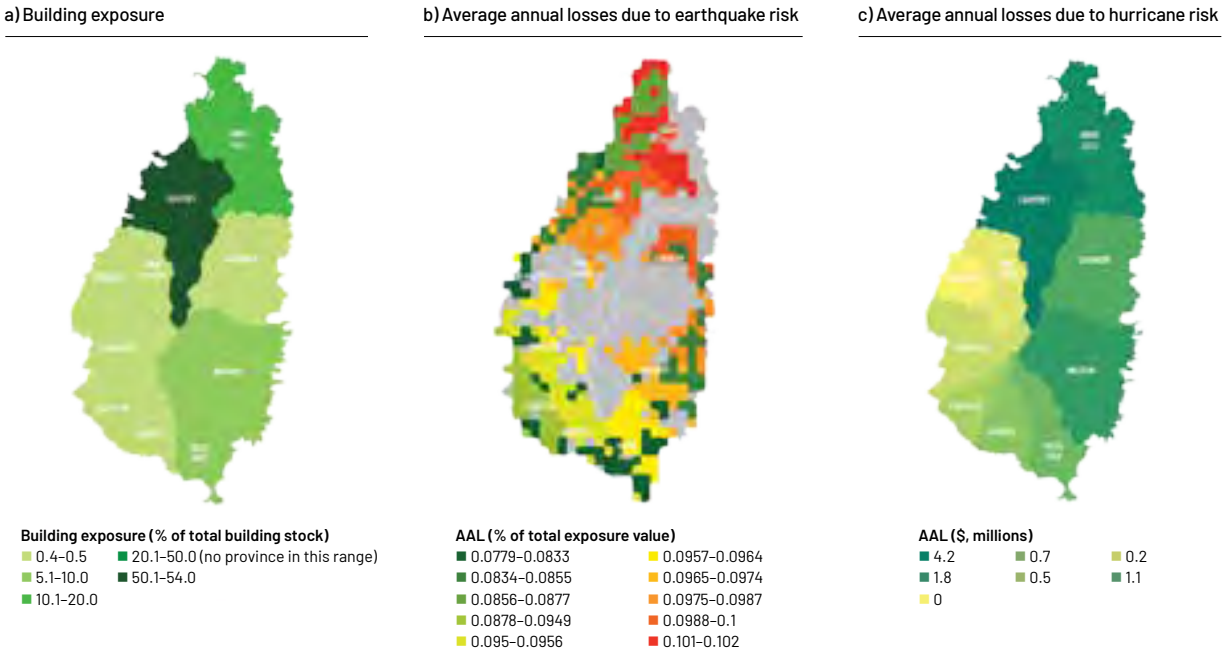
	Building stock	Average annual losses				Probable maximum loss			
		Hurricane		Earthquake		Hurricane		Earthquake	
	$, millions	$, millions	% of GDP	$, millions	% of GDP	$, millions	% of GDP	$, millions	% of GDP
Belize	4,600	17.9	1.05	1.4	0.08	791	46.6	63	3.7
Grenada	2,100	8.2	0.9	1.8	0.2	397	43.6	96	10.5
Jamaica	36,400	67.3	0.5	36	0.3	3,500	25.3	2,000	14.6
St. Lucia	3,000	9.5	0.7	2.6	0.2	382	27.2	148	10.5

Sources: Based on data from GFDRR 2016a-d

Note: Probable maximum loss estimates are based on an event with a 250-year return period.

FIGURE 1.3 >>

Estimated asset losses due to earthquake and hurricane risk in St. Lucia



Source: World Bank 2018b

Limitations

By providing country- and province-level disaggregated estimates of potential damage to buildings caused by hurricanes and earthquakes (*figure 1.3*), these exercises can help governments design disaster risk finance instruments and prepare for disasters. While these assessments are much more precise than those of the global risk models presented in the previous section, the same caveats apply: it is important to regularly update hazard probabilities, exposure layers, and vulnerability curves to monitor how risk is changing. These assessments are only partial and do not include all the types of asset that are at risk from natural disasters, such as infrastructure assets (*chapter 2*), or natural assets (*box 1.3*). These risk profiles therefore provide conservative estimates of governments' contingent liabilities.

Satellite imagery: looking at trends in exposure

While risk profiles are a static vision of risk at one point in time, it is interesting to have a dynamic view of risk, or at least some of its components. Accordingly, collecting data on exposure and vulnerability of assets over time is a challenge. But satellite imagery can provide good information for high-level assessments.

This section evaluates the flood risk faced by people living in urban areas over time using spatially disaggregated estimates of flood risk. For this analysis, satellite imagery of built-up areas in urban extents[6] (Marconcini et al. 2020) is intersected with flood maps to calculate the share of urban built-up area exposed to flooding between 1985 and 2015 in five-year periods. Using data from ThinkHazard![4], the analysis accounts for fluvial, pluvial, and coastal flooding. The proportion of urban areas exposed is calculated for different return periods (5, 50, 100, and 1,000 years) and varying flood depths (0, 15, 50, and 100 centimeters). *Figure 1.4* shows the results for 1-meter flood depth and 100-year return period on the island of St. Vincent. Since the data on built-up areas do not give information on density (a cell is either built-up or not), the analysis is complemented with another that follows the same method but uses number of people living in urban extents for the exposure variable.

Flood exposure in built-up areas

This analysis allows the comparison of built-up area exposure between countries and over time. Guyana, which is a very flat country, has the highest proportion of built-up area exposed to 1-meter flood depth, and has had since 1985. Frequent (1-in-5-year) floods expose over 3 percent of its built-up area, compared to less than 1 percent in most other countries. The only exceptions are Dominica—a mountainous country with limited space for development—and Suriname, a relatively flat country where exposure has increased in recent years. Rare (1-in-100-year) or exceptional (1-in-1,000-year) floods expose 7.5 and 11 percent of built-up areas in Guyana, respectively, compared to 2–3 percent and 3–4 percent in other countries. Only Haiti compares to Guyana's exposure levels for exceptional floods, with about 8 percent of built-up areas. *Figure 1.5* gives an overview of the 1-in-100-year flood exposure results.

BOX 1.3 >>

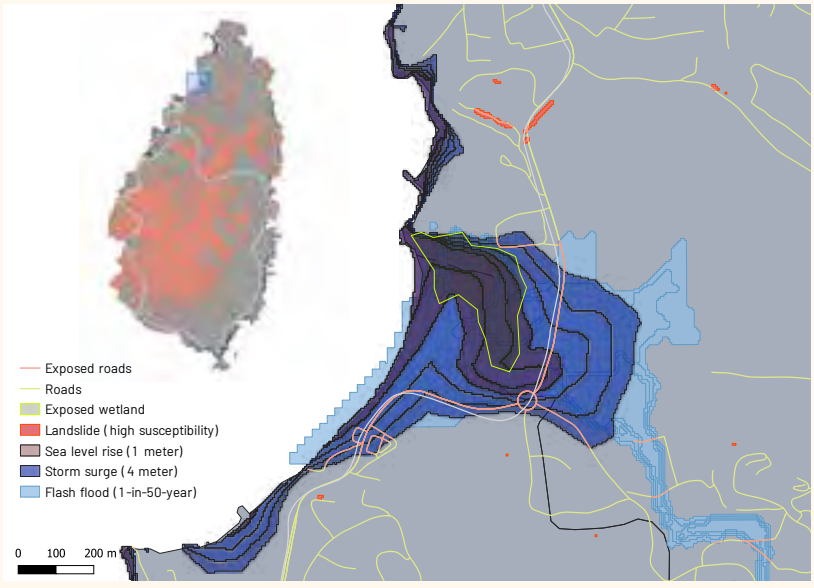
Exposure and vulnerability of natural capital

Buildings and infrastructure are not the only assets threatened by natural disasters. Climate change also threatens some ecosystems and natural habitats, and potential losses can be recorded as a decrease in natural capital. Ecosystems provide important services—like breeding zones for fish—and when these services disappear, their value is lost or has to be replaced by artificially provided services. For example, if mangrove storm surge protection is replaced by a dike, the lost natural capital is substituted by additional physical capital. In the narrow definition of GDP, which excludes ecosystem services, replacing ecosystem-based services with artificial ones would increase GDP and enhance economic growth. But it would also have a negative impact on well-being, because increased investment means reduced consumption.

A case study in St. Lucia shows how natural assets like wetlands, forests, agriculture land, and water ecosystems are exposed and vulnerable to a range of disasters, with potential well-being reductions. St. Lucia's natural environment assets—which include forest reserves, wetlands, rangelands, barren areas, water ecosystems, and agricultural assets—provide critical products like timber and fish, ecological functions like carbon storage and nutrient cycling, and natural defenses. Collectively, they comprise over 600 square kilometers, at least half of which is exposed to one or more hazards. Its wetlands are most exposed: over 50 percent are exposed to storm surges and flash floods (*figure B1.3.1*). Should these events occur simultaneously, 100 percent of the wetlands would be exposed. About one-fifth of the country's water ecosystems are exposed to storm surges, and about 20–35 percent of its forests and agriculture and range lands are exposed to landslides. With 10 percent of the national labor force employed in these sectors, this poses a threat to many livelihoods (Adshead et al. 2020).

FIGURE B1.3.1 >>

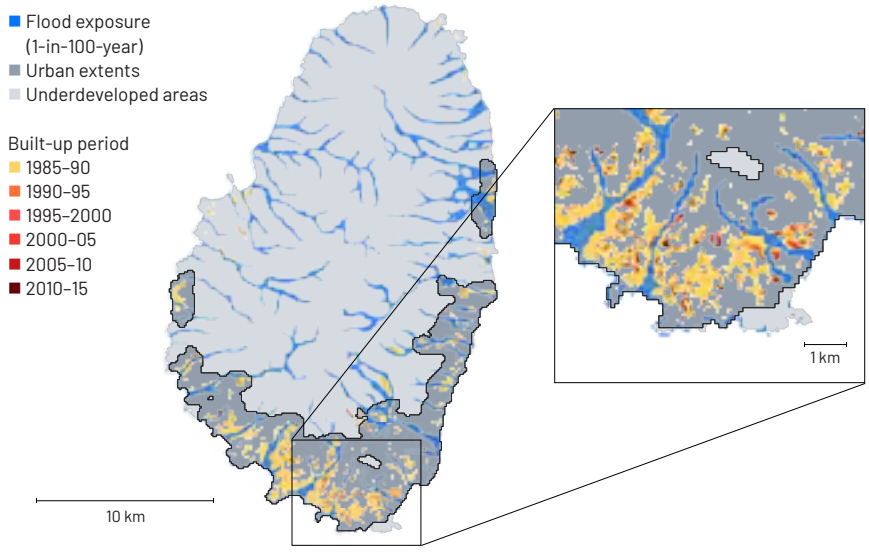
Exposure of wetlands in St. Lucia to multiple hazards



Source: Adshead et al. 2020

FIGURE 1.4 >>

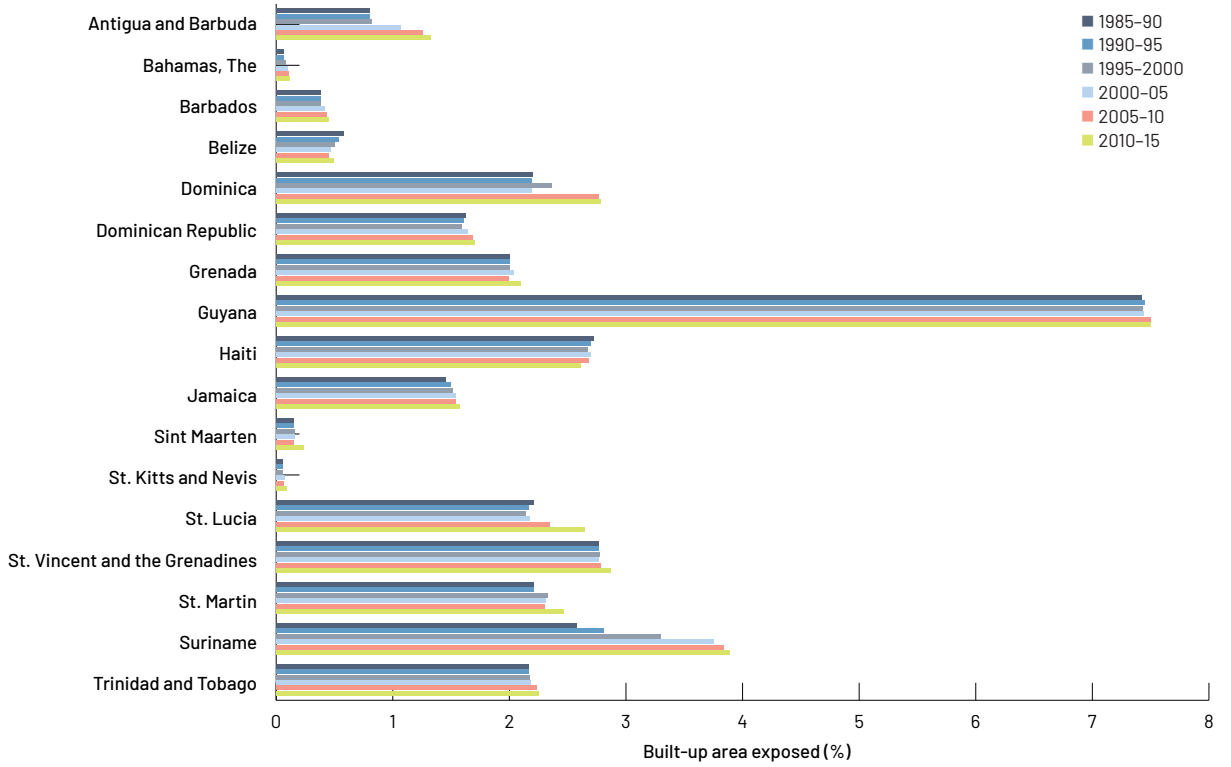
Built-up area exposed to intense flooding on St. Vincent



Sources: Based on data from Sampson et al. 2015 (pluvial and fluvial flood maps); Giardino et al. 2021 (coastal flood maps); WorldPop 2020 (population)[8]; Marconcini et al. 2020 (built-up areas)

FIGURE 1.5 >>

Built-up area exposed to intense flooding over time in Caribbean countries



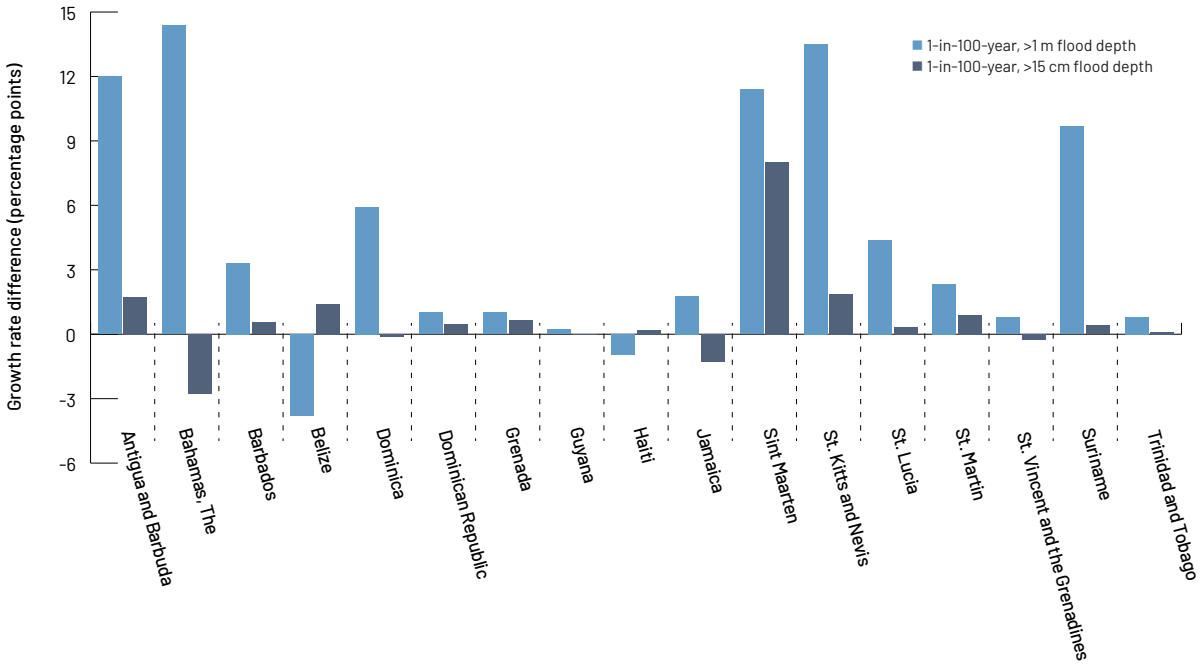
Sources: Based on data from Sampson et al. 2015 (pluvial and fluvial flood maps); Giardino et al. 2021 (coastal flood maps); WorldPop 2020 (population)[8]; Marconcini et al. 2020 (built-up areas)

Notes: Urban areas exposed to 1 meter flood depth and 1-in-100-year floods. Areas are defined as *urban* when the population density surpasses 300 people per squared kilometer and total population is larger than 1,000 people.

The trend in all the countries is one of increasing exposure of built-up areas. But depending on the considered event frequency and flood depth, there are differences between them. For a 15-centimeter flood depth (during 1-in-100 and 1-in-1,000-year floods), exposure rates follow built-up area expansion rates, implying that as villages and cities expand, their exposure to shallower floods also expands. In most countries, exposure rates for greater flood depths (1 meter) have increased at a faster pace than built-up areas have expanded. This suggests that new buildings are being built in areas that are relatively more exposed to intense flooding. ***Figure 1.6*** shows the average growth rate difference between exposed and total built-up areas for 1-in-100-year floods with 0.15 and 1 meter flood depths between 1985 and 2015. When the difference is positive, exposed built-up areas have grown faster than total built-up area in most countries. Larger differences are also observed for 1-meter—compared to 15-centimeter—flood depths. The largest exposure increase relative to urban area expansion is seen in Antigua and Barbuda, The Bahamas, St. Kitts and Nevis, Suriname, and Sint Maarten. For 1-in-1,000-year floods with flood depth of over 1 meter, exposed urban areas in these countries have increased, on average, by at least 10 percentage points over 30 years compared to the expansion of built-up areas.

FIGURE 1.6 >>

Average growth difference between exposed and total urban built-up area in Caribbean countries (1985–2015)



Sources: Based on data from Sampson et al. 2015 (pluvial and fluvial flood maps); Giardino et al. 2021 (coastal flood maps); WorldPop 2020 (population)[8]; Marconcini et al. 2020 (built-up areas)

Notes: A positive difference implies that, on average, the exposed area has grown faster than total area. Areas are defined as *urban* when the population density surpasses 300 people per squared kilometer and total population is larger than 1,000 people.

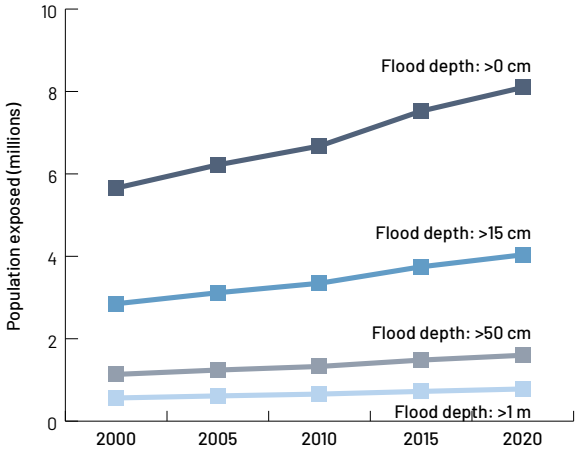
People exposed to flooding

Since the built-up area data do not give information on density, the analysis is complemented with an analysis of population exposed to flooding. The total number of people exposed in the region is increasing over time, even when considering different flood depths (***figure 1.7***). When looking at country-specific exposure patterns, results are consistent with the built-up exposure, and show that people in Grenada, Guyana, Haiti, St. Lucia, Suriname, and Trinidad and Tobago are more exposed than those in the rest of the region. Again, Guyana and Suriname stand out due to their topography—their exposure rates for

1-in-5-year floods with over 15-centimeter flood depth are at 10–12 percent, while 1-in-100 and 1-in-1,000-year events expose 37–57 percent of their populations. Notably, in several countries, the share of urban people exposed is higher than urban built-up area exposed, suggesting that people concentrate in built-up areas that are more exposed to flooding (*figure 1.8*). For example, in St. Lucia during the last two decades, urban built-up exposure rates have been around 2.5 percent for a 1-in-100-year flood with over 1 meter depth, while the share of people exposed to the same event was about twice this amount. In Dominica, Grenada, Guyana, and St. Vincent and the Grenadines, however, the share of people exposed is lower than the share of built-up area exposed.

FIGURE 1.7 >>

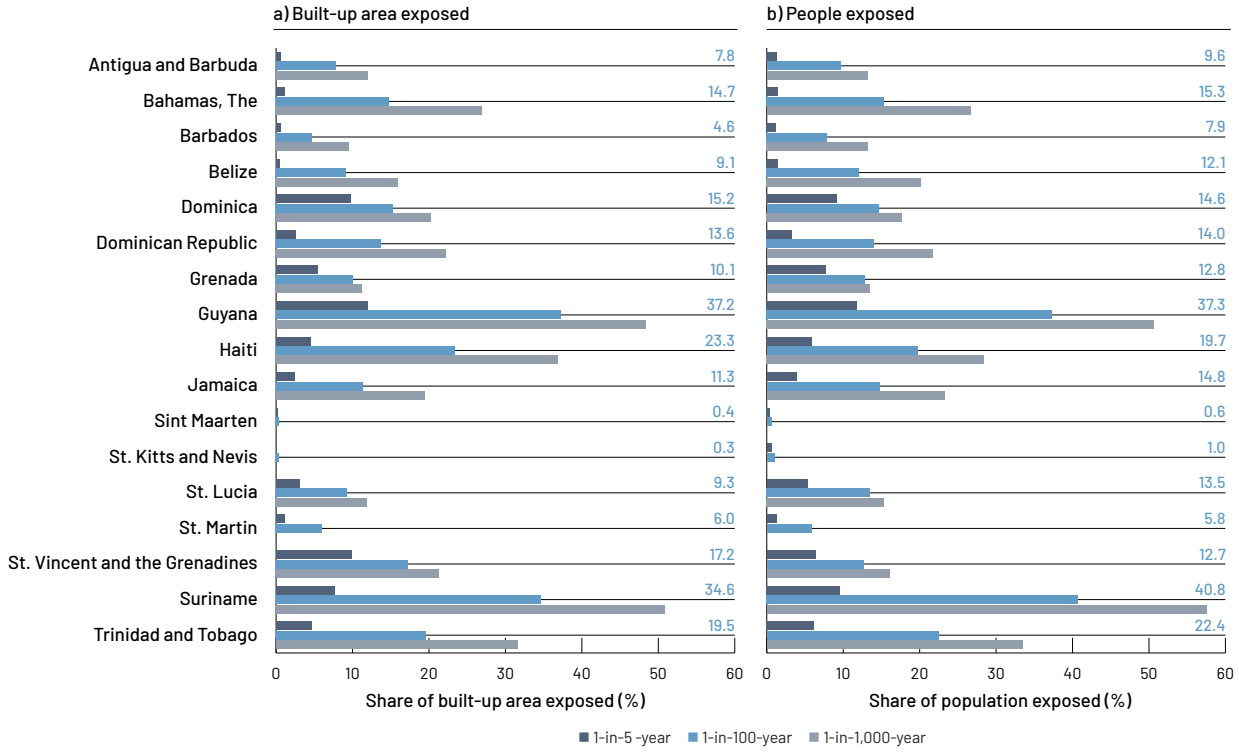
Caribbean population exposed to a 1-in-100-year flood over time



Sources: Based on data from Sampson et al. 2015 (pluvial and fluvial flood maps); Giardino et al. 2021 (coastal flood maps); WorldPop 2020 (population)[8]

FIGURE 1.8 >>

Flood exposure rates in Caribbean countries (2015)



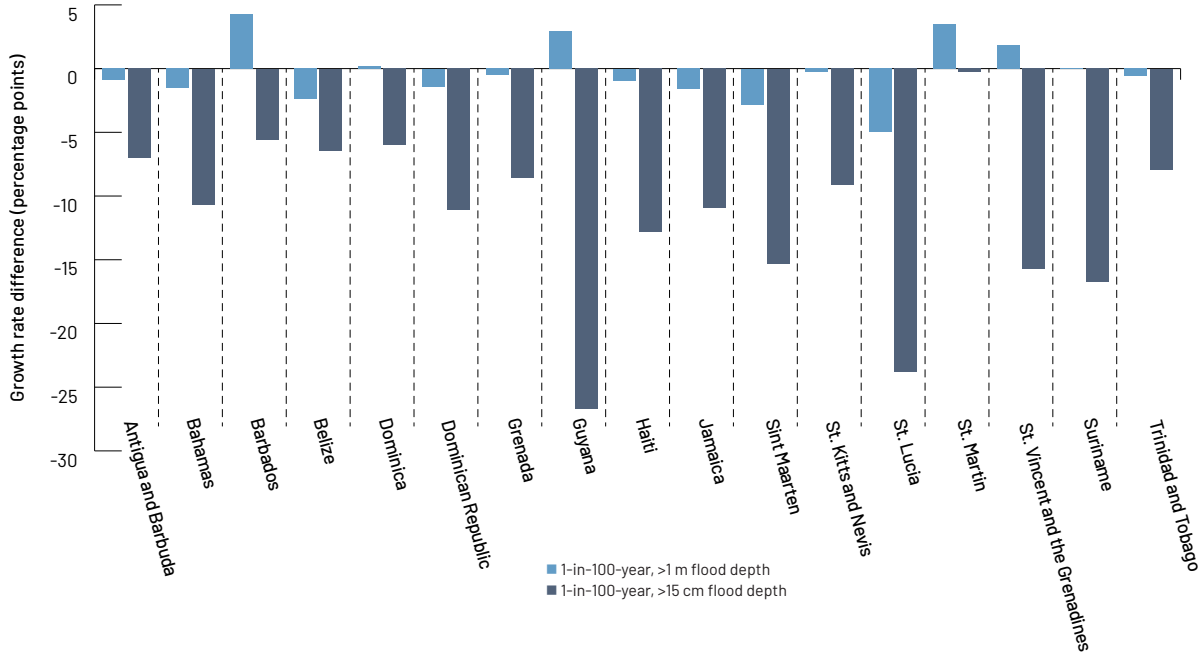
Sources: Based on data from Sampson et al. 2015 (pluvial and fluvial flood maps); Giardino et al. 2021 (coastal flood maps); WorldPop 2020 (population)[8]; Marconcini et al. 2020 (built-up areas)

Notes: Areas are defined as urban when the population density surpasses 300 people per squared kilometer and total population is larger than 1,000 people. Numbers shown at the bar ends refer to the share of population exposed to floods depths of more than 15 centimeters under a 1-in-100-year flood.

In all countries, the total number of people exposed to floods is increasing over time. However, in most countries, total population between 2000 and 2020 grew on average at a faster pace than population exposed (*figure 1.9*). In all countries, population exposed to a 15-centimeter flood depth has increased at a slower pace than total population. For flood depths over 1 meter, only Barbados, Dominica, Guyana, St. Martin, and St. Vincent and the Grenadines saw a bigger increase in the share of people exposed than in total population.

FIGURE 1.9 >>

Average growth difference between exposed and total populations in Caribbean countries (2000–2015)



Sources: Based on data from Sampson et al. 2015 (pluvial and fluvial flood maps); Giardino et al. 2021 (coastal flood maps); WorldPop 2020 (population)[8]
Note: A positive difference implies that, on average, the exposed population has grown faster than total population.

Limitations

This exercise uses satellite imagery and modeled spatial distribution of population to assess the trends in exposure over time. Since it uses global databases and flood models, the same limitations as outlined for global risk models apply, as well as the following caveat: the data use a binary definition of urban areas, so do not capture the differences in density between historical and newly developed areas, which are generally low-density suburban areas. This might explain why we see an increase of built-up areas in flood plains but a slower increase in exposed population. The population data are also based on a model that considers many different parameters, including infrastructure, to predict population distribution. As a result, this type of analysis could overestimate the number of people in some places and underestimate it in others.

Modeling sea level rise and sandy beach erosion: exploring future risks

Combined with socioeconomic growth, climate change is likely to exacerbate the frequency and intensity of storms, causing flooding, erosion, extreme winds, and landslides. These will have a direct or indirect impact on people living on the coast, critical infrastructure, tourism, and coastal ecosystems. In the absence of adaptation against these hazards, it is likely that economic losses will increase and livelihoods will be disrupted. According to estimates by Simpson et al. (2010), 110,000 people in the Caribbean Community (CARICOM)[8] may be displaced in a 1-meter sea level rise and no adaptation scenario.

Climate change and sea level rise will also lead to the definitive loss of land. Land is a natural resource and is important for economic activity. It is part of natural capital, and a loss of land is a loss of capital, with negative consequences on GDP. Further, the loss of land is not only related to permanently-inundated land. Some land may remain above sea level, but become impossible to use productively, either because it floods too often—for example, a coastal zone that floods every year due to more frequent storms and hurricanes—or because of soil salinization, which can make land improper for many agricultural activities.

This section provides estimates of the potential effect of sea level rise for Caribbean countries in terms of coastal flooding due to marine surge and wave setup and associated impacts on the erosion of their sandy beaches. The (change in) risk resulting from sea level rise is estimated until 2100 under different sea level rise scenarios (Vousdoukas et al. 2018) and socioeconomic pathways (Gidden et al. 2019) (*box I1.1*).

Susceptibility to increased coastal flooding due to sea level rise

The areas at risk of flooding are expected to increase due to sea level rise, with differences depending on countries' topography. Relatively flat islands like Antigua and Barbuda are more susceptible to the effect of static sea level rise than steeper islands like Dominica, where the relatively steep coast limits mainland flooding. In Antigua and Barbuda, on the other hand, with its relatively flat coastal zones, a higher mean sea level could permanently flood a large area, increasing the probability of flooding during extreme events over the course of the 21st century. Mainland countries—like Belize, Guyana, and Suriname, which have a relatively mild slope near the coastline—would also be impacted by sea level rise and flooding.

Sea level rise increases the share of population exposed to storm surges and erodes the land where coastal communities build their homes, cultivate their crops, and run their businesses. For example, sea level rise under a moderate climate change scenario (RCP 4.5) is projected to increase the share of people exposed in Antigua and Barbuda by 21 percent by 2050, without considering population growth (and potential densification in at-risk areas) (*table 1.4*). Grenada, Guyana, and Turks and Caicos are most susceptible to the effects of sea level rise, with the share of population exposed expected to increase between 40 and 100 percent between 2010 and 2050. Guyana, Suriname, and Trinidad and Tobago face the largest risk of a retreating shoreline, with an estimated retreat of 53, 58 and 43 meters, respectively, by 2050 under RCP 4.5 (Giardino et al. 2021).

When looking at risk towards the end of the century in high climate change scenarios (RCP 8.5), the countries with the highest expected annual people exposed are Dominica (1.8 percent of the population exposed), Guyana (4.7 percent), Suriname (2.8 percent), and St. Martin (2.9 percent). Those with the lowest values are Barbados, the Dominican Republic, Haiti, St. Vincent and the Grenadines, and Trinidad and Tobago, with less than 0.1 percent of their population exposed (*figure 1.10*). For more detailed results under different scenarios please refer to (Giardino et al. 2021).

TABLE 1.4 >>

Potential impact of sea level rise in 2050 under a moderate climate change impacts scenario

	Average nearshore slope	Average annual population exposed			Average shoreline retreat		Average landmass loss	
		2010	2050		2050		2050	
		% of total population	% of total population	% change with respect to 2010	m	% of sandy coastline	km²	% of total landmass
Antigua and Barbuda	0.01	0.23	0.28	21.7	31	0.03	2.8	0.63
Bahamas, The	0.08	0.38	0.46	21.1	30	0.00	104.0	0.75
Barbados	0.03	0.01	0.01	0.0	8	0.01	0.6	0.14
Belize	3.30	0.25	0.26	4.0	37	0.01	9.9	0.04
Dominica	0.41	1.46	1.51	3.4	1	0.05	0.0	0.00
Dominican Republic	0.01	0.05	0.06	20.0	15	0.00	6.4	0.01
Grenada	0.00	0.15	0.21	40.0	28	0.16	0.5	0.15
Guyana	0.36	1.61	2.32	44.1	53	0.07	4.1	0.00
Haiti	0.21	0.05	0.06	20.0	13	0.00	5.8	0.02
Jamaica	0.02	0.24	0.3	25.0	27	0.02	3.0	0.03
Sint Maarten	0.00	0.45	0.49	8.9	33	0.14	0.8	2.35
St. Kitts and Nevis	0.38	0.30	0.34	13.3	19	0.06	0.6	0.24
St. Lucia	0.01	0.13	0.14	7.7	23	0.08	0.7	0.10
St. Vincent and the Grenadines	0.02	0.07	0.07	0.0	13	0.04	0.5	0.12
Suriname	0.11	1.37	1.72	25.5	58	0.64	0.5	0.00
Trinidad and Tobago	0.00	0.03	0.03	0.0	43	0.06	3.2	0.06
Turks and Caicos	0.09	0.04	0.08	100.0	21	0.01	7.5	0.79
Total region	n.a.	**6.8**	**8.3**	**22.3**	**453**	**0.01**	**150.8**	**0.03**

Source: Giardino et al. 2021

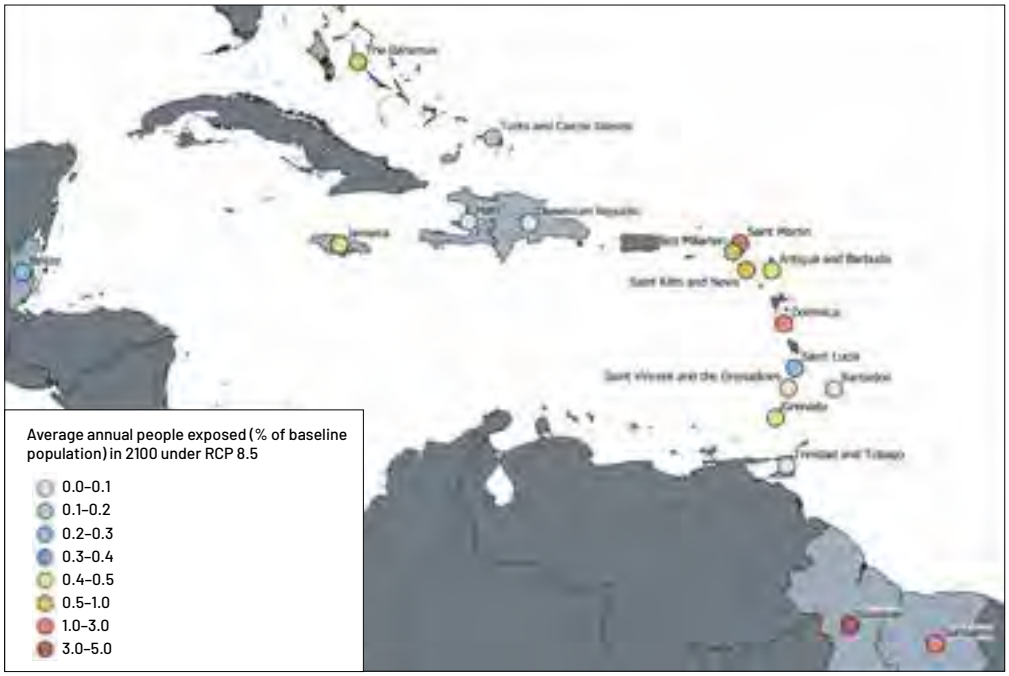
Notes: The values in blue show the lowest third in each column; those in yellow are the middle third; and those in red, the highest third. The presented values for population exposed in 2050 do not assume population growth and are based on 2010 values.

FIGURE 1.10 >>

People exposed by 2100 under RCP 8.5 in the Caribbean

Source: Giardino et al. 2021

Note: Calculations are based on 2010 socioeconomic exposure.



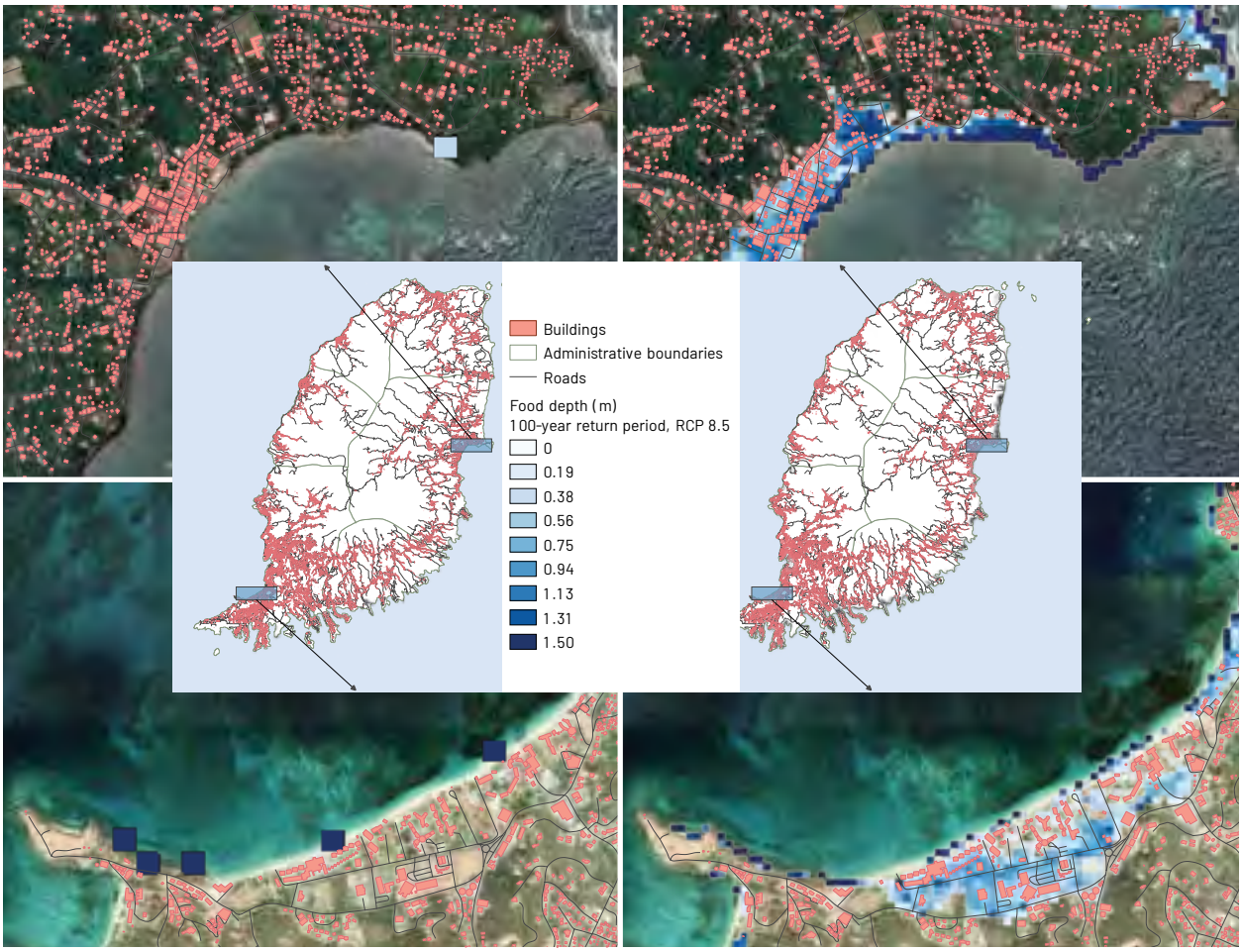
Comparing sea level rise risks using high-resolution topography data

To calculate flood extents under different sea level rise scenarios, the analysis uses global topography (elevation) data (Yamazaki et al. 2017). As is common with global databases, even though the data used are relatively accurate compared to other global datasets (Giardino et al. 2021), their relatively coarse resolution fails to accurately reflect all local details in the topography of countries' and islands' shores. This is especially important for (relatively) steep islands, where the elevation quickly rises from the shoreline to over 10-meter hills. For these conditions, global elevation data tend to overestimate elevation at the shore, sometimes leading to wrongful predictions of no flooding, when these areas are exposed to floods. This is the case in Grenada, where simulations using local light detection and ranging (LiDAR)-based[9] digital elevation data show several areas exposed to floods in case of a 1-in-100-year event (***figure 1.11***). Although the difference between local and global digital elevation data is expected to be smaller for islands characterized by milder slopes at the shore, vertical biases might still play a role (Giardino et al. 2021).

Countries with steep shores also face an erosion risk to their rocky coast that was not possible to model in this study. However, the accelerated erosion of sandy beaches due to sea level rise was modeled and is presented in the next section.

FIGURE 1.11 >>

Coastal flood maps for Grenada, based on global (left) and local (right) digital elevation models



Source: Giardino et al. 2021
Notes: DEM = digital elevation model, RP = return period.

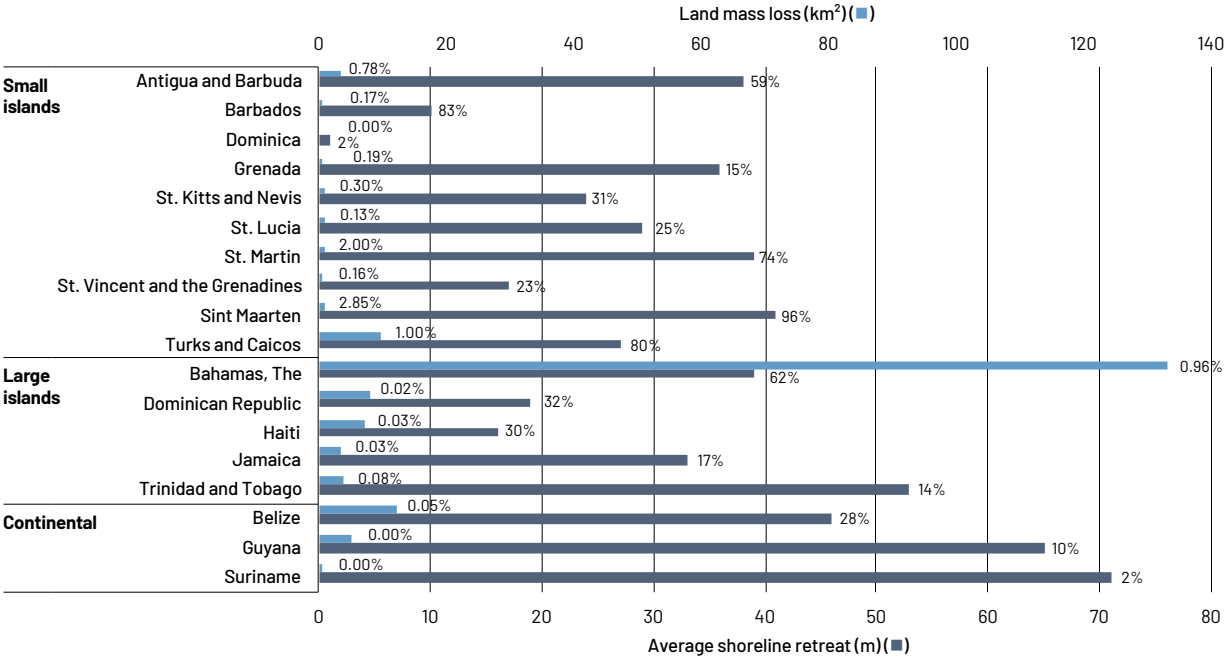
Potential land loss to the sea by 2050

As well as increasing the coastal flood extent during storms, sea level rise accelerates the erosion of sandy beaches. Using data on the location and extent of sandy erodible beaches (Luijendijk et al. 2018) and their nearshore slopes (Athanasiou et al. 2019), this section quantifies the potential erosion of sandy beaches. These calculations estimate only the effect of sea level rise on sandy beach retreat and do not consider the possible effect of sea level rise on other (for example, muddy, gravel, or rocky) coastal types.

Results indicate that on average, for all the Caribbean countries and islands included in this study, a shoreline retreat of sandy beaches of 35 meters is projected under a high climate change scenario by 2050, increasing to 98 meters by 2100. *Figure 1.12* shows that the largest average projected shoreline retreats (dark gray bar) are in Belize (46 meters), Guyana (65 meters), Suriname (71 meters), and Trinidad and Tobago (53 meters) by 2050 under high climate change impacts. While the absolute retreat is large, in countries such as Belize and Trinidad and Tobago, a relatively small part of the coastlines is sandy, decreasing the risk of sandy area land loss. Combining average shoreline retreat with the length of its sandy coastline, the light blue bars provide an indication of each country's total potential sandy area land loss. The total sandy land mass at risk of being swallowed by the sea in the Caribbean is significant: under a high climate change impact scenario, 192 square kilometers of sandy beaches are expected to be lost by 2050, increasing to 543 square kilometers by 2100. The country with the highest projected sandy beach loss is The Bahamas, where, by 2050, almost 133 square kilometers of sandy land are projected to be lost under a high sea level rise scenario and no adaptation. This is due to a combination of mild nearshore slopes and a long coastline spanning over 5,550 kilometers, around 62 percent of which is sandy. Belize, Turks and Caicos, the Dominican Republic, and Haiti are also projected to lose a large amount of sandy beach area by 2050 under RCP 8.5, at 12, 10, 8, and 7 square kilometers, respectively.

FIGURE 1.12 >>

Average shoreline retreat and projected land mass loss by 2050 under RCP 8.5 in Caribbean countries



Source: Based on data from Giardino et al. 2021

Notes: Calculated as the average value of the shoreline retreat of all the sandy points of one country. The percentages at the end of each bar indicate the relative length of the sandy coastlines to the total length of the coastline of each country and relative projected landmass loss to total country area.

Note that the results presented here use high climate change impacts (RCP 8.5) to stress-test the current situation and give a signal to countries that more in-depth analysis is needed. However, the magnitude of the impacts could be lower if the world managed to significantly reduce greenhouse gases emissions in the next decades. Reducing greenhouse gas emissions following an RCP 4.5 scenario can decrease projected land loss by almost 20 percent in 2050 and almost 40 percent in 2100, relative to the RCP 8.5 scenario.

Limitations

These estimates use global elevation datasets, which underestimate coastal flooding in countries with steep shores. Although they require a lower level of effort, using these datasets increases inaccuracy, as demonstrated when comparing flood extents using global and local elevation data in Grenada (*figure 1.11*). When available, the study uses LiDAR digital terrain models to calibrate the model for some countries, but these datasets are not always available due to their high cost. In addition, for some countries, there was no available information on existing levels of coastal protection. Instead, the analysis assumes that all countries are protected against events with a return period of up to 10 years. The focus is on coastal flooding through sea level rise, and the analysis disregards any other hazards—such as rainfall, flooding, and extreme winds—which are likely to increase in the foreseeable future.

A limitation on the results for erosion is the sole focus on sandy beaches, as the analysis does not consider the possible effects of sea level rise on any other coastline types. The results also assume that the shoreline moving landward is not hindered by infrastructures behind the beach and there is enough sand to be eroded, while in fact sandy beaches might be backed up by hard structured and/or non-erodible rocky formations, preventing erosion. This can result in overestimating the presented erosion projections. Finally, it considers neither storm- nor human-induced erosion, which may also be at play.

These analyses give a first high-level assessment for decision makers, planners, and actors in the tourism sector on the risk of erosion and can flag the need for coastal management plans. However, they are not accurate enough to guide, for example, infrastructure design. To inform the choice or design of specific adaptation actions, such as beach nourishment, more detailed modeling is needed.

Summary

This chapter shows that a large share of physical capital (buildings, infrastructure) and natural capital (wetlands, forests, land) is exposed to natural hazards in Caribbean countries and that this exposure is increasing with climate change. While exposure is different across countries, and it is hard to collect data on the vulnerability of capital to hazards, damages from past disasters presented in the introduction bring further evidence that risk to physical capital in the Caribbean is high and represents a threat for the people and economies of the region. Besides, an analysis of trends in exposure shows that in most countries, new built-up infrastructure and low-density residential areas have expanded in flood plains, most likely due to geographical constraints. This trend increases the value of capital that will need to be repaired in case of damage by hazard, thus increasing contingent liabilities for governments.

Endnotes

1. This includes Anguilla, Antigua and Barbados, Aruba, The Bahamas, Barbados, Belize, British Virgin Islands, Cayman Islands, Cuba, Dominica, the Dominican Republic, Grenada, Guadeloupe, Guyana, Haiti, Jamaica, Montserrat, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos, and U.S. Virgin Islands.
2. https://www.emdat.be/.
3. Disasters in the database fulfill at least one of the following criteria: (1) 10 or more people reported killed; (2) 100 or more people reported affected; (3) Declaration of a state of emergency; (4) Call for international assistance.
4. https://thinkhazard.org/en/.
5. The losses associated with hurricanes account for wind damage only, not damage from flooding or storm surge.
6. Urban extents are defined as the areas where the population density surpasses 300 people per squared kilometer and total population is larger than 1,000 people. Data on population count and density comes from (see note 7).
7. *High Resolution Gridded Population Dataset for Latin America and the Caribbean in 2000, 2005, 2010, 2015 and 2020*. www. worldpop.org
8. Member states are Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname and Trinidad and Tobago.
9. LiDAR is an optical remote-sensing technique that uses laser light to densely sample the surface of the earth, producing highly accurate three-dimensional measurements.

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2

CHAPTER 2 >>

Lifeline infrastructure

Chapter 1 showed how physical assets—mostly buildings, urban infrastructure, and land—in the Caribbean are exposed to different shocks.

These assessments consider infrastructure losses in their narrowest sense, looking at how assets could be damaged by natural hazards. But infrastructure assets exist in a system of interconnected networks, such that infrastructure resilience depends not only on the resilience of its assets but also on the ability to deliver reliable services and reduce the impact of shocks on users along the network (*figure 2.1*). The consequences of infrastructure disruptions can be catastrophic or benign, depending on whether users—including people and supply chains—can cope with them. For example, toppling power poles disrupting a critical part of the power grid can have costly consequences for users in an entire region when households, stores, and hospitals, which depend on electrical power to maintain fresh supplies and take care of their patients, have few alternatives to buffer against these outages. For lifeline (transport, telecommunications, water, and energy) infrastructure, it is important to take a systemic approach to resilience, to reduce asset lifecycle costs, provide more reliable services, and reduce the total impact of disruptions on users.

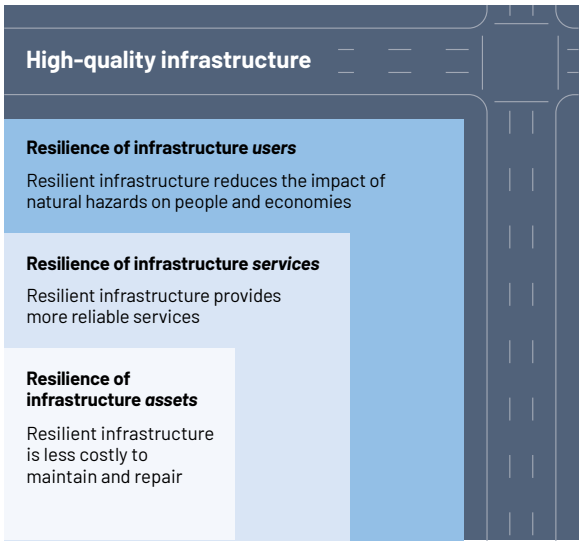
This section starts by identifying exposure of lifeline infrastructure assets in Caribbean countries to explore, through examples from the transport, power, water, and health supply sectors, and how damage to assets can translate into much bigger consequences through network effects.

Assets

Infrastructure assets in the Caribbean are exposed to different hazards, including pluvial and fluvial flooding, coastal surges, hurricanes (measured by wind speed), landslides, and earthquakes. In a background paper prepared for this report, Schweikert et al. (2021) use global datasets to measure infrastructure asset exposure. For earthquake data, they use a combination of local and global quantitative data and global qualitative data. They assess landslide susceptibility semi-quantitatively, categorizing an area as having a high, medium, or low risk while considering factors such as slope, lithological and geological conditions, soil moisture, vegetation cover, precipitation, and seismic conditions. The paper looks at road infrastructure, power plants, bridges, hospitals, water treatment facilities, ports, and airports, as data on these assets were available for at least a few countries. It excludes telecommunication infrastructure due to lack of data. An overview of the results is presented in ***table 2.1***. For a complete list of the data used, their resolution, and country-level exposure results, see Schweikert et al. (2021).

FIGURE 2.1 >>

The three levels of resilience of infrastructure systems



Source: Hallegatte, Rentschler and Rozenberg 2019

As seen in the DaLA summary in the introduction (***box I1.2***), historically, transport infrastructure assets have been most damaged by extreme events. They are also the assets for which most data are available for measuring exposure.

Roads

Roads are most exposed to hurricane wind and landslides. Road infrastructure is categorized as primary, secondary, tertiary, or other. Of the hazards considered, roads are most exposed to hurricanes and landslides (60–70 percent) and earthquakes (47 percent), and, to a lesser extent, pluvial flooding (7 percent), fluvial flooding (3 percent), and coastal surge (less than 1 percent) (***table 2.1***).

In Antigua and Barbuda, Belize, Barbados, Dominica, Grenada, Jamaica, and St. Kitts and Nevis, almost all primary roads are exposed to hurricane wind, while in the Dominican Republic and Haiti, about half are exposed. But even when roads are not directly vulnerable to wind, they can still be damaged by debris or trees falling on the road due to high wind speeds.

The costliest hazards for roads are landslides. In most countries, at least 50 percent of primary roads are in locations with medium or high landslide susceptibility. The exception are Guyana, Barbados, and Belize, which have very low exposure. Few primary roads are in locations exposed to coastal surge flooding (less than 2 percent using a 50-year return period). Similar patterns of exposure hold across secondary and tertiary road infrastructure.

TABLE 2.1 >>

Hazard exposure of Caribbean infrastructure assets

Infrastructure assets	Total amount (km/facility or asset count)	Hazard exposure					
		Infrastructure as % of total for which data are available					
		Flood (fluvial)	Flood (pluvial)	Coastal surge	Hurricane (wind speed)	Landslide (susceptibility)	Earthquake
Primary roads	6,195	4	9	0	74	63	56
Secondary roads	18,790	4	9	0.3	63	60	46
Tertiary/other roads	49,378	3	7	0.2	67	70	47
Bridges	6,866	10	26	1	55	60	56
Power plants (fossil fuel/other)	53	2	13	2	66	47	59
Power plants (renewables)	19	16	21	0	58	79	63
Water/wastewater treatment facilities	56	7	13	0	11	84	96
Ports (small and very small)	60	3	2	3	63	32	58
Ports (medium)	8	0	0	0	63	25	63
Airports (small)	171	2	8	1	33	21	19
Airports (medium/large)	82	1	7	0	82	27	32
Hospitals/health centers	490	1	5	0.2	49	67	65

Source: Schweikert et al. 2021

Notes: Results are presented as percentage of total infrastructure assessed. Cells in blue show the lowest third across all exposure numbers (the least exposed assets); those in yellow, the middle third; and those in red, the top third (the most exposed assets). Pluvial and fluvial flooding and coastal surge are assessed based on a 1-in-50-year flood; landslide susceptibility is measured qualitatively, characterizing regions as having low, medium, or high susceptibility; and earthquake is equivalent to a 10 percent probability of occurrence in 50 years.[1] Ports are classified by size following the World Port Index.[2]

Bridges

Bridges are often critical pieces of infrastructure for a functioning transport network and can be costly to repair. Over 50 percent of all bridges in the Caribbean are exposed to hurricane wind, landslides, and earthquakes (*table 2.1*). In Antigua and Barbuda, The Bahamas, Barbados, Dominica, Grenada, Jamaica, St. Kitts and Nevis, Turks and Caicos, and St. Vincent and the Grenadines, all or almost all bridges are exposed to hurricane wind. In Belize, the Dominican Republic, and Haiti, about half are exposed. As with roads, even when bridges are not directly vulnerable to wind (except for extreme wind speed), they can be damaged or made impassable by trees or debris falling on the bridge.

Landslides are also very costly, with almost all bridges in Antigua and Barbuda, the Dominican Republic, Grenada, St. Kitts and Nevis, St. Lucia, Trinidad and Tobago, and St. Vincent and the Grenadines in landslide-susceptible locations. In the other countries, about one- to two-thirds of all bridges are exposed. In Antigua and Barbuda, Barbados, Dominica, the Dominican Republic, Jamaica, St. Lucia, St. Kitts and Nevis, Trinidad and Tobago, and St. Vincent and the Grenadines, almost all bridges are at risk of seismic activity (which can also trigger landslides). Flooding risk varies by location, but overall, about a quarter of bridges are exposed to pluvial flooding, about 10 percent to fluvial flooding, and a small minority (1 percent) to coastal surge flooding.

Ports and airports

Ports and airports are exposed to several hazards. Ports in the Caribbean, which are critical to trade, are vulnerable to sea level rise, coastal surge, and other hazard types. For all the 68 ports included in Schweikert et al. (2021),[3] exposure to hurricane and seismic hazards is at least 50 percent (*table 2.1*).

Airports are categorized as *small*, *medium*, and *large*. Small airports have only light aviation passenger traffic, while medium and large airports see high general aviation traffic.[4] There are over 170 small airports throughout the Caribbean (for passenger traffic only), mostly located in Suriname (51), Guyana (36), The Bahamas (26) and the Dominican Republic (23). Overall, these airports have relatively low exposure to most hazards except hurricane wind, which remains an important threat for about one-third of them (*table 2.1*). Hurricanes also pose the largest risk to the functioning of medium and large airports, which have general air traffic and where damage might therefore have greater network effects and impose larger economic losses. Regionally, 61 of the 77 medium-sized airports are exposed to hurricanes, with the largest exposure seen in The Bahamas, where 27 out of 28 airports are exposed. There are only a few large airports in the Caribbean—in The Bahamas, Belize, the Dominican Republic, and Jamaica—and these are all exposed to hurricanes.

Power plants

In many countries, all power plants are exposed to earthquakes. Overall, both fossil fuel and renewable power plants are most exposed to hurricane winds, earthquakes, and landslides (*table 2.1*), but exposure varies per country. In Antigua, Barbados, Dominica, the Dominican Republic, St. Kitts and Nevis, Trinidad and Tobago, and St. Vincent and the Grenadines, all power plants are exposed to earthquakes. In most of these countries, they are also exposed to hurricanes and landslides. In some countries—such as The Bahamas, Grenada, and, to a lesser extent, Belize—seismic risk is low, but power plants are exposed to hurricanes and landslides. Haiti's fossil fuel power plants are not exposed to hurricanes, earthquakes, or landslides, but their two renewable facilities are built in locations that are susceptible to landslides. And while flooding is not the main hazard to power plants in most of the Caribbean countries considered, it is a significant threat in Suriname, Haiti, and Dominica.

Water

Water infrastructure is primarily exposed to landslides and seismic activity. As it is extremely difficult to find complete georeferenced information on water infrastructure throughout the Caribbean, much of the data used in the analysis were sourced from local agency websites, Google Maps, and other queries. Mostly data on water and wastewater treatment facilities were found, yet this spans only six countries (Antigua and Barbuda, the Dominican Republic, Grenada, Jamaica, and Trinidad and Tobago) and is likely incomplete. For these countries, over 80 percent of facilities are in areas with landslide susceptibility and seismic risk (*table 2.1*). None are exposed to coastal surge, and the risk of flooding is relatively low (6 percent are susceptible to fluvial flooding and 10 percent to pluvial flooding). The Dominican Republic has 50 facilities, which are all in areas of seismic risk. Nearly all are in areas that are susceptible to landslides.

Hospitals and health care

Hospitals and health centers are most exposed to landslides (67 percent), earthquakes (65 percent), and hurricanes (49 percent) (*table 2.1*). Flooding forms a much smaller risk—about 1–5 percent of facilities are exposed in 1-in-50-year fluvial, pluvial, or coastal flooding. Hospitals and health care facilities in all countries except Guyana and Suriname are exposed, to a certain degree, to landslides, earthquakes, and hurricanes. The countries with the most exposed facilities are the Dominican Republic (162), Trinidad and Tobago (116), and Haiti (108). In the Dominican Republic and Trinidad and Tobago, about 90 percent of facilities are exposed to landslide and earthquake risk; in Haiti, about one-third are exposed to hurricane and landslide risk. Fluvial flooding poses a smaller threat, yet about 15 percent of facilities in Jamaica, St. Lucia, and St. Kitts and Nevis are exposed. Exposure to coastal surge and fluvial flooding is generally low, with less than 1 percent of facilities exposed in most countries. The exceptions are Suriname and Haiti, where 13 and 3 percent are exposed to fluvial flooding, respectively.

While this exercise gives an overview of infrastructure asset exposure to multiple hazards, it does not consider vulnerability data (which do not exist for most assets). As such, it was not possible to assess the risk to infrastructure assets and associated contingent liabilities for governments and utilities. Miyamoto International (2021) provides examples of vulnerability curves for some assets and hazards in the Caribbean, but these do not exist for most assets and hazards.

Telecommunications

Telecommunication infrastructure is not included in the analysis above. However, an analysis of the 2017 Atlantic hurricane season—one of the worst ever recorded—shows that natural disasters take a heavy toll on mobile network providers in the Caribbean: 50 percent of mobile network providers were directly impacted during this season and some operating companies experienced over 95 percent damage to infrastructure (GSMA 2020). In the countries worst affected by Hurricanes Irma and Maria, all parts of mobile network operations were impacted. These disasters damaged physical mobile infrastructure and impacted everything needed to restore connectivity—from emergency equipment, personnel, and access, to power supply and capacity. A huge amount of telecommunications equipment suffered irreparable damage, requiring import of equipment and experienced personnel, highlighting the need of vendors to have the scale of stock needed to meet demand of mobile network operators across multiple islands and for governments to have the arrangements in place to allow fast-track approaches of importing telecommunications equipment (GSMA 2020).

Network effects

Although the lack of vulnerability information makes it hard to assess the exact damages to infrastructure assets that countries could face, it is possible to assess the wider network disruptions that could occur if infrastructure assets were to be damaged. Network effects—for example, when goods cannot reach their destination, people cannot access hospitals, and power cannot be delivered to communities—mean that indirect costs are potentially much larger than direct damages. Looking at networks effects allows authorities to anticipate larger losses and identify critical assets—that is, those that would lead to the highest economic or social losses if damaged (Rozenberg et al. 2019).

Criticality of ports

Caribbean countries rely extensively on maritime transport for trade. Around 95 percent of their bilateral trade (by value) is maritime, compared to about 55 percent of global trade (Verschuur, Koks and Hall, forthcoming). Their economies, characterized by high overall trade openness and low diversification, also depend on foreign products to meet domestic consumption and production: in the Caribbean, every dollar increase in final demand results in 2.4 times more port-level imports than global averages.[5] The dominance of maritime trade is mainly determined by location: as most Caribbean countries are island states, maritime transport is usually the fastest and cheapest carriage. The value-to-weight ratio of trading products and income, which determines the affordability of air transport, also plays a role. Ports are key assets in facilitating maritime trade and their disruption can have widespread consequences for entire supply chain networks.

The impact of disruption will depend on the amount of trade a port handles, the relative embeddedness in the local economy, and whether disruption could be mitigated by using other ports—that is, if there is redundancy in the port network. Although most Caribbean ports are relatively small, the importance of maritime trade and the absence of other available ports mean that economies are vulnerable to port disruptions. For example, Antigua and Barbuda, Belize, Barbados, Dominica, Grenada, Guyana, St. Kitts

and Nevis, St. Lucia, Turks and Caicos, and St. Vincent and the Grenadines each has only one to three ports. In countries that have several ports, the smaller ports might not have deep enough harbors to accommodate large ships. For example, Jamaica has 11 ports, but only Kingston is categorized as medium-sized, handling over $2.9 million yearly, in trade value terms (Verschuur, Koks and Hall, forthcoming). Assessing whether the loss of this location could be compensated by using smaller ports would be useful for emergency planning.

To measure the criticality of ports through the potential effect of port disruptions on supply chains, it is possible to use information on total domestic industry output that is directly or indirectly dependent on trade that flows through a port (Verschuur, Koks and Hall, forthcoming). Trade through individual Caribbean ports contributes on average 3.1 percent to domestic industry output and only 0.02 percent to the global industry output. Ports that are critical to domestic output include Paardenbaai, Aruba (21.7 percent); Pointe A Pierre, Trinidad and Tobago (18 percent); Bridgetown, Barbados (12 percent); Kingston, Jamaica (11.7 percent); and Road Harbor and Freeport, The Bahamas (10.2 percent).[6]

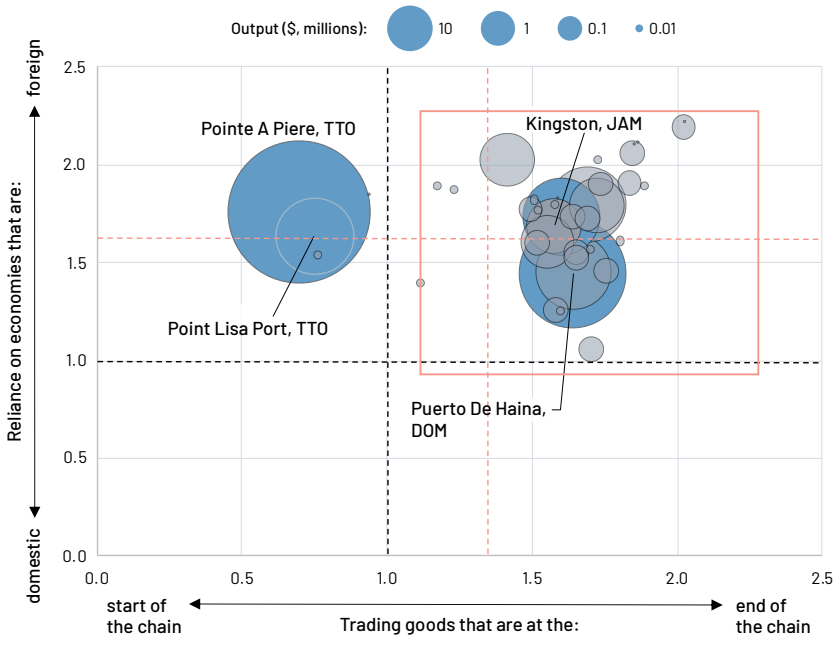
How port disruptions propagate through the economic system depends on the relative embeddedness in global or domestic production processes of goods that flow through that port, and on forward or backward linkages of those goods. For example, raw materials have more forward linkages compared to final products, so disruption of their flow would affect downstream supply chains. ***Figure 2.2*** shows that most Caribbean ports have relatively high foreign dependency and larger backward linkages (red box), illustrating that they mainly import final consumption goods. So, for example, disruption of Port of Kingston or Puerto de Haina could have costly consequences for domestic consumption. Point A Pierre and Point Lisa Port in Trinidad and Tobago both stand out with larger forward linkages relative to the other ports, indicating that their role as export hub for petroleum and petrochemicals serves production stages downstream in the supply chain.

FIGURE 2.2 >>

The role of Caribbean ports in supply chains

Source: Adapted from Verschuur et al., forthcoming

Notes: Only Caribbean ports for which MRIO data were available (www.worldmrio.com) are included.[5] The y axis shows the relative embeddedness of goods that flow through a port in domestic vs foreign production processes, indicative for their dependency on domestic vs global economies to meet final demand. The x axis shows the relative forward vs backward linkages of goods that flow through a port, which are indicative of their position in the chain. Raw materials are at the start of the chain and final consumption goods are at the end. The size of the dot corresponds to total port output losses. The black dotted line depicts the equal importance of both components, the red dotted line indicates the global median. Most Caribbean ports are within the solid red box, indicating relatively larger foreign dependency and backward industry linkages—that is, goods flowing through the port are mainly final consumption goods. Ports highlighted in blue and annotated are mentioned in the text.



Criticality of roads

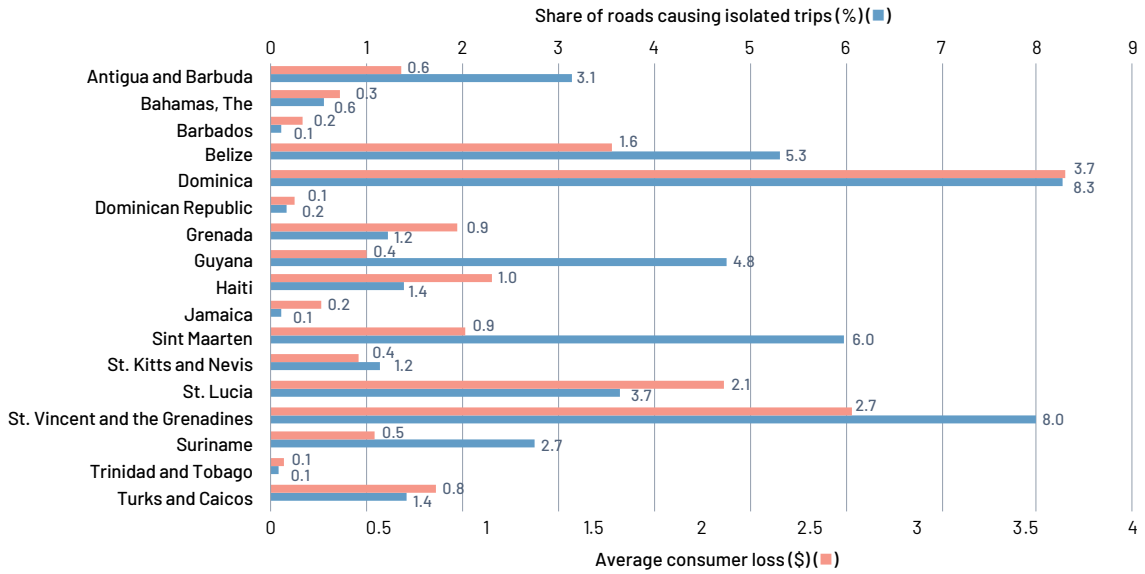
Criticality analyses of roads can help governments and planners anticipate widespread network disruptions and prioritize interventions. They are particularly important in the Caribbean, where financial resources are limited, and a significant part of countries' GDP is already allocated to infrastructure. In this context, it is crucial to identify where interventions are most needed to strengthen assets, thus enhancing system-level resilience.

Analyzing the criticality of a country's road network identifies the segments that are most likely to result in high impacts on society if damaged. For each disruption, the analysis estimates the number of trips that would become impossible in case of failure or damage and assesses additional travel distances and extra costs to the road user for trips that would remain possible. Those components that would have the largest impacts on the whole network if damaged are considered critical. Governments and planners can use this type of analysis to identify, for example, which areas of a road network should be prioritized for hardening.

One way to identify the most critical links in a network is to remove links one by one and recalculate travel costs for users having to use alternative routes (or becoming isolated from some destinations). Doing this systematically can also help compare the level of resilience of different networks. ***Figure 2.3***, which presents the result of single link disruptions for most Caribbean countries, shows very different levels of resilience across the region. For example, in Barbados or Jamaica, only 0.1 percent of individual links lead to isolated trips—that is, trips that can no longer be completed via any other route—and thus the isolation of communities if they are disrupted. On the other hand, in Belize, Dominica, Sint Maarten, and St. Vincent and the Grenadines, more than 5 percent of all links in the network would isolate users if disrupted. Looking at average consumer losses from road disruptions (due to longer routes or isolation) shows that resilience is lowest in Dominica, Guyana, Turks and Caicos, and St. Vincent and the Grenadines. These results are not surprising, as these islands are constrained by mountainous terrains and some destinations are accessed by a single road.

FIGURE 2.3 >>

Consequences of single road disruptions in Caribbean road networks



Source: Koks et al., forthcoming

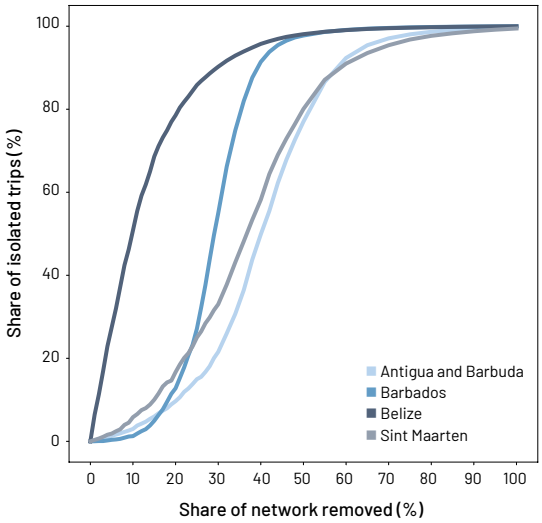
Notes: "Share of roads causing isolated trips" refers to the share of roads that cause isolation of users; the larger the share, the more trips become isolated or unfeasible in case of disruptions. "Average consumer loss" refers to road user losses that arise from taking longer routes or travel becoming unfeasible as parts of the network are isolated by disruptions.

Figure 2.4 shows the result of gradually removing a random share of the network in Antigua and Barbuda, Barbados, Belize, and Sint Maarten. As the share of the network removed increases, so does the share of isolated trips. However, the pace at which losses increase differs significantly per country and gives an idea of the redundancy of a countries' transport network. For example, in Belize, disrupting a relatively small share of the network results in a larger share of isolated trips than in Antigua and Barbuda or Sint Maarten (*figure 2.4*).

Network disruptions are often costly for users (either through longer routes or isolated trips). By combining travel costs with known elasticities of demand, it is possible to calculate the consumer surplus loss arising from disruptions in each country's network. *Figure 2.5* shows the losses when one-fifth of the network is randomly removed for different Caribbean countries. For Belize, removing 20 percent of the network results in 95 percent surplus losses, while in Antigua and Barbuda and Sint Maarten—which have a more redundant network around cities—the average loss is much lower, at 28 and 20 percent, respectively (but when critical roads are hit, losses can be much higher).

FIGURE 2.4 >>

Fraction of trips that are disrupted when part of the road network is removed



Source: Koks et al. forthcoming

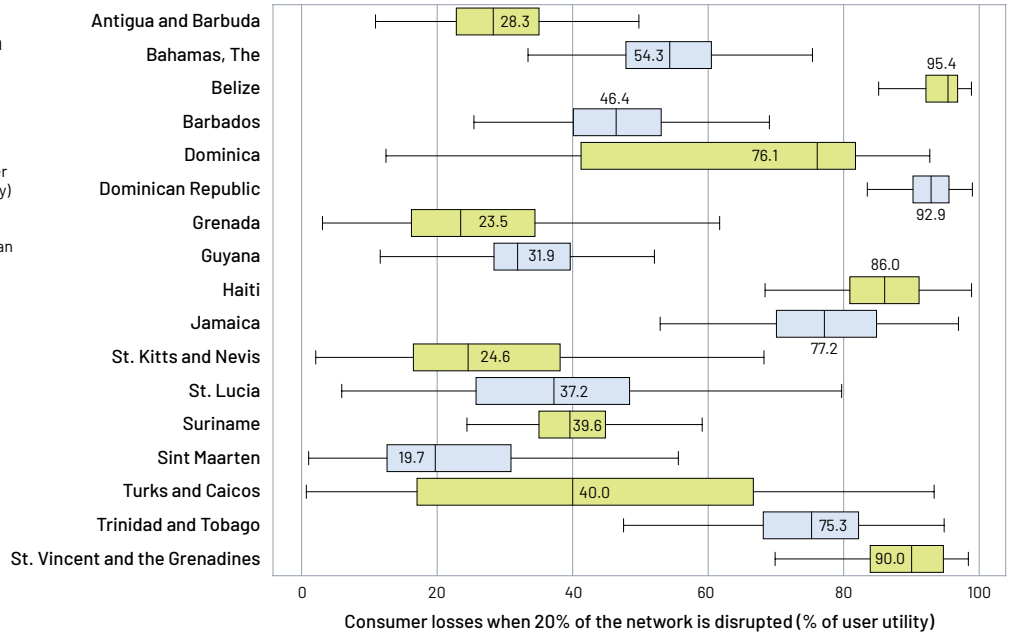
Note: The figure shows how the mean fraction of total trips that can no longer be completed via any route increases as a larger share of the network is removed for different countries.

FIGURE 2.5 >>

Losses in Caribbean countries when one-fifth of the road network is removed

Source: Koks et al., forthcoming

Note: The figure shows the distribution of estimated consumer losses (as percentage of user utility) when 20 percent of a country's network is disrupted. The value shown inside each box is the median value and the outer edges of the boxes represent the 25th and 75th percentile values, respectively.

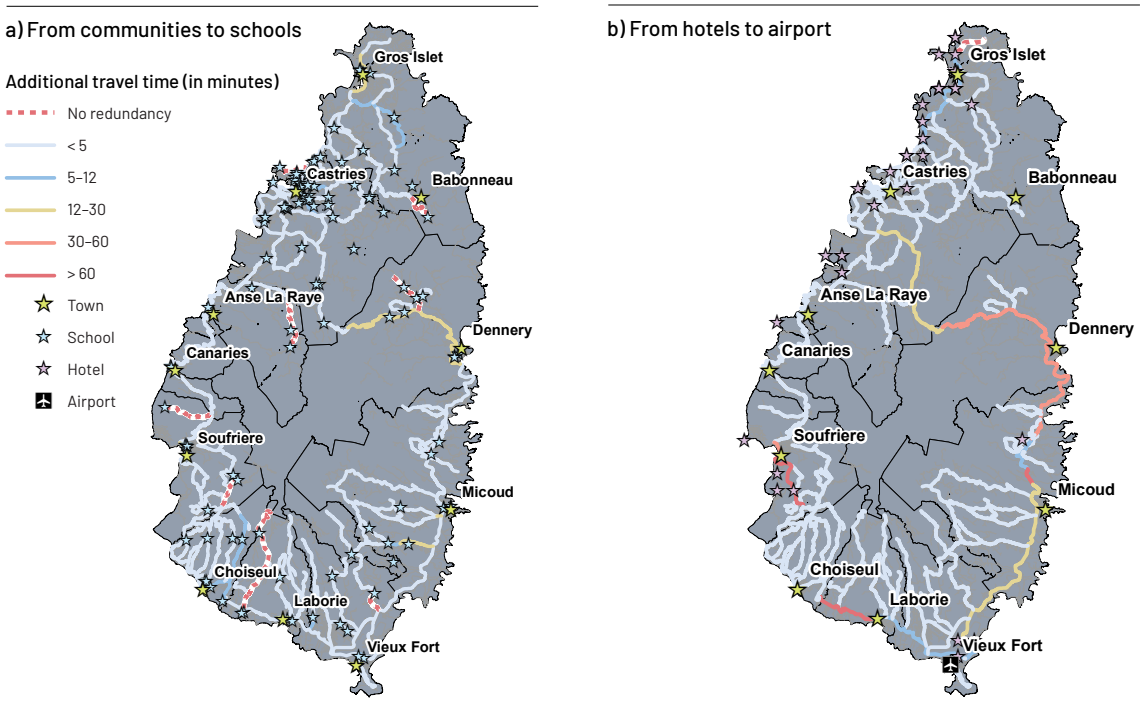


To further identify critical roads, it is possible to differentiate between road users. In St. Lucia, a model was developed to calculate the impact of road disruption on travel time between key locations, including settlement-school and airport-hotel connections, to capture criticality for different users. The model searches for alternative routes to reach the school or hotel while considering road type (primary, secondary, and tertiary) and quality. As *figure 2.6* shows, disruption of most routes leads to a limited (under five minutes) increase in travel time. However, disruption of some segments in the northern and eastern part of the island can increase travel time by 12–30 minutes. For some segments, there is no redundancy. This implies no alternative routes, so when connections are disrupted, some schools become inaccessible. Most of these segments are secondary or tertiary roads in poor to very poor state in the southwest of the island, but some secondary, good quality roads in the northern part also have no redundancy. Disruption of these segments can have severe consequences for education when children and teachers cannot access their schools.

This example from St. Lucia shows that road criticality depends on the users that are considered, a result already discussed in Hallegatte, Rentschler and Rozenberg (2019). To illustrate this point further, the next section analyses the criticality of the road network in Dominica and the Dominican Republic for different users.

FIGURE 2.6 >>

Changes in road criticality, depending on who is using them



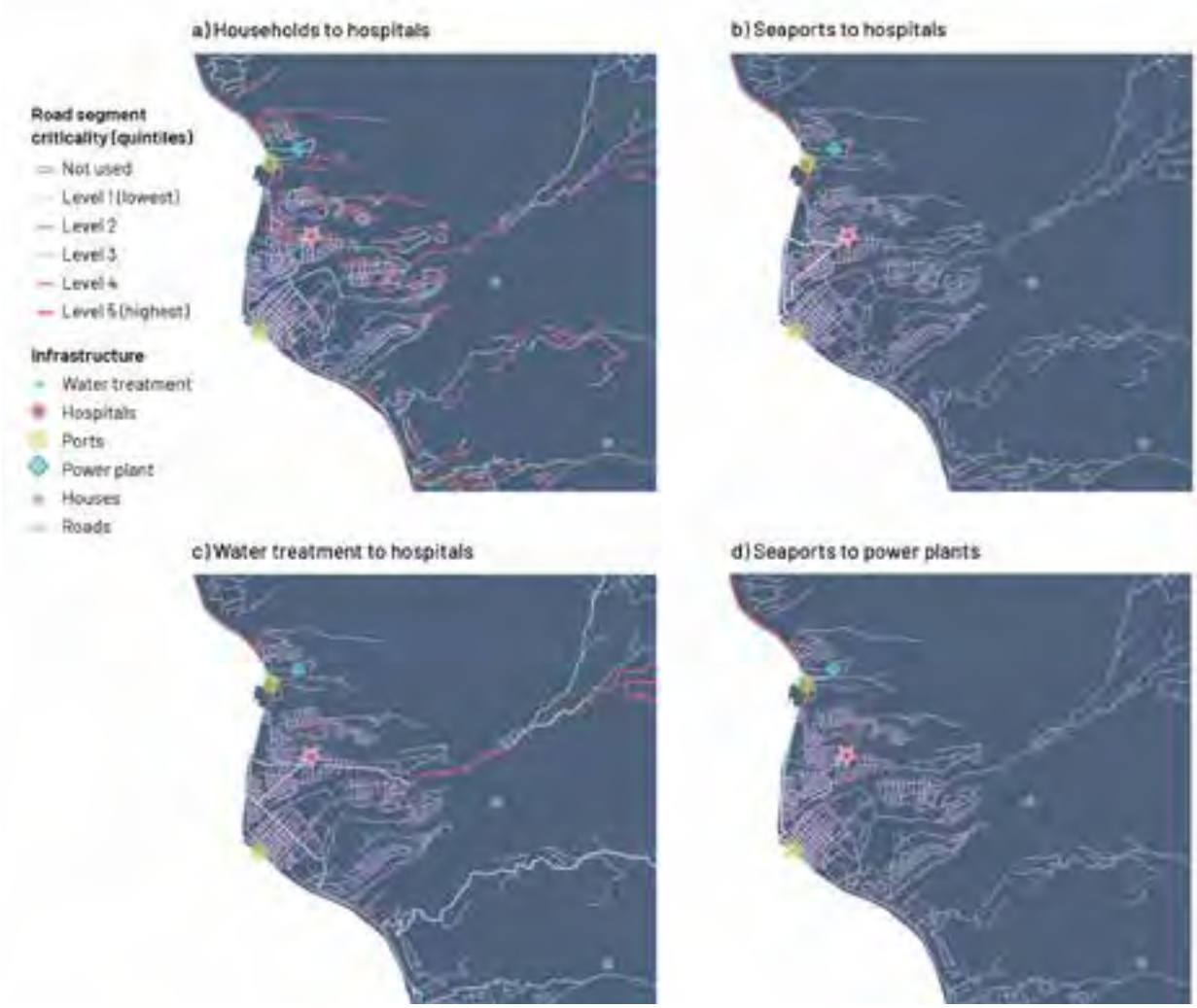
Source: Based on the outputs of the Vision 2030 project, funded by GFDRR/ACP-EU[7]

Impact of infrastructure disruptions on users

To further analyze the impact of transport disruptions on users and guide decision makers in their prioritization process, this section considers different origin-destination pairs in Dominica and the Dominican Republic: households, seaports, and water treatment plants to hospitals, seaports to power plants (*figure 2.7*) and power delivery to buildings (*figure 2.10*).

FIGURE 2.7 >>

Criticality assessments for different users in Dominica



Source: Schweikert, L'Her and Deinert, forthcoming

Connectivity to hospitals

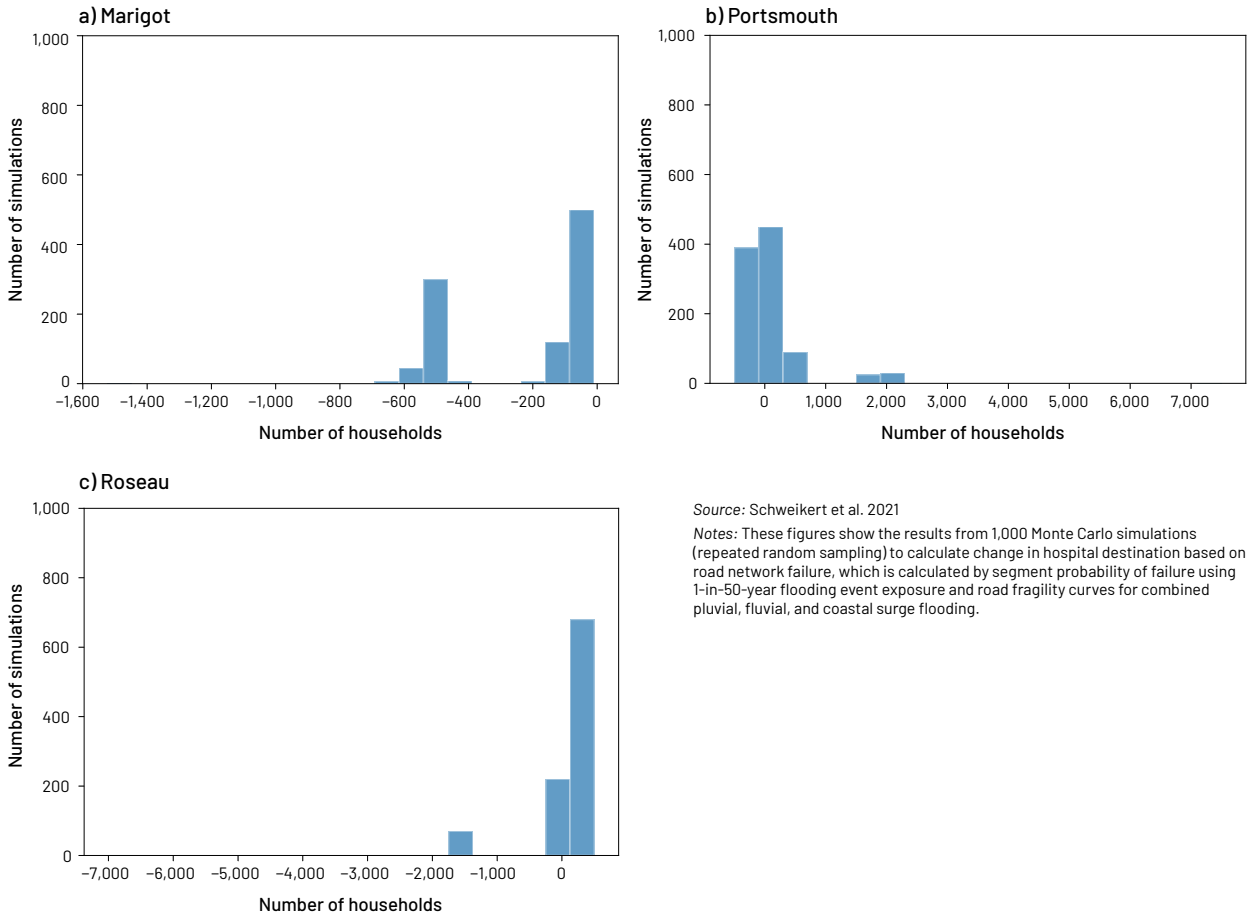
The assessment of the criticality of roads for Dominica's health sector uses households, seaports and water treatment plants as origin points and three hospitals as destination points. *Figure 2.7a–c* show that many roads are critical for households to reach hospitals, especially segments households use that are close to the hospitals (which tend to isolate hospitals when disrupted) and those crossing the island (which tend to isolate remote households when disrupted). Adding information on hospital operations

from stakeholder consultations also changes the criticality of some roads. For example, considering that Roseau, in the southeast, has the only hospital where critical care is available changes the criticality of some segments in the northwestern part of the island.

To go further, the analysis considers accessibility in times of disaster when hospital accessibility is critical, not only for patients but also for caregivers and suppliers. If roads are disrupted, people might have to use a different facility from their usual one, posing logistics issues for the health system. Considering the three hospitals in Dominica and assuming households choose the shortest route to a hospital facility, under perturbed network conditions (when some links are disrupted), as many as 2,000 households would change their destination to reach a hospital (*figure 2.8*). These changes significantly increase traffic flow along some road segments by as much as 50 percent. This has important implications for traffic management and health system resilience, as hospitals would have to plan for an increase in patients in case of road disruptions.

FIGURE 2.8 >>

Many households in Dominica change their destination based on perturbed road conditions



Source: Schweikert et al. 2021

Notes: These figures show the results from 1,000 Monte Carlo simulations (repeated random sampling) to calculate change in hospital destination based on road network failure, which is calculated by segment probability of failure using 1-in-50-year flooding event exposure and road fragility curves for combined pluvial, fluvial, and coastal surge flooding.

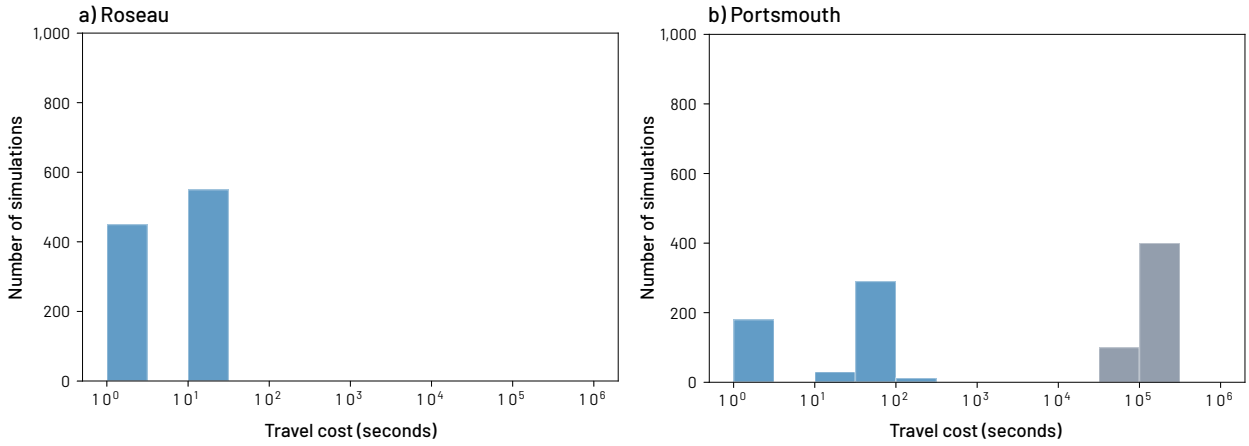
Fuel delivery to power plants

Most Caribbean countries are severely dependent on imported fuels—through their seaports—to power their electricity system. *Figure 2.7d* shows the critical road segments for fuel delivery from the seaport

to power plants around Roseau. A criticality analysis of the road segments used for diesel delivery from Dominica's ports to its two diesel-fueled power plants—in Portsmouth and Roseau—shows that the Portsmouth power plant is most vulnerable to fuel loss during a road segment failure (*figure 2.9*). Although the power plants are located relatively close to ports, some road links have large impacts on travel time, especially in Portsmouth, completely cutting off fuel supplies. For some segment failures, alternative routes are unavailable, increasing travel time by more than 27 hours, assuming it takes a day to repair a failed route segment (Schweikert et al. 2021).

FIGURE 2.9 >>

Road disruptions causing fuel delivery delays to power plants in Dominica



Source: Schweikert et al. 2021

Notes: Results are obtained running Monte Carlo simulations (repeated random sampling). Results in gray indicate that supply access was completely cut off by road failure until those roads were repaired. Results in blue indicate that an alternative (longer) route was available.

Disruption of power delivery to buildings

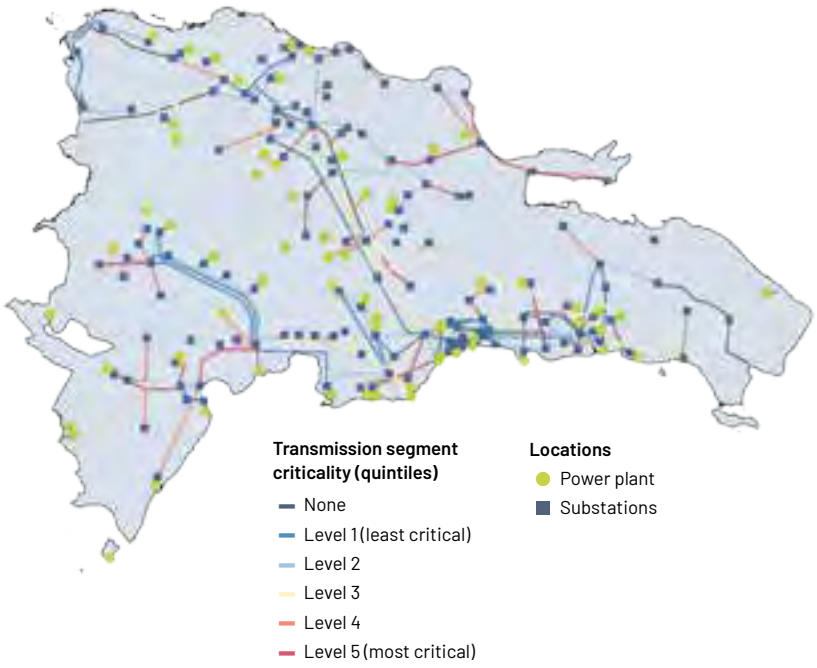
Reliable power provision is crucial for households and businesses. Despite many data gaps,[8] this example from the Dominican Republic illustrates how some segments of the power network are more critical to power delivery than others in terms of number of users. The inoperability of some segments (levels 4 and 5 in *figure 2.10*) would result in lost power delivery of most people. These segments are situated on lines that connect multiple power plants or near dense building clusters. For planning purposes, these results could help prioritize the lines that should be hardened and the poles that should be upgraded—for example, wooden poles are more likely to topple during storms than composite structures. Disruption of the blue segments of the grid have a lower overall effect on power delivery. For some segments, however, the effect of disruption is likely underestimated as the network data used in this example are not complete.[8] Including line voltage, directionality, substation location, and distribution infrastructure would also improve the analysis.

FIGURE 2.10 >>

Power delivery loss from transmission line failure in the Dominican Republic

Source: Schweikert et al. 2021

Notes: Origin locations are power plants, destinations are substations, with power traveling along a homogenous, bidirectional transmission line network. Each substation is weighted based on the population it serves and every power plant is weighted based on the megawatts of power it produces. The criticality of each transmission line segment indicates its relative importance—from least critical (blue) to most critical (red). More critical segments indicate that a greater population is served and/or power could fail to be delivered if that segment fails.



Impacts of water and power disruptions on the tourism industry

Disruptions of infrastructure services result in revenue losses for firms, and these increase with duration of outage. Firms cope by investing in backup infrastructure, such as water tanks and power generators. To understand their dependence on different services, a survey in the Caribbean region asked firms to approximate revenue loss for disruptions of different lengths, in the absence of backup infrastructure (Erman et al. 2021). The survey found that, if power infrastructure is disrupted for one day, 45 percent of firms would experience a drop in daily revenue by 50 percent or more, and 26 percent would be able to maintain sales. If power disruptions last more than a week, 89 percent of firms would experience a 50 percent drop or more in daily revenue. For longer outages of any service they depend on, very few firms can maintain daily revenue. But while many can maintain sales (albeit lower) with extended phone, internet, and boat transportation disruptions, 47–61 percent would have to shut down completely in case of water and road disruptions (Erman et al. 2021).

Water service disruptions are a common occurrence for firms in the tourism industry in the Caribbean. The survey found that, on average, firms experience 41 disruptions a year—about one outage every nine days when equally distributed over a year—lasting, on average, about 19.3 hours. These large averages are driven by a huge variance in reporting, both in terms of frequency and duration. The medians are six outages per year and six hours in length. Among the countries experiencing the most disruptions per year are Antigua and Barbuda (75), the Dominican Republic (85), and St. Lucia (81). For firms in the Dominican Republic, this implies one disruption every 4.3 days. On average, Antigua and Barbuda, the Dominican Republic, and Trinidad and Tobago experience longer disruptions than other Caribbean countries with 26, 32.6, and 29.3 hours, respectively (Erman et al. 2021).

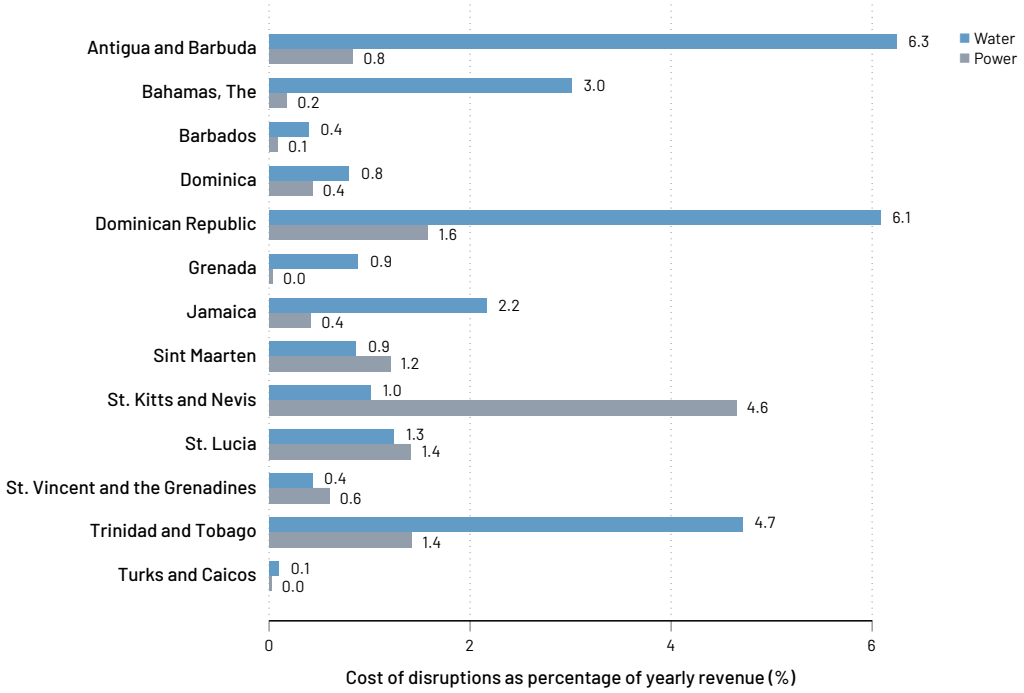
Reliability of energy is also a problem for the tourism industry in the Caribbean. The survey found that, on average, firms experience 37 power disruptions a year, lasting an average of 8.7 hours. There was some variation in reporting here, as median outage frequency and duration are 12 per year and 3 hours per outage, respectively. Antigua and Barbuda and the Dominican Republic have the largest number of power disruptions per year, with 68 and 81, respectively. This corresponds to one disruption every 5.4 days in Antigua and Barbuda

and one every 4.5 days in the Dominican Republic. Disruptions in the latter are also among the longest in the region, lasting about 12.5 hours. Firms in Dominica and St. Kitts and Nevis experience fewer power disruption than other countries, but they last longer, at 11.6 and 15.7 hours on average, respectively (Erman et al. 2021).

Knowing the most prominent cause of disruption can help governments target policy measures to overcome them and build a more reliable infrastructure system. In the survey, firms were asked to indicate whether they experience more disruptions during the hurricane season. Most indicated that power (62 percent) and road disruptions (71 percent) are more frequent during the hurricane season. For water, 57 percent indicated no seasonal difference in frequency of outages, and that these were mainly caused by poor management of the water infrastructure rather than extreme weather conditions. Several Caribbean countries have experienced severe drought in recent years. Low water levels in reservoirs makes water companies regulate water access more stringently, which could make them appear responsible for the outages. While most firms indicated that road and water disruptions are more frequent during the hurricane season, they mostly reported that a relatively low share of total outages in water and road infrastructure are caused by natural hazards (Erman et al. 2021).

FIGURE 2.11 >>

Losses due to water and power disruptions in Caribbean countries, in the absence of backup infrastructure



Source: Erman et al. 2021

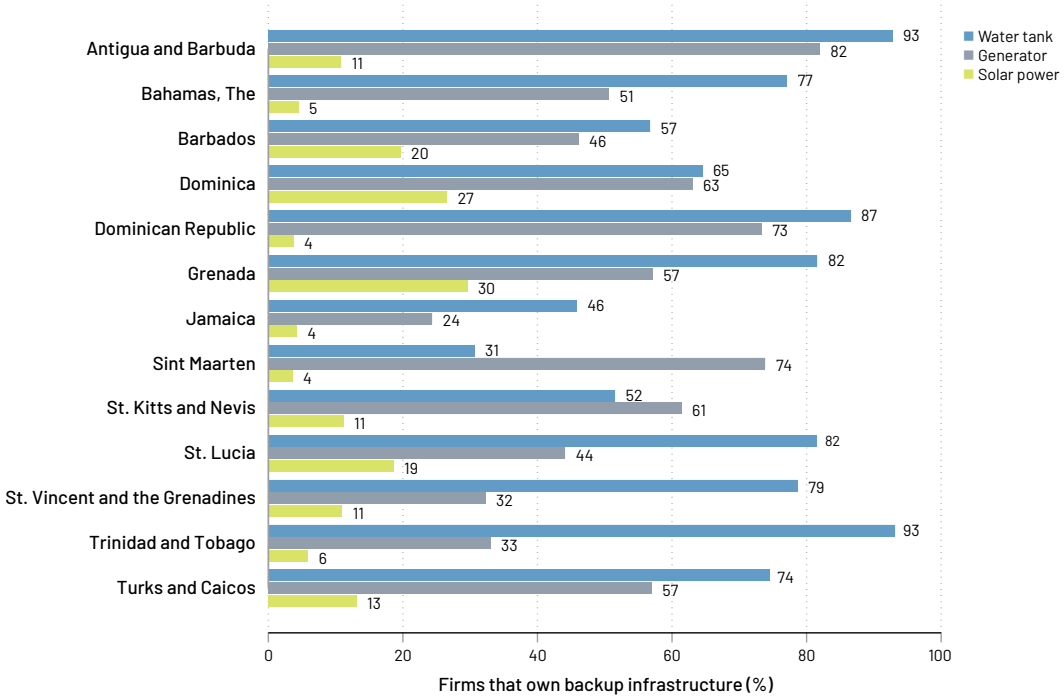
Note: Forgone revenue due to disruptions in water and power infrastructure is calculated as percentage of yearly sales.

Infrastructure disruptions translate into significant costs for firms. To calculate the expected losses from disruptions, the assessment combined expected revenue loss associated with disruptions with the length and frequency of disruptions firms experience annually and information on firms' yearly sales. Results indicate that an average firm loses about 3 percent of its yearly sales to water disruptions and 1.1. percent to power outages. Firms in Antigua and Barbuda, The Bahamas, the Dominican Republic, and Trinidad and Tobago incur the largest losses to water disruptions, while power disruptions have the largest impact on firms in St. Kitts and Nevis, the Dominican Republic, St. Lucia, and Trinidad and Tobago (***figure 2.11***).

Backup infrastructure can help firms overcome periods of shortage. However, it will only help if the shock is brief. Water tanks and generators are common in the region: 72 percent of firms own a water tank and 57 percent a generator. Solar power is present in the region, but only 10 percent of firms rely on it as a form of energy. It is most common in the hotel sector, while water tanks and generators are common in the three examined sectors hotels, restaurants, and touring/attraction/taxi/rental sector (*figure 2.12*).

FIGURE 2.12 >>

Backup infrastructure ownership in Caribbean countries



Source: Erman et al. 2021

Notes: Figure also includes firms that indicated using a rainfed water tank or generator as their main source of water or electricity, respectively. Country weights applied.

Backup infrastructure will only help firms maintain their business and revenues if the disruption is shorter than the length of backup infrastructure functionality. For example, if a water disruption lasts one day and the water tank lasts half a day, the firm will experience business disruption for half a day, even after having invested in backup. The data show that in the Caribbean tourism industry, the backup infrastructure firms have invested in seems to be enough to buffer the disruptions that they experience, but note that calculations assume firms can use the full capacity of the backup they own—so, water tanks are filled and generators are fully charged. For example, 96 percent of firms with backup infrastructure can buffer average water disruptions and 99 can buffer average electricity disruptions. In countries that experience frequent and longer water disruptions, more firms lack the capacity to buffer an average disruption and will therefore experience revenue losses, despite owning backup infrastructure. In Antigua and Barbuda, Dominica, Grenada, and St. Lucia, 7–14 percent of firms cannot buffer water disruptions with the water tanks that they own (Erman et al. 2021).

Firms that experience losses due to power and water outage fall into two groups: those that do not own backup infrastructure and those that own backup infrastructure, but not enough to buffer disruptions.

Those that do not own backup infrastructure lose, on average, about 1.1 percent of yearly revenue to water outages and 0.7 percent to power outages. Those that own a water tank that is not large enough to help them through the average water outages they experience lose about 0.3 percent of yearly sales to water outages. There are not enough data to calculate the losses for firms with insufficient generators to cover average outages since very few firms fall within this category.

Summary

This chapter discusses the importance of infrastructure assets and networks for Caribbean countries' populations and economies. Lifeline infrastructure assets are highly exposed to natural hazards in the region, yet they are vital to postdisaster response and recovery efforts. While power and water outages are frequent, many firms own backup infrastructure that helps them cope with short-term disruptions. Firms cannot cope, however, when big disasters interrupt water and power services for longer than a few days. In the event of disasters, the transport network plays a key role, since disruptions can affect countries' ability to receive international postdisaster support (if ports and airports are damaged) as well as access to health care and other lifeline networks, such as energy supply (due to reliance on petroleum transported on roads) and backup water supply.

Endnotes

1. To represent earthquake risk, commonly, the probability functions of the earthquake hazard (the return period) and the building damageability (the probability of exceedance, or loss estimate) are both accounted for, which statistically, corresponds to an effective return period of 475 years.
2. National Geospatial Intelligence Agency, Maritime Safety Information. *World Port Index* (accessed May 2, 2020). https://msi.nga.mil/Publications/WPI.
3. According to World Port Index classification, of the 68 Caribbean ports included in the study, 8 are medium, 39 are small, and 21 are very small. No ports are classified as large.
4. Based on the definition by Megginson (https://ourairports.com/about.html#credits), small airports have little to no scheduled service and light general aviation traffic; medium airports have scheduled regional airline service, or regular general aviation or military traffic; and large airports have major airline scheduled services with millions of passengers per year, or denote major military bases.
5. Based on countries for which data from the Eora Global Multi-Regional Input-Output (MRIO) were available: Aruba, The Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, the Dominican Republic, Guyana, Haiti, Jamaica, Suriname, and Trinidad and Tobago.
6. The percentages show the share of products imported through a port that are directly consumed in a country or used in production processes to produce goods for domestic consumption.
7. World Bank analysis led by Xavier Espinet to support project preparation.
8. There are also many gaps in connection of the transmission network, therefore some segments have a criticality of "none" despite (likely) being physically connected to the network. Also, the assumption was made that a local distribution network line serving population relies on power from the substation it is closest to. No voltage data were available, so a homogenous, bidirectional network was also assumed.

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3

CHAPTER 3 >>

Private sector vulnerabilities and losses

Chapters 1 and 2 focused on how disasters affect physical and natural capital, and the impacts of infrastructure disruptions on users. Those impacts are the easiest to measure and model, but they represent a small fraction of the total impacts of disasters on an economy.

This chapter looks at how key economic sectors are affected by these asset damages and infrastructure disruptions, and by broader shocks such as the COVID-19 pandemic. By looking at firms' vulnerability and shock absorption capacity—which are crucial for economic growth and job creation—this chapter assesses key aspects of economic resilience.

The chapter begins by categorizing Caribbean economies into three main economic structures. It then takes a closer look at the vulnerability of the tourism, agriculture, and fisheries sectors. It also looks at the financial sector, which is vulnerable through its connection with other sectors and has the potential to either reduce or amplify shocks, depending on its resilience. It is primarily based on background papers written by Makara (2021), Scott et al. (2020), and Masetti (2021).

Economic structures of Caribbean countries

Despite sharing many common features—such as a relatively small domestic market and no land border to main export partners—Caribbean economies have substantially different economic structures. Countries can be roughly grouped into three categories, based on their economic structure.

1. Tourism-dependent economies: St. Lucia, Antigua and Barbuda, Anguilla, Barbados, The Bahamas, the Dominican Republic, Grenada, and St. Kitts and Nevis all rely strongly on tourism. The share of the hotel and restaurant sector exceeds 8 percent of gross value added in all these countries and reaches up to 26 percent in St. Lucia.[1] The hotel and restaurant sector captures only a part of tourism-related activities, which are often also linked to the travel and domestic retail and services sectors.[2] ***Figure 3.1*** shows that tourism represents the majority of exports in those countries. The tourism sector is also labor intensive and directly employs 413,000 workers across the Caribbean, providing roughly 18 percent of total employment (ILO 2020).

2. Commodity-dependent economies: The second group includes Guyana, Trinidad and Tobago, and Suriname, the commodity-rich countries in the southern Caribbean where the mining and quarrying sector represents a high share of total gross value added. This is primarily due to large hydrocarbon sectors in Trinidad and Tobago and Guyana, and gold in Suriname and Guyana. While hydrocarbon production has matured in Trinidad and Tobago, Guyana only recently discovered vast offshore oil reserves, which are among the largest in the world on a per capita basis. Oil production started in 2019 and it is projected that the hydrocarbon sector will expand rapidly over the next years. The presence of extractive commodities in countries like Trinidad and Tobago also supports relatively large manufacturing sectors that often comprise downstream processing of hydrocarbon and mining products.

3. Agriculture-dependent economies: The third group consists of countries with a high share of agriculture in total gross value added, including Haiti, Guyana, Dominica, Belize, and Suriname.[3] In many countries, however, the socioeconomic importance of the agriculture sector is higher than indicated by its share in gross value added: because it is labor intensive, it represents a significantly higher share of total employment than output. For example, it is estimated that more than 40 percent of Haiti's labor force is engaged in mostly small-scale agricultural activities (World Bank 2020), but the sector's share in gross value added is 19 percent.

Besides these heterogeneities in terms of sectoral focus, gross value added data presented in ***table 3.1*** also show a high importance of the following sectors in most countries:

- Wholesale and retail trade (13 percent median share)
- Transport and communication (12 percent)
- Real estate, renting, and business activities (11 percent)
- Education, health, and other social and personal services (11 percent)

TABLE 3.1 >>

Sectoral gross value added (%) for Caribbean economies

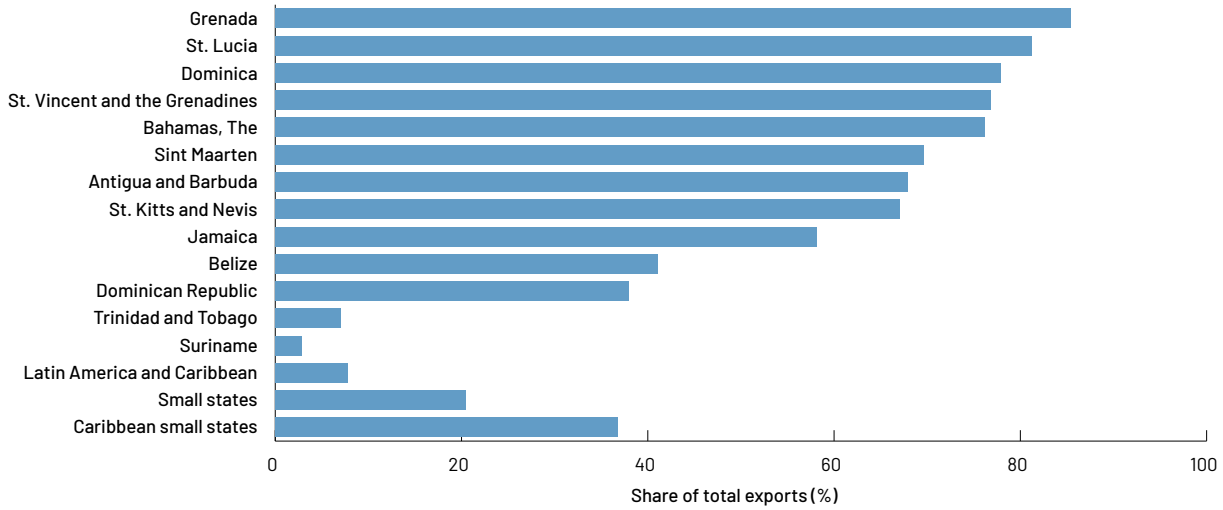
	Agriculture, livestock, forestry, and fishing	Hotels and restaurants	Mining and quarrying	Construction	Education, health, and other social and personal services	Electricity, gas, and water supply	Financial intermediation	Manufacturing	Public administration and defense; compulsory social security	Real estate, renting, and business activities	Transport, storage, and communications	Wholesale, retail trade
Anguilla	1	13	0	17	11	2	11	2	9	12	9	12
Antigua and Barbuda	2	12	1	16	10	4	7	3	9	13	11	12
Bahamas, The*	1	9	1	6	14	3	10	3	6	23	11	14
Barbados*	1	14	0	6	11	3	10	6	6	20	12	11
Belize*	13	6	0	4	9	4	9	8	14	7	13	17
Dominica	14	1	2	12	10	3	5	3	11	7	18	14
Dominican Republic	6	8	2	12	18	2	5	14	5	8	10	9
Grenada	6	8	0	9	27	3	6	4	7	11	12	8
Guyana	15	0	22	9	9	3	4	6	9	1	0	11
Haiti	19	0	0	22	0	1	2	8	2	4	13	27
Jamaica*	8	4	3	8	10	3	10	9	8	11	8	18
Montserrat	1	2	3	5	14	3	9	3	30	15	8	8
St. Kitts and Nevis	1	9	0	20	16	1	8	6	10	10	11	7
St. Lucia	2	26	0	4	10	4	7	3	5	22	13	4
St. Vincent and the Grenadines	9	2	0	8	11	4	7	6	12	15	13	13
Suriname*	13	4	7	9	1	3	5	16	11	6	13	13
Trinidad and Tobago*	0	1	11	6	4	4	8	18	10	9	8	20
Average	**7**	**8**	**3**	**10**	**11**	**3**	**7**	**7**	**10**	**11**	**11**	**13**
Median	**6**	**7**	**1**	**9**	**10**	**3**	**7**	**6**	**9**	**11**	**12**	**11**

Source: Masetti 2021

Notes: Data as of 2018, except for countries marked *, which indicates data as of 2017. Color increases in intensity at 5, 10, 15 and 20 percent thresholds. The three main economic structures are in blue and other sectors in gray.

FIGURE 3.1 >>

Tourism contribution to exports in Caribbean countries (2017)



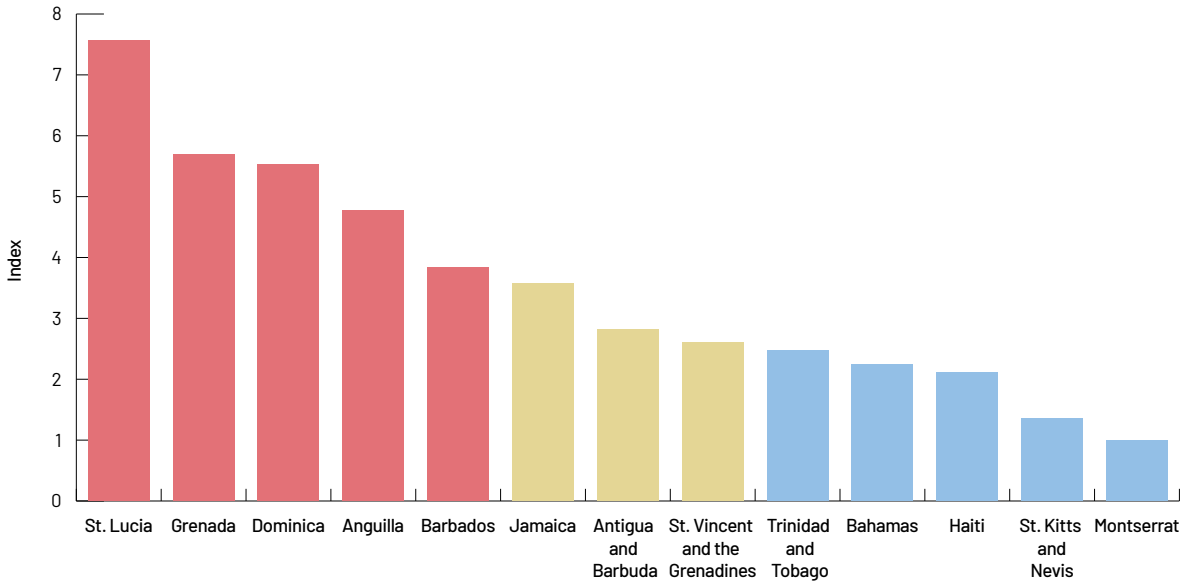
Source: Based on data from WDI database (last accessed April 2021)[4]

An analysis conducted for this report (Masetti 2021) assesses sectoral vulnerability to tropical storms—the most prevalent type of natural hazard in the region[5]—by regressing sectoral growth for each sector separately on continuous storm wind damage. Note that total gross value added growth falls by 0.6 percentage points following an *average* storm event and by 4.2 percent following a *very strong* storm event (Masetti 2021).[6] When disaggregated by economic sector, the analysis finds very different levels of vulnerability to shocks across the Caribbean: in the year of a storm event, gross value added declines significantly in the agriculture (-0.142), hotel and restaurant (-0.123), mining and quarrying (-0.276), and trade (-0.071) sectors, whereas other sectors experience no significant impact. One year after a storm event, its impact continues to depress growth in both the agriculture and hotel and restaurant sectors. In contrast, the construction sector seems to rebound, probably due to enhanced reconstruction activity. The trade sector also appears to recover its contemporaneous losses in this time.

Masetti (2021) constructed a country-specific measure of economic vulnerability, where higher values indicate higher vulnerabilities to storms. This economic vulnerability index does not consider the historic occurrence or frequency of storm events or the likelihood of future storms. It only relates countries' current economic structure with the average vulnerability of a given sector to storms in the Caribbean. Since it is based on historic correlations between storms and economic activity, it is not designed to capture the impact of climate change, which might alter these relations—for example, if storms bring increasingly bigger surges on coastal areas. ***Figure 3.2*** shows that St. Lucia has the highest structural vulnerability. This can be explained by the high share of hotels and restaurants in St. Lucia's gross value added. As growth in this sector is vulnerable to storms, the index is high. Grenada, Dominica, and Barbados also have high index values, whereas in St. Kitts and Nevis and Montserrat, structural economic vulnerabilities are comparatively low.

FIGURE 3.2 >>

Economic structural vulnerability to storms in Caribbean countries



Source: Adapted from Masetti 2021

Notes: Relative scoring across the countries using terciles. Red bars indicate a high economic structure vulnerability index, yellow bars indicate a medium economic structure vulnerability index, and blue bars indicate a low economic structure vulnerability index.

Impact of shocks on tourism

The tourism sector is highly dependent on external demand and, as such, is exposed to many shocks, from natural disasters to economic and health shocks. Natural disasters damage the infrastructure that tourists rely on and tend to delay or reduce tourists' arrival, global economic crises reduce tourists' purchasing power, and health crises like the COVID-19 pandemic prevent them from traveling.

Natural disasters

Hurricanes have had disastrous impacts on the tourism sector in Caribbean countries. For example, in 2004, Hurricane Ivan damaged or destroyed 90 percent of guest rooms in Grenada, equivalent to approximately 29 percent of GDP (Mimura et al. 2007), and in 2015, Tropical Storm Erika caused $482 million of economic damages in Dominica (90 percent of GDP), with more than one-third of the island's hotel capacity suffering complete losses (Government of the Commonwealth of Dominica 2015). After this event, officials in Dominica claimed it had set the country's tourism development back 20 years. In 2017, a series of major storms and other natural disasters worldwide resulted in the second-highest incurred losses ever recorded ($330 billion) and did not spare the tourism sector (Munich Re 2018). The WTTC's multi-storm analysis estimated that the 2017 hurricane season caused a loss of over 826,000 visitors (-2.5 percent of expected visitors and down 4 percent from 2016), with the region's GDP experiencing a loss of over $292 million (WTTC 2018). It also estimated that recovery in some destinations would take up to four years, during which time the tourism sector would "miss out" on an additional $3 billion in tourist spending due to damage to resorts, beaches, attractions, and other infrastructure (WTTC 2018). The 2017 hurricanes also had a notable impact on insurance costs, with Caribbean hoteliers advised to plan for a 10–40 percent increase in insurance premiums due to losses caused from the 2017 hurricane season (Curaçao Chronicle 2017). In other cases, insurers refused to continue insuring assets in the Caribbean (KPMG 2018). The impact on tourism sector investment, however, was limited.

Several studies have looked at the average impact of hurricanes on tourism in the Caribbean. Granvorka and Strobl (2013) conducted the only regionwide analysis of the impact of hurricanes on tourism, examining the impact on tourist arrivals in 26 countries over the 2003–08 period. The results indicate that an average hurricane strike causes tourism arrival to drop by 2 percent in the 12 months after the storm, while the largest event—Hurricane Ivan in 2004—was estimated to have reduced arrivals by 20 percent. A more recent analysis conducted for this report (Scott et al. 2020) find a much higher impact for the 2008–18 period. After accounting for fluctuations in global economic trends, disease epidemics, institutional capacity, and adaptation investment, Scott et al. find that hurricanes reduce tourist arrivals by 11 percent during the 12 months following the hurricane damage, compared to a year with low damage or no hurricanes. When looking at monthly impacts, they find that hurricanes initially reduce tourism arrivals by over 30 percent, recovering to the season average in the following three months.

However, not all hurricane seasons have the same impact on tourism, as the intensity and frequency of hurricanes vary. In 2016, only Hurricane Matthew had a force that caused substantial damage, whereas the following year, Hurricanes Harvey, Irma, and Maria all caused substantial damage across countries and territories in the Caribbean. Scott et al. (2020) extend their analysis to determine the differential impacts of hurricane seasons on tourist arrivals during the six-month period following a hurricane's landing. Because Hurricanes Harvey, Irma, and Maria hit one month after the other (Hurricane Maria had the highest sustained wind speed of the three), together they led to a 33 percentage point average reduction in tourist arrivals. In 2008, Hurricanes Ike and Gustav reduced tourist arrivals in affected countries by 20 percent on average, and in 2010, Hurricane Alex reduced arrivals in Belize by almost 25 percentage points. The 2011 season affected several Caribbean countries, reducing tourism arrivals by 9 percentage points.

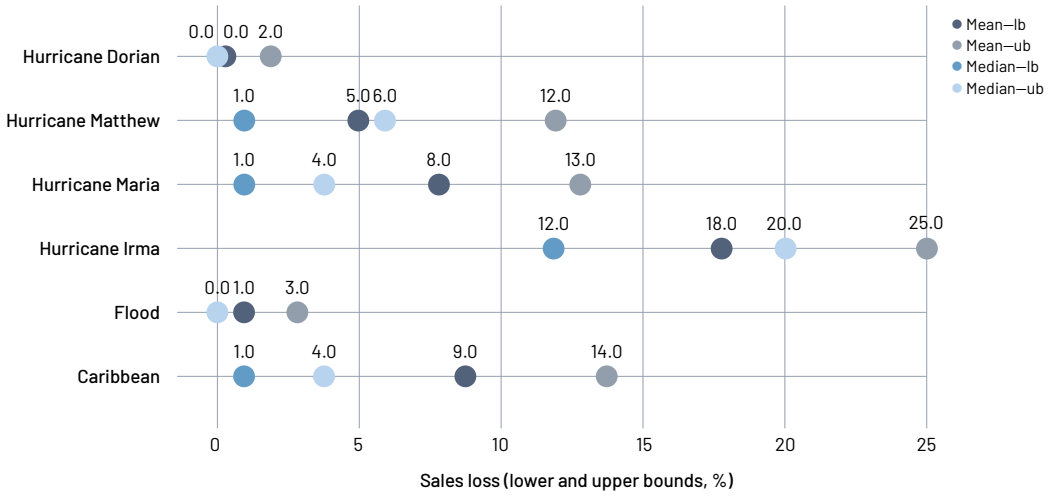
Erman et al. (2021) provide more detailed information on the impact of hurricanes on sales in the tourism sector. As expected, the survey found that natural disasters force businesses to close, resulting in immediate losses in sales. These may continue after firms reopen, because prolonged reconstruction of vital infrastructure and tourist attractions often limits travel and because tourists are less willing to return to a country after a disaster. The survey results indicate that the five main contributing factors to reduction in sales were:

- Halted international air transport (44.8 percent)
- A negative perception of the country due to disaster (37.6 percent)
- Cruise ships rerouted or stopped coming (26.1 percent)
- Travel agencies rerouted or stopped sending tourists (25.5 percent)
- Damage to touristic attractions (24.4 percent).

It also estimates that, six months after the disasters hit, an average loss for the whole Caribbean ranges between 9 and 14 percent. The losses are more salient after Hurricane Irma, where, on average, firms lost between 18 and 25 percent (*figure 3.3*).

FIGURE 3.3 >>

Accumulated loss in sales attributed to natural shocks in the Caribbean (%)



Source: Erman et al. 2021

Notes: lb = lower bound; ub = upper bound. Average losses per firm and accumulated losses six months after the natural shock. Countries affected by these natural disasters include Antigua and Barbuda, The Bahamas, Dominica, the Dominican Republic, Jamaica, Sint Maarten, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and Turks and Caicos.

Economic shocks

Economic cycles in the source markets of advanced economies have historically transferred rapidly to the Caribbean tourism sector (Laframboise et al. 2014). The onset of the global economic crisis in late 2008 is a good example. The severe economic contraction in 2009 resulted in a global decline in international arrivals from 916.7 million in 2008 to 883.2 million in 2009 (UNWTO 2020). This approximately 4 percent reduction stands in sharp contrast to the sustained 6–7 percent growth between 2004 and 2007. Arrivals in the Americas region, which includes the Caribbean, also declined by 4.2 percent in 2009 (from 147.8 to 141.7 million) but recovered to 150.1 million arrivals in 2010 (UNWTO 2020). The economic crisis impacted strongly on the Caribbean tourism sector, with a 9 percent decline in arrivals between 2008 (20.1 million) and 2009 (18.3 million), while the Pacific islands and Middle East saw the largest decline in international

tourist arrivals. Recovery in the Caribbean lagged the wider Americas region and global rebound, with arrivals not returning to prerecession levels until 2012. There were, however, large differences in recession impacts and recovery at country level, with Antigua and Barbuda, The Bahamas, and Barbados experiencing a 10–15 percent fall in arrivals, while Cuba and Jamaica experienced no absolute declines (ECLAC 2010). The cruise market saw similar differential country impacts, with Puerto Rico, Jamaica and the U.S. Virgin Islands experiencing sharp declines of 10–15 percent, but Barbados, Dominica, Belize, St. Lucia, and Grenada seeing a rise in arrivals (ECLAC 2010).

Commodity-exporting Caribbean countries are also subject to external economic shocks, including commodity price and demand shocks. Fluctuations in oil prices, for example, can have substantial impacts on the balance of payments and fiscal outcome of countries that are highly reliant on oil exports. An unexpected fall in commodity sales, either due to oversupply from other countries or reduced demand, can also have detrimental effects. For example, Trinidad and Tobago benefited from oil price increases in the 1970s, allowing the government to invest in large investment projects. But it began to face serious economic problems when global oil prices weakened in 1982–83 and petroleum output declined. Its overall fiscal position shifted from a surplus in 1981 to deficits of nearly 15 percent of GDP in 1982–83 as oil revenues declined, and the economy contracted in 1983 as output fell in both the oil and non-oil sectors. In 2018, the state-owned oil company, Petroleum Company of Trinidad and Tobago Limited (Petrotrin), shut down its refinery due to insolvency issues. This closure followed five years of losses amounting to TT$8 billion, the steady decline of oil production, and increasing debt burdens, and led to 1,700 layoffs (Argus Media 2018; Government of the Republic of Trinidad and Tobago 2019). This case exemplifies how commodity-dependent economies are exposed to economic shocks, such as commodity price fluctuations.

Disease outbreaks

In their assessment of the impact of past disease outbreaks on the Caribbean tourism sector, Scott et al. (2020) find no discernible effect on tourists arrival. This contrasts with other sources and other perceptions of events like the Zika outbreak, which affected every country in the Caribbean, with a country average of 378 cases. A United Nations Development Programme (UNDP) study noted that the Caribbean was the most affected subregion, with a negative impact five times greater than South America's (UNDP 2017).

There is limited research available on the impact of the Zika virus epidemic on the tourism sector. However, one study estimated that the total short-term cost of Zika to the Caribbean region between 2015 to 2017 ranged from $1.8 billion to $3.4 billion, with most of this due to lost revenue from tourism (UNDP 2017). The United States Center for Disease Control issued a Level 2 Travel Notice for several Latin America and Caribbean countries (CDC 2016), and there is anecdotal evidence of cancelations—and of airlines, cruise ships, and resorts changing their cancellation policies—because of Zika. Forbes speculated that losses could exceed $63 billion ($11 billion in Caribbean Islands) (Canal 2016), but there has been no analysis of Zika's impact on arrivals in any country. Between August 2016 and January 2018, more than 800,000 Zika cases were reported in the Americas (Scott et al. 2020). A recent analysis by the InterAmerican Development Bank corroborates Scott et al. (2020) results, finding that Zika had a nonsignificant impact on tourism in Latin America and the Caribbean (IADB 2020) .

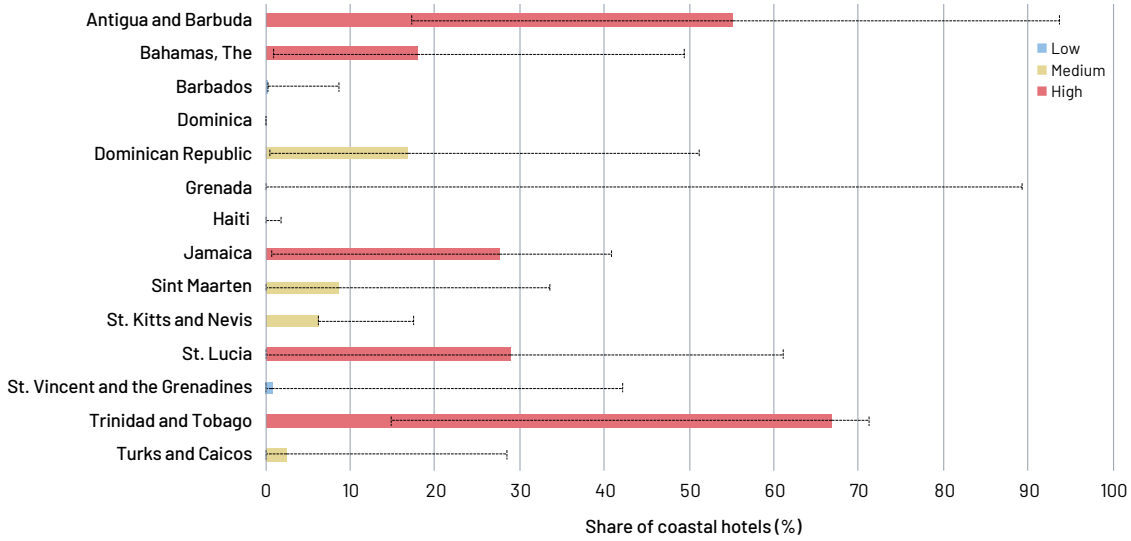
Future climate change impacts

Under sea level rise projections, the erosion of sandy beaches is expected to accelerate (Giardino et al. 2021). This phenomenon directly affects the profitability of the tourism sector (Thinh et al. 2019). Combining sandy beach shoreline changes presented in *chapter 1* with geo-localized tourism allocations in the Caribbean indicates that, under a moderate CO_2 emissions pathway (RCP 4.5), 13 (30) percent of nearshore hotels will experience beach loss resulting in a 17 (38) percent decrease in tourism revenue for the regions by 2050 (2100) (Campbell, Spencer and Strobl 2021). Countries with large shares of hotels that

can no longer profit from the proximity of a sandy beaches by 2050 are Trinidad and Tobago, Antigua and Barbuda, St. Lucia, and The Bahamas (*figure 3.4*). However, it is important to consider that the level of uncertainty is relatively large, especially for large time horizons. For the 2100 estimate, the regional share of hotels affected estimates varies between 2 and 35 percent with 95 percent confidence.

FIGURE 3.4 >>

Hotels in Caribbean countries experiencing beach loss by 2050 under a moderate climate change scenario



Source: Based on data from Campbell, Spencer and Strobl 2021

Notes: Coastal hotels are those that are located within 1km (Euclidean distance) from the beach. The bars show the mean share of hotels experiencing beach loss; the error bar represents the 95 percent confidence interval. Countries are categorized according to the mean amount of projected beach loss. Countries with low beach loss are in the bottom third; those with medium beach loss are in the middle third; and those with high beach loss are in the top third.

COVID-19 >>

The unprecedented case of the COVID-19 pandemic

The COVID-19 pandemic and global economic crisis has had an unprecedented effect on Caribbean economies, and its toll on the tourism sector has been particularly strong. The crisis was due to a combination of domestic lockdowns (which purposefully reduced economic activity to solve the sanitary crisis), an almost complete drop in international tourism demand, and declining commodity prices. Combined with drops in remittances in some countries, these have resulted in sharp downward revisions of the region's growth prospects. The International Monetary Fund (IMF) expects the Latin America and Caribbean region to return to pre-pandemic output levels in 2023 and GDP per capita in 2025 (IMF 2021).

Of course, domestic lockdowns are only a fraction of the impact of COVID-19 on Caribbean economies. The most prolonged disruption and economic devastation from the pandemic occurred in the region's tourism-reliant economies due to the plummeting of global tourism demand. While these countries can influence the conditions necessary to successfully restart their tourism economies—for example, by reopening their borders to international arrivals, implementing policies on inbound quarantine and health screening requirements, developing new public health regulations and surveillance programmes for hotel and resorts, providing health coverage or insurance for travellers, and increasing marketing campaigns—the recovery of their tourism economy largely depends on the policies of source market countries. Travel restrictions, together with depressed traveler confidence, caused international travel to halt completely in April and May 2020 as more than 80 percent of world destinations closed their borders (UNWTO 2020). By early September 2020, the proportion of closed destinations had fallen to 29 percent. But travel restrictions, including border closures and quarantine requirements, reduced the number of commercial flights and cruises into the Caribbean region. The United Nations World Tourism Organization (UNWTO) estimates that international tourist arrivals fell by 83 percent in January to March 2021, compared to the same period in 2020, following an unprecedented drop of 73 percent in 2020 as travel restrictions remained high and consumer confidence low (UNWTO 2021).

The uncertainty and dynamics of the pandemic—including public health and economic recovery policy responses—make projections of the impacts of COVID-19 on the tourism sector extremely challenging, with all estimates of eventual consequences interpreted with extreme caution. COVID-19 is no ordinary shock to global tourism, with no analogue since the massive expansion of international tourism began in the 1950s (Gössling, Scott and Hall 2020). Some projections suggest the eventual impact of the COVID-19 pandemic may be 6–10 times that of the 2008–09 global economic crisis, and early evidence points to a devastating impact on Caribbean tourism. According to Tourism Analytics (2021), regional stopover arrivals for January to May 2021 dropped by 44 percent compared to 2020, while arrivals declined by 66 percent from January to December 2020 compared to 2019. The Caribbean Tourism Organization made a preliminary projection that the 50 percent reduction in regional stayover arrivals in 2020 would take the Caribbean back to 1995/96 levels, reversing 25 years of growth (CTO 2020).

A tourism firm survey conducted for Erman et al. (2021) asked Caribbean respondents about the impact of COVID-19 on sales. The data show a devastating impact as the average net sales change by month for countries, depending on their tourism dependance (very high, high, low) (***figure 3.5a***). Countries with a lower dependency on tourism seem to have suffered as much as the other countries initially, making a small recovery towards September 2020. In June and July, countries with high dependence made a slight recovery, but sales fell again in August. Restaurants fared slightly better than hotels and tour/attraction firms, but impacts across the board are huge (***figure 3.5b***).

Figure 3.5a and ***3.5b*** show total sales losses by sector between March and November 2020. During this period, hotels lost 90 percent of total sales (57 percent of annual sales) and restaurants lost about 77 percent of total sales (51 percent of annual sales).

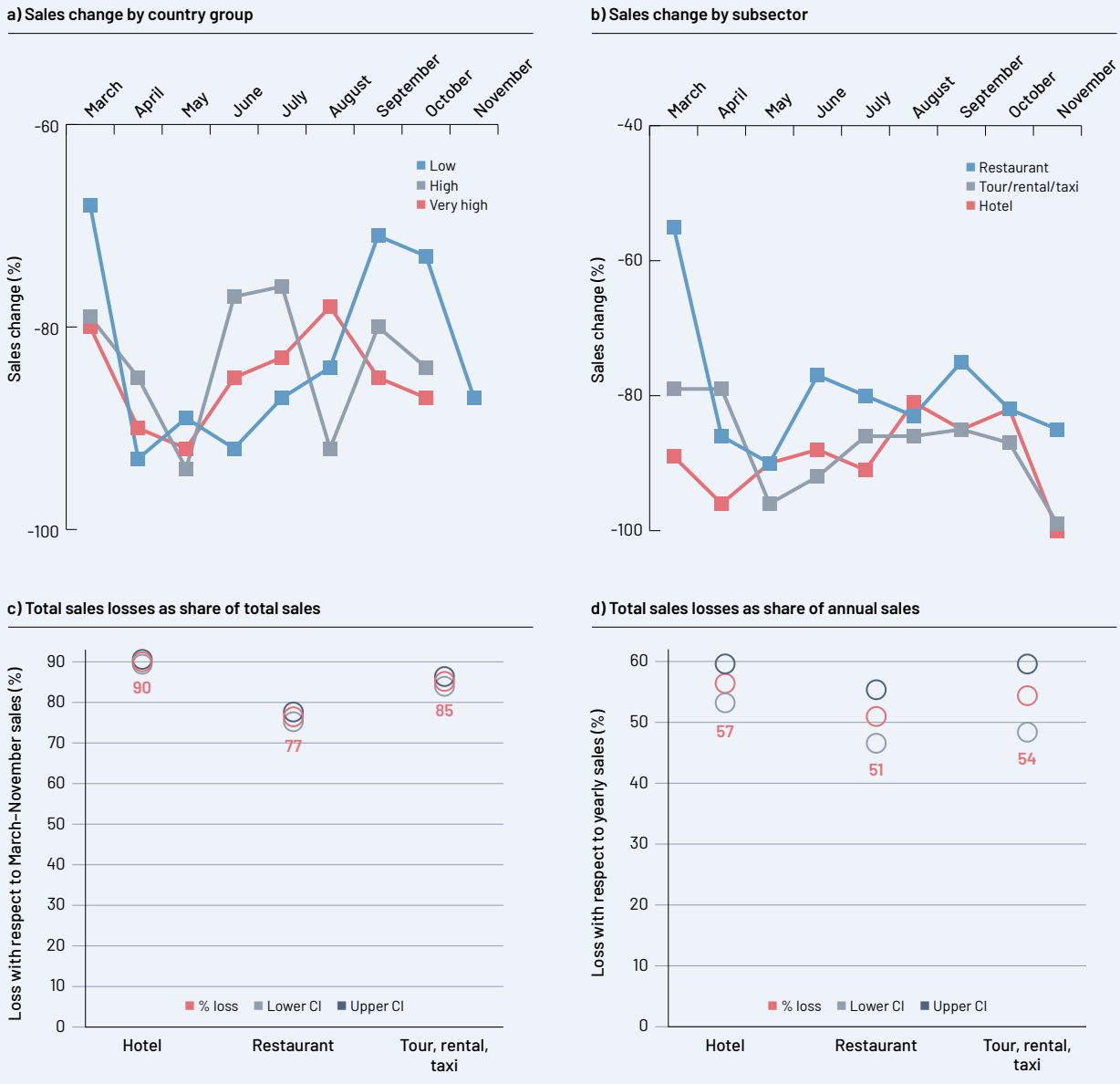
COVID-19 >>

Industry confidence is slowly rising for the May to August 2021 period as the pace of vaccination rollout and policies to safely restart tourism have increased hopes for a rebound in some markets (UNWTO 2021). While uncertainty remains high due to the ongoing pandemic and surge of new variants, 60 percent of a panel of UNWTO experts project a rebound in 2022, up from 50 percent in January 2021. The remaining 40 percent of experts expect a rebound in 2021, mostly during the second half of the year (UNWTO 2021).

However, the International Air Transport Association has warned that international passenger demand may not recover to pre-COVID-19 levels until 2024 (IATA 2020). The UNWTO also projects a return to 2019 levels in terms of international arrivals in 2024 or later (UNWTO 2021).

FIGURE 3.5 >>

Impact of COVID-19 on Caribbean tourism industry sales (March-November 2020)



Source: Erman et al. 2021
Note: CI = confidence interval

Impact of shocks on agriculture and fisheries

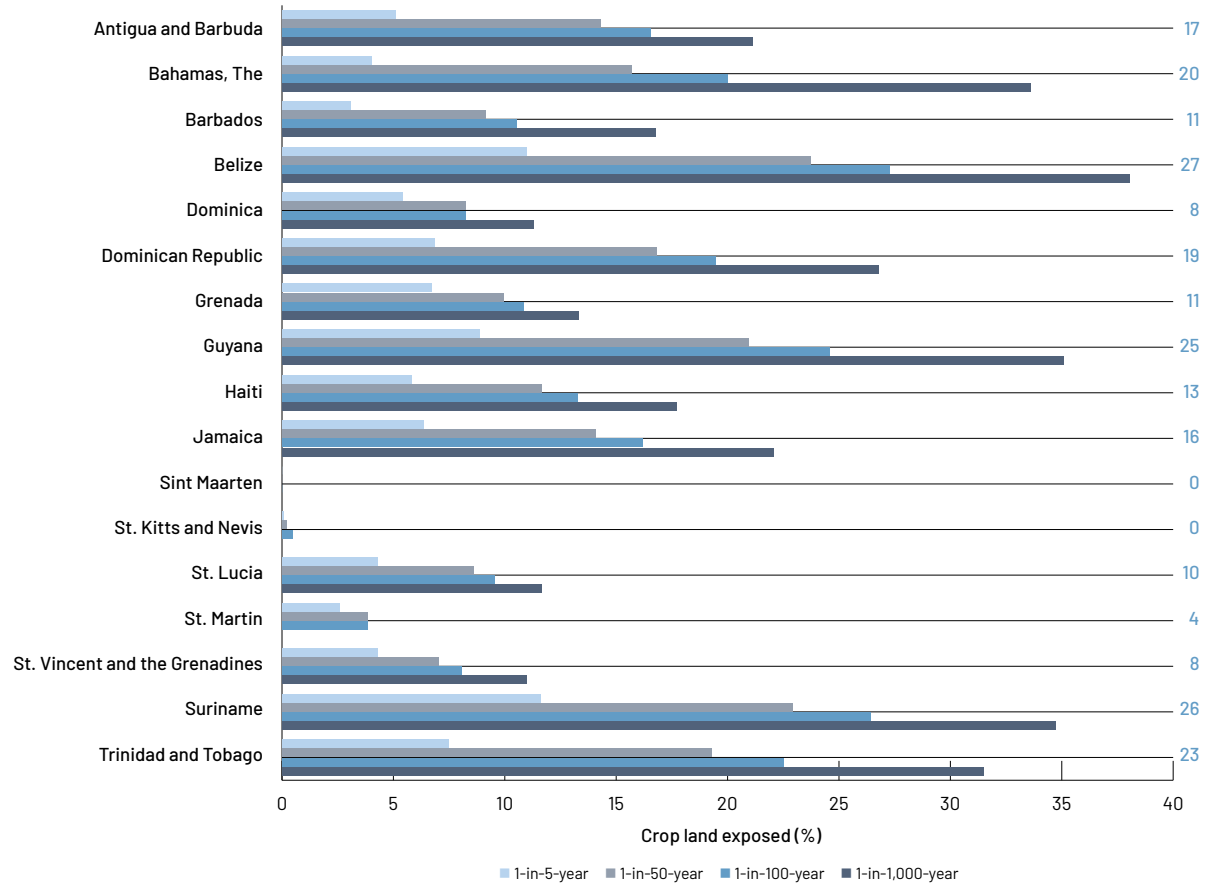
Agriculture accounts for 23 percent of employment in the Caribbean (62 percent in Haiti) and has always been an integral part of the Caribbean economy. The sector is characterized by a dual system: a large-scale, export-oriented sector based on traditional plantation crops such as sugarcane and bananas, juxtaposed by a small-scale farming sector that focuses on staple local crops. This duality characterizes the agriculture sector in most Caribbean small island developing states (SIDS) (Beckford and Campbell 2013). The majority of the poor rely on agriculture for their livelihoods (Ramasamy 2013)—for example, 9 of Jamaica's 14 parishes are over 70 percent rural and 65 percent of the population depends on agriculture as a major source of their livelihood (Campbell, Barker and McGregor 2011).

Floods and tropical storms

Agriculture is one of the sectors most affected by floods and hurricanes. Crop lands in Belize and Suriname are particularly exposed to frequent floods with moderate depths (11–12 percent of the land has a 20 percent chance of be exposed to at least 15 centimeters every year), and roughly 26–27 percent percent of crop lands in Guyana, Suriname and Belize are exposed to 1-in-100-year flood events (*figure 3.6*).

FIGURE 3.6 >>

Crop lands exposed to 15-centimeter flood depths in Caribbean countries



Sources: Based on data from Sampson et al. 2015 (pluvial and fluvial flood maps); Giardino et al. 2021 (coastal flood maps); Teluguntla et al. 2014 (crop lands)
Note: Numbers shown refer to the share of crop land exposed under a 1-in-100-year flood.

According to the International Center for Tropical Agriculture, between 2000 and 2016, Belize's agricultural losses due to hurricanes and tropical storms totaled over $232 million (CIAT 2018). In February 2018 alone, excessive rain and flooding caused sector losses of $1.9 million. In 2007, Hurricane Dean destroyed 90 percent of Dominica's banana production and 95 percent of Belize's papaya crop. The hurricane also caused $128 million–$3.7 billion in damages to Jamaica's agriculture sector, destroying approximately 75 percent of the country's vegetable crops and all banana production in some parts of the country. Between mid-August and early September 2008, Cuba was hit by Tropical Storm Fay, Hurricane Gustav, and Hurricane Ike. High winds knocked maturing fruit from trees, uprooted citrus trees, bent sugarcane at the root, and damaged homes, greenhouses, and storage facilities, while flooding damaged immature and harvested crops as well as processing and storage facilities and local transportation networks (Shannon and Motha 2015). In Dominica, a postdisaster needs assessment estimated that Hurricane Maria had caused $55.27 million in damage and $124.37 million in losses to the agriculture sector, with total damage and loss to crops estimated at $129.9 million and damage to infrastructure at $35.43 million (Government of the Commonwealth of Dominica 2017). A rapid DaLA conducted after the December 2013 floods in St. Vincent and the Grenadines estimated that the agriculture sector sustained damage of $1.37 million (Government of Saint Vincent and the Grenadines 2014).

Climate change and agriculture

Climate change will worsen extreme events and bring additional threats to agriculture production. The agriculture sector in the Caribbean is also vulnerable to a range of climate change impacts—from lower wet season rainfall to higher temperatures, sea level rise, and an increase in hurricane intensity (Knutson et al. 2020). Direct and indirect impacts related to climate change have already been observed in the Caribbean, causing significant economic losses (*table 3.2*). These impacts are expected to worsen in the future and can significantly affect the socioeconomic well-being of those working in the agriculture and fishery sectors, particularly the rural poor, who rely heavily on fishing and farming for subsistence. These impacts also have implications at national government level for domestic productivity, food sovereignty, export trade, and foreign currency earnings (Campbell, Barker and McGregor 2011; Plagányi 2019; Monnereau and Oxenford 2017).

TABLE 3.2 >>

Summary of impacts of climate change in the Caribbean

Issue or resource	Predicted change	Threatened sectors	Potential impact
Freshwater	» Alteration of hydric balance » Saline intrusion from sea level rise (rise of 0.18–0.59m by 2099)	» Water resources, agriculture, forestry, aquaculture	» Human health » Water supply » Economic loss
Marine and coastal ecosystems	» Sea level rise » Sea surface temperature rise (1–3°C) » Acidification (0.14–0.35 unit reduction of ocean pH by 2099)	» Fisheries, tourism, agriculture, aquaculture	» Coral reefs, mangroves, and fishing grounds affected » Loss of biomass and biodiversity » Economic loss
Climate	» Precipitation (-48.3 to +28.9%) » More intense hurricanes with larger peak wind speeds	» Multisectoral	» Estimated at several hundred million dollars

Source: Adapted from Pérez-Ramírez 2017

Note: Summary includes: Anguilla, Aruba, Antigua and Barbuda, The Bahamas, Barbados, Belize, British Virgin Islands, Cuba, Dominica, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Montserrat, Netherlands Antilles, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, and U.S. Virgin Islands.

In Jamaica, various studies since the 1990s have shown a trend towards higher surface temperatures, longer and deeper drought events, and more intense extreme weather events (Campbell, Barker and McGregor 2011; Government of Jamaica 2021). *Table 3.3* shows the effects of extreme weather events on Jamaica's agricultural sector from 2002 to 2008. These changes in climate will affect food production at all scales, with small farmers increasingly vulnerable to stresses and shocks. Some crops will become limited and require increased use of irrigation technology due to lower water availability, while others will exceed their critical temperature threshold, leading to a decline in growth and productivity. A the same time, local stressors—such as lack of basic public services like water supply, poverty, high fertilizer costs, and cheap food imports due to economic trade liberalization—will affect the adaptive capacity of small farmers (Campbell, Barker and McGregor 2011).

TABLE 3.3 >>

Effect of extreme events on the Jamaican agriculture sector (2002–08)

Year	Annual change in agricultural GDP (%)	Annual change in domestic food production (%)	Event	Damage to agriculture sector ($)
2002	-8.3	-11.3	» Heavy rainfall May/June and September	» Flood damage: $15 million
2004	-10.4	-15.6	» Drought first half year » Hurricanes Charley, Ivan	» Hurricane Ivan: $121.4 million » Hurricane Charley: $1.3 million
2005	-7.3	-3.4	» Drought first four months » Hurricanes Dennis, Emily » Tropical Storm Wilma	» Combined effects of storms : $14.3 million
2007	-8.7	-9.5	» Hurricane Dean	» $128.6 million
2008			» Drought first three months » Hurricane Gustav	» $22.5 million (estimate)

Sources: Based on data from Campbell, Barker and McGregor 2011; Government of Jamaica 2021

One drought-related climate impact that greatly affects agriculture is the occurrence of bushfires. In Grenada, the 2009–10 severe drought unexpectedly resulted in a 65 percent increase in bushfires in areas above an altitude of 1,500 feet. This was attributed to decreased forest coverage after Hurricane Ivan in 2004 and Hurricane Emily in 2005, which damaged forests and increased solar exposure. In the short term, these fires reduced the crop harvest. Long-term impacts include the loss of a wide variety of tree crops—including nutmeg, cocoa, and citrus—and the destruction of significant swaths of agricultural fields. The cost of rehabilitating farmlands alone was approximately equivalent to the value of three years of production. The number of small farmers who could acquire water also fell from 206 to 100, reducing the agricultural lands that could be irrigated by 53 percent (Peters 2015).

As temperatures rise, several crops will start experiencing heat stress and will no longer be grown under ideal climate conditions for maximizing yields. The International Food Policy Research Institute model results show that the largest negative impact of climate change in Latin America and the Caribbean will be on sugar cane, followed by maize and cotton (Piñeiro et al. 2020). The study finds that, compared to a scenario without climate change, maize yield losses due to climate change through 2030 in the Caribbean will be roughly 16.5 percent. *Figure 3.7* shows the percent difference between agriculture yields in 2050, with and without climate change, for select Caribbean economies and subregions. Based on the Hadley Centre Global Environment Model (HGEM) the percent difference in yields ranges from 7 percent

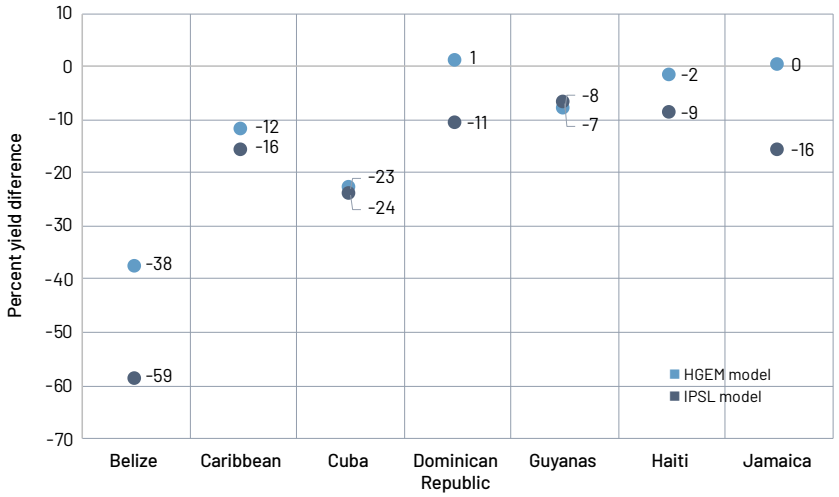
(Guyanas) to 59 percent in Belize. Under the Institut Pierre Simon Laplace (IPSL) model, agriculture yields will be 38 percent lower in Belize, while countries such as the Dominican Republic, Haiti, and Jamaica will experience little to no difference.

FIGURE 3.7 >>

Yield difference in 2050 due to climate change (RCP 4.5) in the Caribbean

Source: Rosegrant et al. 2017

Notes: A negative number indicates a lower expected yield in 2050 compared to a situation without climate change while a positive number implies a higher expected yield. *Caribbean* refers to 25 Caribbean SIDS; *Guyanas* includes Guyana, Suriname, and French Guiana.



Climate change and fish stocks

Climate change also has direct and indirect impacts on fish stocks. Within the CARICOM region, the fisheries sector employs 200,000 fishers and 100,000 people who work in fish processing and marketing and generally support the industry. Fish supplies 7 percent of protein intake in the Caribbean, and insular Caribbean fishery production represents 1 percent of Latin American production and about 0.2 percent of world fishery production. Since 1995, aquaculture in the Caribbean has seen an annual growth rate of 11 percent in volume and 8 percent in value, with annual production fluctuating between 28,000 and 39,700 tons from 1995 to 2012. The Caribbean contributes 0.04 percent of global aquaculture production (Pérez-Ramírez 2017).

The most widespread impacts affecting fisheries in the Caribbean are sea level rise, rising sea surface temperatures, ocean acidification, and increasing storm intensification (Pérez-Ramírez 2017). Sea level rise has already caused beach erosion and the relocation of housing and fishery landing sites. Recent storms and hurricanes have also caused significant damage to the sector. In Jamaica, Hurricane Gustav caused $14 million in damages to the marine fisheries sector in 2008, mainly through the loss of fishing gear. In Dominica, Tropical Storm Erika caused over $2 million in damages to the fisheries sector, 95 percent of which affected boats and engines (Monnereau and Oxenford 2017).

These climate change impacts can also directly affect—and even alter—the physiology, behavior, growth, distribution, reproductive capacity, and mortality of fish. Indirectly, they can alter the productivity, composition, and structure of the marine ecosystems that fish rely on for food. Although knowledge of how climate and environmental factors impact fish at individual, population, and ecosystem level is limited, changes that can be attributed to climate change have already been observed at all levels (Brander 2010).

Productivity in fisheries is predicted to decrease in tropical and temperate regions and to increase closer to the poles. This is because marine organisms are expected to shift geographical distributions to maintain

their appropriate thermal environments. These regional shifts will result in discrepancies in food production, fishing opportunity, and profits from fisheries. Under current climate conditions and policies, these impacts will be unequally distributed, with tropical developing countries and SIDS experiencing the greatest vulnerability (Free et al. 2020).

The Caribbean fisheries sector is already affected by overfishing, habitat alteration, poor fisheries management, and other challenges, which are only compounded by the effects of climate change. Despite their vulnerability to climate change, there is a dearth of information on climate change impacts on fisheries and aquaculture in Caribbean countries. However, many changes have already been observed at harvest and postharvest sector levels among the four major Caribbean fish groups. Categorized by general habitat type, equipment and techniques used to harvest them, and scale of fishery and postharvest operations, these are: (1) reef-associated shallow shelf species, (2) shrimp and ground fish, (3) deep slope species, and (4) oceanic pelagic species (Monnereau and Oxenford 2017).

Sea surface temperature extremes caused repeated mass bleaching events on the Mesoamerican barrier reef system in Belize, Honduras, and Guatemala in 1993, 1998, 2005, and 2010. The 2005 event occurred after sea surface temperatures and thermal stress values surpassed any figures in 150 years of records for the Caribbean Sea; 80 percent of all Caribbean coral reefs were affected by the bleaching and up to 40 percent died.[8] Coral bleaching damages critical fish habitats, decreases fish production, and impacts the protection of beaches and landing sites. The combination of rising sea surface temperatures and eutrophication caused by anthropogenic activities, such as fertilizer use in agriculture, have caused influxes of pelagic sargassum since 2011 (which also have a negative impact on tourism). These disrupt fishing operations and communities by limiting access to fishing grounds and vessels, impeding vessel movement in ports, damaging vessel motors, interfering with fish gear, affecting the ability to catch certain pelagic species, and impacting the postharvest sector (Monnereau and Oxenford 2017).

The postdisaster needs assessment conducted in Dominica after Hurricane Maria in 2017 estimated $2.41 million in damage and $0.50 million in losses to the fisheries sector, which was still recovering from significant damage and losses experienced in 2015 with the passage of Tropical Storm Erika. In total, 128 vessels were estimated to be damaged or destroyed. Other losses included fishing gear and vendor equipment, estimated at $0.32 million. Infrastructural damages to government and cooperative fisheries buildings were estimated at $0.42 million, including damage to roofs, fuel pumps, ice machine rooms, freezer storages, and other supporting infrastructure (Government of the Commonwealth of Dominica 2017).

COVID-19 >>

Impacts of the COVID-19 pandemic on the Caribbean food system

Most Caribbean countries depend on food imports to satisfy domestic supply, making them particularly vulnerable to disruptions in the food chain (FAO 2020a). Current assessments predict a reduction in both supply and demand for agricultural products, pointing to possible disruptions in trade and logistics (FAO 2020b). Since SIDS specialize in exporting perishable labor-intensive foods, they are particularly vulnerable to disruptions in logistics and customs delays (FAO 2020a). There are many views on the duration of the impact of COVID-19 on food supply, in terms of price dynamics, differential impacts between domestic and international markets, difference across countries and commodities, and likely recovery paths and policy actions for mitigation (FAO 2020b, 2020a). According to a survey by the FAO national offices in the Caribbean, reduced availability of food in supermarkets and informal markets at the start of the crisis was a common supply problem. The survey also found that the problems caused by COVID-19 were concentrated on supply rather than demand (***figure 3.8***).

Taveras and De Los Santos (2020) find that agricultural and livestock production in the Dominican Republic increased between January and March 2020 compared to the same period in 2019. Survey respondents indicated that the main limitations were: labor for harvesting, as circulation was restricted during normal working hours, transport (during the first days of January), and lack of markets. They also expected agricultural production to decline in the medium- to long-term due to lack of income from producers and highlighted the following problems:

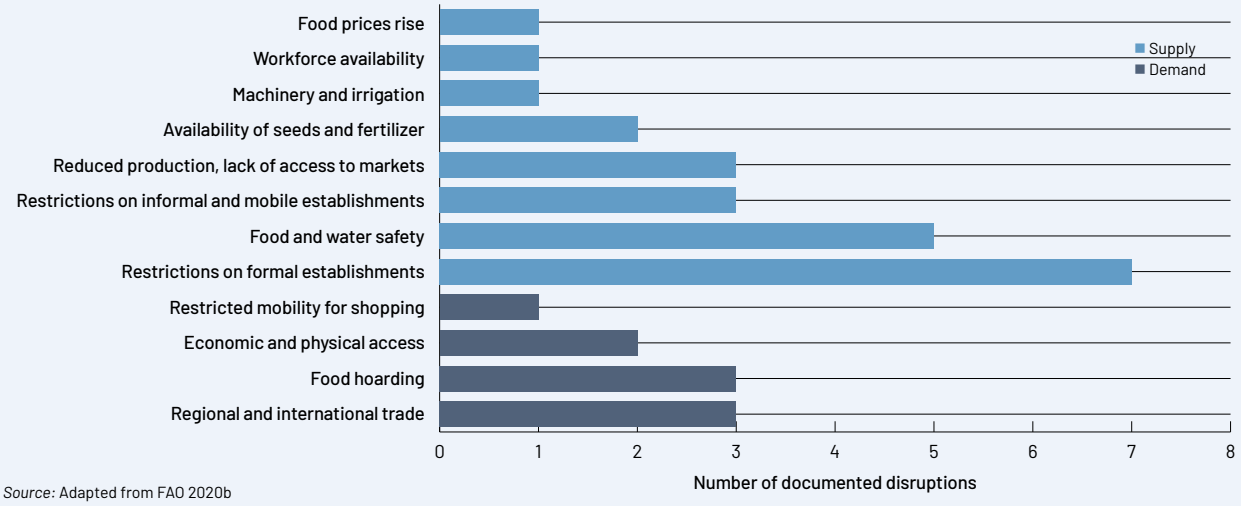
- Limited financial and compliance capacity among producers, due to reduced income in the absence of markets (hotels and restaurants) and reduced exports
- Vulnerability to the virus among older producers
- Limited rural extension and technical assistance
- Decrease in labor (mainly Haitian)
- Increased production costs

Agricultural demand and trade have both slowed down due to a deceleration in overall GDP growth and increasing unemployment rates (FAO 2020b). The start of the pandemic also saw the closure of resorts, restaurants, and other businesses, reducing food demand and resulting in an accumulation of food waste stocks (FAO 2020a).

According to the World Food Programme, 2.9 million people in the Caribbean were estimated to be food insecure in July 2020, compared to 1.2 million in April (WFP 2020). The number of severely food insecure remained stable, at a little more than 400,000.

FIGURE 3.8 >>

Impact of COVID-19 on the Caribbean food system



Source: Adapted from FAO 2020b

Impact of shocks on the financial sector

The financial sector's connection with other sectors makes it vulnerable to shocks. It also has potential to reduce or amplify shocks, depending on its resilience. In most countries, the sector is dominated by banks, which account for more than 50 percent of total assets. It is much larger than indicated by the share of financial intermediation in gross value added, with total sector assets in 2018 accounting for 169 percent of regional GDP.[9] In Barbados, Trinidad and Tobago, and the ECCU, the financial sector accounts for around 200 percent of GDP. Some countries, such as The Bahamas and Barbados, also have significant offshore banking sectors that are equivalent to 72 and 11 times their respective economies (Ogawa et al. 2013). In absolute terms, the Caribbean financial sector accounted for around $137 billion in 2018. Trinidad and Tobago and Jamaica—the largest economies in the region—have the largest financial sectors, with 37 and 21 percent of total Caribbean financial sector assets, respectively.

Capacity to withstand shocks

The largest fallout from the 2007–09 global financial crisis was the collapse of the CL Financial Group and the Stanford Group. The collapse of CL Financial and its related companies was a major shock to the Caribbean financial system, which was already grappling with the global financial crisis. In 2007, CL Financial Group's assets were equivalent to 30 percent of the region's GDP (Liu and Monroe 2010). Faced with liquidity and solvency issues brought on by the deterioration of global economic conditions in 2008, spillover effects were seen in all the CARICOM countries except Jamaica and Haiti.

Following the impact of the global financial crisis, many Caribbean central banks began implementing stress tests to assess the vulnerability and resilience of their financial systems. Although these originally looked at the resilience of individual financial institutions, the global financial crisis emphasized the need for stress testing methodologies that seek to quantify risks to the whole financial system. Bank officials have since incorporated climate stress testing measures to assess ways in which the climate crisis could affect the financial system. For example, physical risks arising from damage to property and transition risks arising from changes in policy and technology affecting the global transition to a low-carbon economy are becoming part of stress testing at the IMF (Adrian, Morsink and Schumacher 2020). For Caribbean countries such as The Bahamas and Jamaica, some IMF stress tests address the potential physical risks from natural disasters, using them as shocks that trigger adverse scenarios. The results of IMF stress tests for The Bahamas reveal that the overall banking system is resilient to a range of adverse scenarios but that some domestic banks and the two largest credit unions were vulnerable to asset quality shocks (IMF 2019).

Exposure and vulnerability to natural hazards and climate risks

There is increasing global recognition that climate change and environmental challenges can lead to risks for the financial sector. Globally, an increasing number of central banks are incorporating climate-related risks into their financial stability frameworks—by December 2020, 83 central banks and financial sector regulators had joined the Network for Greening the Financial Sector (NGFS).[10] Although no Caribbean central bank has joined the NGFS yet, the Central Bank of Trinidad and Tobago has taken its first steps towards joining.

Climate and natural disaster-related financial risks originate from two types of risk source:

» Physical sources of risk: These include natural disasters and global warming, and can lead to economic costs and financial losses. They can be gradual, such as rising temperatures and sea levels, and changes in precipitation, or abrupt, extreme weather events, such as tropical storms or other

natural disasters. This type of shock can cause protracted negative growth and large losses for banks and other financial institutions. After a natural disaster, nonperforming loans tend to increase and capital ratios fall. Deterioration in banks' health often forces them to reduce lending after a natural disaster, putting a further strain on economic activity and slowing recovery.

» Transitional risks: These are related to economic adjustment costs during the transition towards a greener, carbon-neutral economy. This can include climate mitigation efforts, whereby abrupt policies to reduce CO_2 emissions and therewith limit climate change could have a significant impact on the economy. On a broader note, policy pressure to tackle environmental pollution and improve livelihoods can involve significant adjustment costs for companies and households. Disruptive technological change—for example, in moving to cleaner sources of energy—and changing consumer and market behaviors towards greener products and services could also result in structural economic shifts. When this change is abrupt, the transition towards a greener and carbon-neutral economy can prompt rapid revaluations of underlying financial assets.

A first step for assessing the exposure of financial institutions to climate and natural disaster-related risks is looking at the sectoral composition of their loan portfolio. Given the dominance of banks in Caribbean financial sectors and limited data availability on the sectoral asset composition of non-banks, this assessment focuses on the banking sector. The largest share of bank loans in the Caribbean are personal loans—that is, loans to individuals—which account, on average, for almost 50 percent of all loans. In some countries, the share is much higher—for example, in Montserrat, they account for up to 85 percent of all loans. This highlights the importance of household financial health for banks' asset quality. If, for example, a natural disaster results in widespread job losses and reduced income, the related deterioration in households' ability to service their debt would have large impact on banks' health. The wholesale and retail trade, public administration, and service sectors make up the largest share of loans to economic sectors. The hotel and restaurant sector receives on average 6.2 percent of total loans extended by domestic banks, although in Grenada and Anguilla, this figure is almost double. It is important to note that many large hotels are part of multinational corporations and do not rely on Caribbean financial institutions.

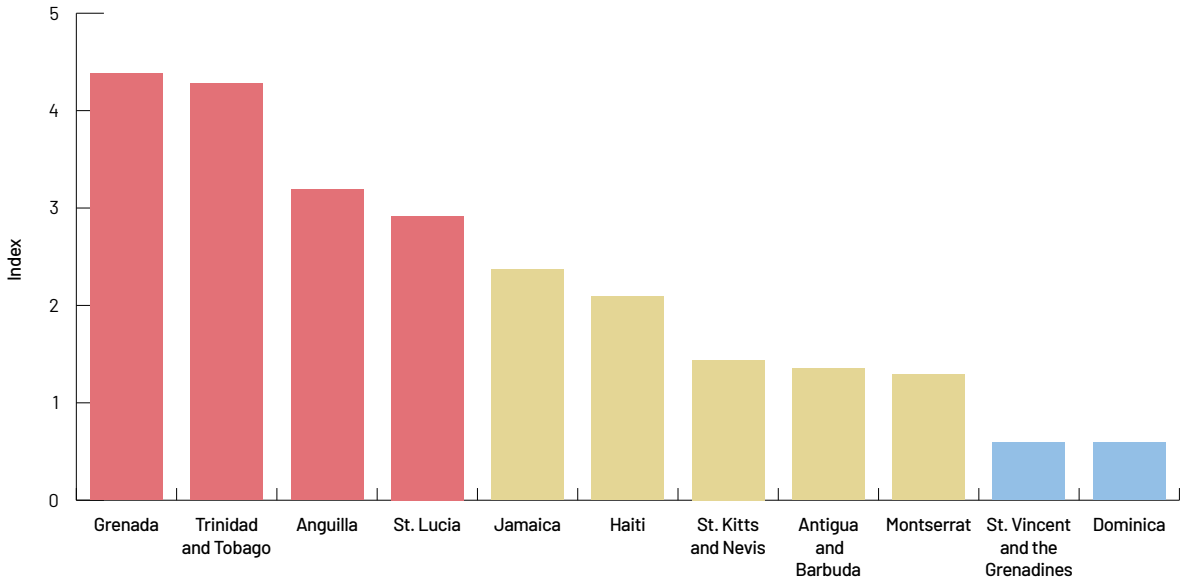
To assess the exposure of banks' loan portfolios to physical risks from natural disasters, the assessment combined sectoral loan exposure with sectoral vulnerability to natural disasters. Coupling the importance of a sector for total lending in a country with the vulnerability of this sector to tropical storms creates a financial sector vulnerability index. This measure assumes that loans to sectors that experience a more negative growth impact after a storm are more likely to turn nonperforming, negatively impacting the health of banks. The index is structured so that higher values indicate higher vulnerabilities to storms.

There are some caveats to this assessment, however, as the index only covers direct exposure to a certain sector and does not account for problems in one sector spilling over into other categories—for example, personal loans due to job losses stemming from a disaster disruption in that sector. Importantly, the index does not consider the historic occurrence or frequency of storm events or the likelihood of future storms. It only relates a country's financial sector loan portfolio with the average vulnerability of a given sector to storms in the Caribbean.

Applying this methodology results in the financial sector vulnerabilities indicated in ***figure 3.9***. Grenada and Trinidad and Tobago have the highest structural financial sector vulnerability. In Grenada, this is primarily due to the hotel and restaurant sector's large share of total loans (12.5 percent). In Trinidad and Tobago, the index is pushed up by lending exposure in the mining and quarrying sector.

FIGURE 3.9 >>

Financial sector vulnerability to storms index in Caribbean countries



Source: Masetti 2021

Notes: Relative scoring across the countries using terciles. Red bars indicate a high financial sector vulnerability index, yellow bars indicate a medium financial sector vulnerability index, and blue bars indicate a low financial sector vulnerability index compared to their peers.

Summary

Caribbean countries rely heavily on three sectors—tourism, commodities, and agriculture and fisheries—which are all vulnerable to climate shocks. Tourism and commodities are also vulnerable to external demand shocks. Although this chapter does not discuss shocks for commodity sectors at any length, it demonstrates that both the tourism and agriculture and fisheries sectors are particularly vulnerable to climate and disaster shocks. And while the financial sector could act as a risk mitigation tool through risk sharing mechanisms, in practice, it is itself quite vulnerable in most countries and might amplify—rather than alleviate—some shocks.

Endnotes

1. Using a broader definition of tourism, the ILO estimates that, on average, tourism directly accounts for 13 percent of GDP in the English and Dutch Caribbean (ILO 2020).
2. For example, the World Travel and Tourism Council (WTTC) definition of tourism includes sectors that deal directly with tourists—such as hotels, travel agents, airlines, and other passenger transport services—and the activities of restaurants and leisure industries that deal directly with tourists.
3. Guyana and Suriname can be classified both as agriculture- and commodity-dependent due to the high share of agriculture—as well as mining and quarrying—in its gross value added.
4. https://databank.worldbank.org/source/world-development-indicators.
5. Of the 280 country-specific disaster events recorded over the past two decades in the Caribbean on EM-DAT, 158 were storms (https://www.emdat.be/).
6. A Category 5 hurricane would be considered a very strong storm event, while a Category 2 hurricane would be considered an average storm event.
7. Oceanic pelagic fish typically inhabit waters below the continental shelf. Examples include swordfish, tuna, mackerel, and sharks.
8. The World Bank Marine Conservation and Climate Adaptation Project for Belize, financed by the Adaptation Fund, aims to enhance marine conservation and climate adaptation measures to strengthen the climate resilience of the Belize Barrier Reef system, including improvements of the coral reef protection.
9. The country sample includes Anguilla, The Bahamas, Barbados, Belize, the Eastern Caribbean Currency Union (ECCU), Guyana, Jamaica, Haiti, Suriname, and Trinidad and Tobago, as well as CARICOM members. The average ratio of banking sector assets to GDP among the largest 20 Latin American and Caribbean economies is 91 percent.
10. https://www.ngfs.net/en.

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4

CHAPTER 4 >>

Macroeconomic and fiscal vulnerabilities and losses

This chapter starts by characterizing the overall macroeconomic and fiscal vulnerability of the Caribbean region to a broad range of external shocks.

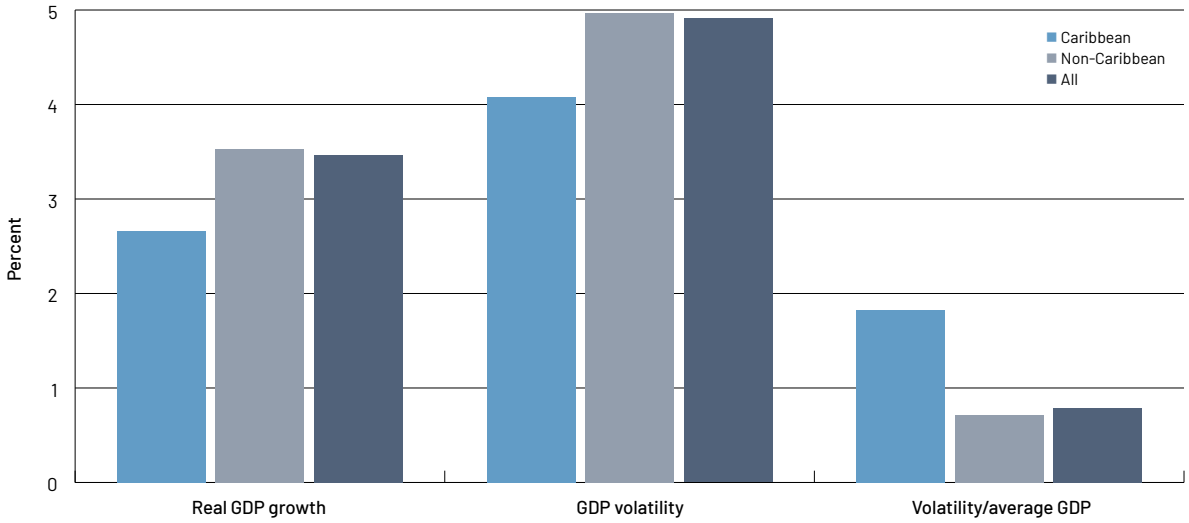
Against these vulnerabilities, it then synthesizes the econometric assessment to review the historical impacts of shocks on GDP growth, fiscal revenues, and debt. It closes with two forward-looking assessments using macroeconomic models.

Macroeconomic vulnerabilities

Since 2010, Caribbean countries have shown persistently weak economic growth. Annual GDP growth rates average only 0.8 percent, compared with 4.7 per cent in other small states (OECD et al. 2019). Most Caribbean islands also exhibit high levels of growth volatility, creating uncertainty, hindering economic growth, and negatively affecting public finances (Beuermann and Schwartz 2018) (*figure 4.1*). Although Caribbean countries do not show higher absolute volatility than other SIDS, relative volatility to average growth rate is significantly higher than other economies.

FIGURE 4.1 >>

Real GDP growth and volatility in the Caribbean and rest of world (2000–18)



Source: Based on data from World Bank, World Development Indicators (accessed February 2021)[1]

This low growth and high volatility are attributed to the high exposure and vulnerability of assets to natural hazards (*chapters 1 and 2*), reliance on sectors with low productivity growth (*chapter 3*), and low economic diversification. High reliance on trade and limited government capacity to respond to shocks and smooth the business cycle can also exacerbate volatility in Caribbean economies. Indeed, economic growth in the Caribbean has become more volatile since the 2008 global financial crisis, with one possible explanation being that the higher debt levels related to the postglobal financial crisis recovery have handcuffed the policy space to stabilize the economy after shocks.

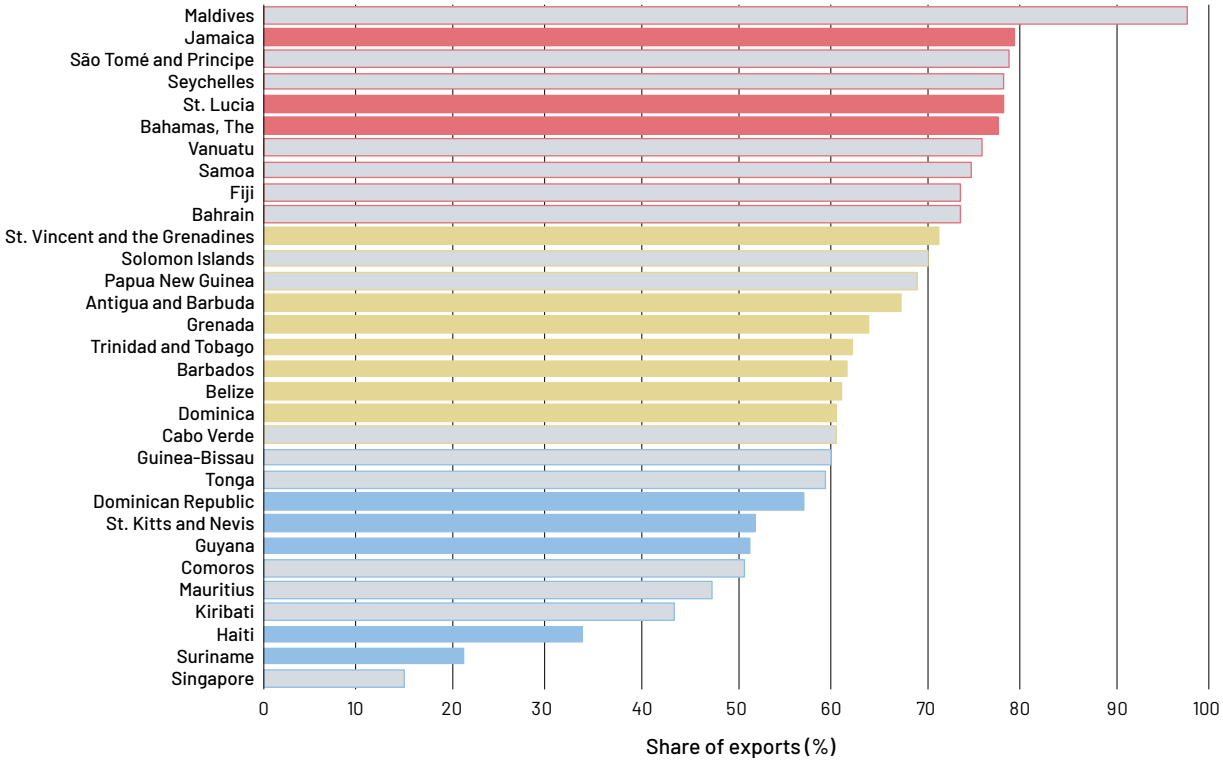
Lack of economic and export diversification and trade openness

As described in *chapter 3*, many Caribbean economies are heavily dependent on agriculture, commodities, and tourism for their exports, sectors that are often characterized by low technology spillovers and productivity growth (*figure 4.2*). Most Caribbean countries can be classified as tourism-dependent or commodity exporters. Both are highly reliant on external demand, with global fluctuations in commodity prices or tourism demand increasing output volatility and reducing macroeconomic stability. Eastern Caribbean countries like St. Lucia, Barbados, and St. Vincent and the Grenadines have the highest concentration of exports, making them vulnerable to external shocks (*figure 4.2*).

Export diversification across exporting destinations and industries is often proposed as a strategy to increase countries' resilience to external shocks by diversifying risks (Koren and Tenreyro 2007; Haddad et al. 2013; Jansen, Lennon and Piermartini 2009; Farshbaf 2012). However, it is worth noting that the direct impacts of diversification on economic growth remain mixed, given the benefits of economies of scale and comparative advantage. In Caribbean countries, diversification is limited by population and labor force, and high specialization of the economy maximizes the benefit of their comparative advantage.

FIGURE 4.2 >>

Share of agriculture, tourism, and commodities in exports in the Caribbean compared with other SIDS (2000–18)



Source: Based on data from World Bank, World Development Indicators (accessed February 2021)[1]

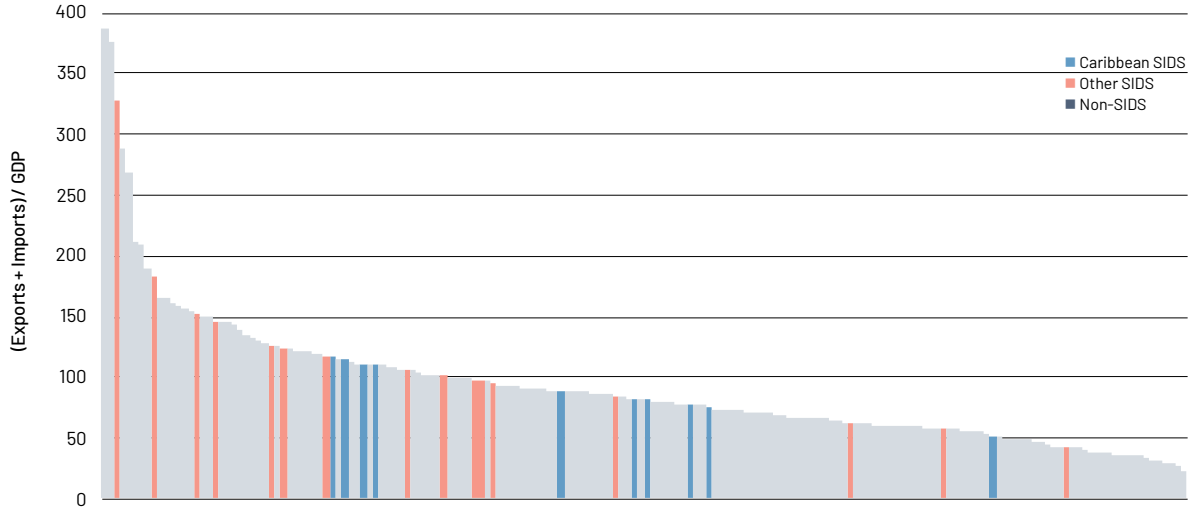
Notes: Countries in blue are in the bottom third; those in yellow are in the middle third; and those in red are in the top third of all SIDS that are most reliant on the three sectors. Caribbean countries are in colors; other SIDS are in gray.

Trade openness in Caribbean countries is also relatively high, which can affect macroeconomic volatility (*figure 4.3*). Measured by overall value of trade (exports and imports) as a percentage of GDP, trade openness represents an economy's overall connection with the international market, as opposed to export diversification, which focuses on exposure to sector-specific shocks. Caribbean countries with the highest trade openness are Belize, Dominica, Grenada, and St. Kitts and Nevis.

The impact of trade openness on economic resilience is ambiguous and depends on country-specific circumstances. While higher reliance on international trade may lead to higher vulnerability through external shocks and volatility, it can also imply economic diversification among exporting industries, importing industries, and the domestic economy. In the context of SIDS, trade openness is a potential source of volatility, given the lack of diversification. However, given their small populations, internal demand is small, so openness—which allows countries to exploit global demand—can be key to generating income.

FIGURE 4.3 >>

Trade openness in the Caribbean SIDS (2013–19)



Source: Based on data from World Bank, World Development Indicators (accessed February 2021)[1]

Early trade literature argued that trade openness was critical for economic growth, theoretically establishing a positive link between the two based on both comparative advantage and the spillover effects of knowledge and technology. However, more recent empirical studies show mixed results, with the benefits of trade conditional on trading economies' income level and capacity. The inability to exploit knowledge accumulation or trading products with low technology requirements can lead to no or even detrimental effects on economic growth. As explained above, a high exposure to international trade can also lead to a higher vulnerability to external shocks and thus higher economic volatility. However, Briguglio et al. (2009) highlight a "small state paradox" in that highly open economies can and do generate high GDP per capita despite openness usually generating volatility, which is often considered harmful to an economy.

To summarize, while the lack of diversification and trade openness are sources of volatility and reduce resilience to shocks in Caribbean countries, they are also sources of economic growth, especially in small countries. Easterly and Kraay (2000) point out that there are no obvious disadvantages in income level and growth for small states, although they experience higher economic volatility due to higher trade openness. Given those structural vulnerabilities, the role of appropriate policies—economic diversification, stronger governance, and efficient financial markets—is key to benefit from trade openness and specialization, and to prevent them from becoming a source of high volatility.

Limited government capacity to respond to shocks

The insurance and financial markets are not always well developed in the Caribbean, which limits risk sharing and resource mobilization for private actors after a shock and increases the need for governments to react by implementing countercyclical policies, including monetary policy and fiscal policy (Rojas-Suarez 2015). These policies are discussed in detail in Part 2; this section gives an overview of the main challenges.

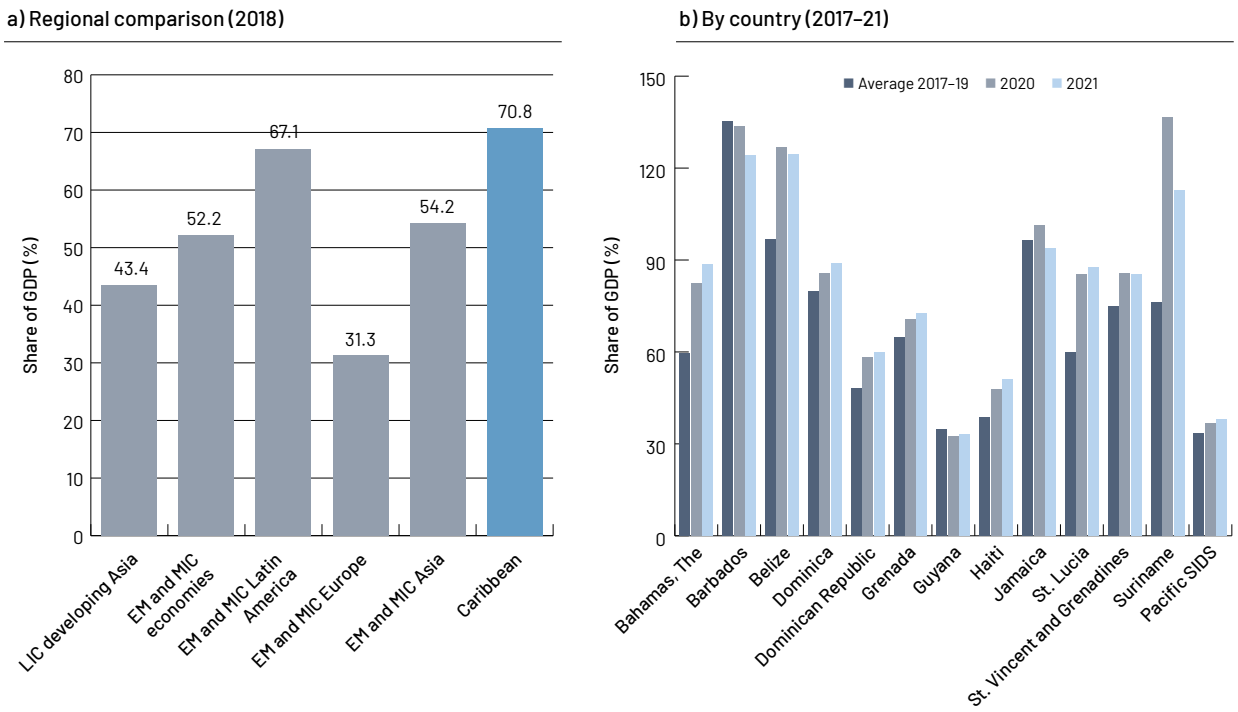
Caribbean governments often have limited capacity and space to respond to shocks, increasing countries' vulnerability to natural disasters and external shocks. Several factors in the region prevent the effective

use of macro policy tools, such as fiscal and monetary policy, as a response to external shocks or natural disasters. First, export-oriented economies require a relatively stable exchange rate environment, which leaves little room for monetary policy to react to other factors besides exchange rate changes. Fiscal policy is therefore an essential tool for governments to respond to shocks, but their ability to use it is limited by the prevailing high levels of public debt in the region (***figure 4.4***).[2] Debt has also been exacerbated by the COVID-19 pandemic.

Since the level of debt service affects fiscal space, the level of public debt in any given year is one of the most important indicators for government debt sustainability and capacity to repay external debt (Abbas et al. 2011; Jaimovich and Panizza 2010; Panizza 2008).[3] As a region, the Caribbean benefits significantly from bilateral or multilateral concessional financing during crises; and high debt levels compromise a country's creditworthiness and its ability to borrow. This in turn reduces governments' fiscal space, preventing the effective use of fiscal policy as a response to external shocks or natural disasters. Resilience calls for fiscal space that is large enough to respond effectively to a financial downturn. Reduced debt levels would give governments easier access to debt markets and allow them to respond more aggressively to a recession or financial crisis by reducing tax collections or increasing spending.

FIGURE 4.4 >>

Gross public debt in the Caribbean region



Source: Based on data from IMF's World Economic Outlook database (accessed April 2021)[4]
Notes: LIC = low-income country; EM = emerging market; MIC = middle-income country.

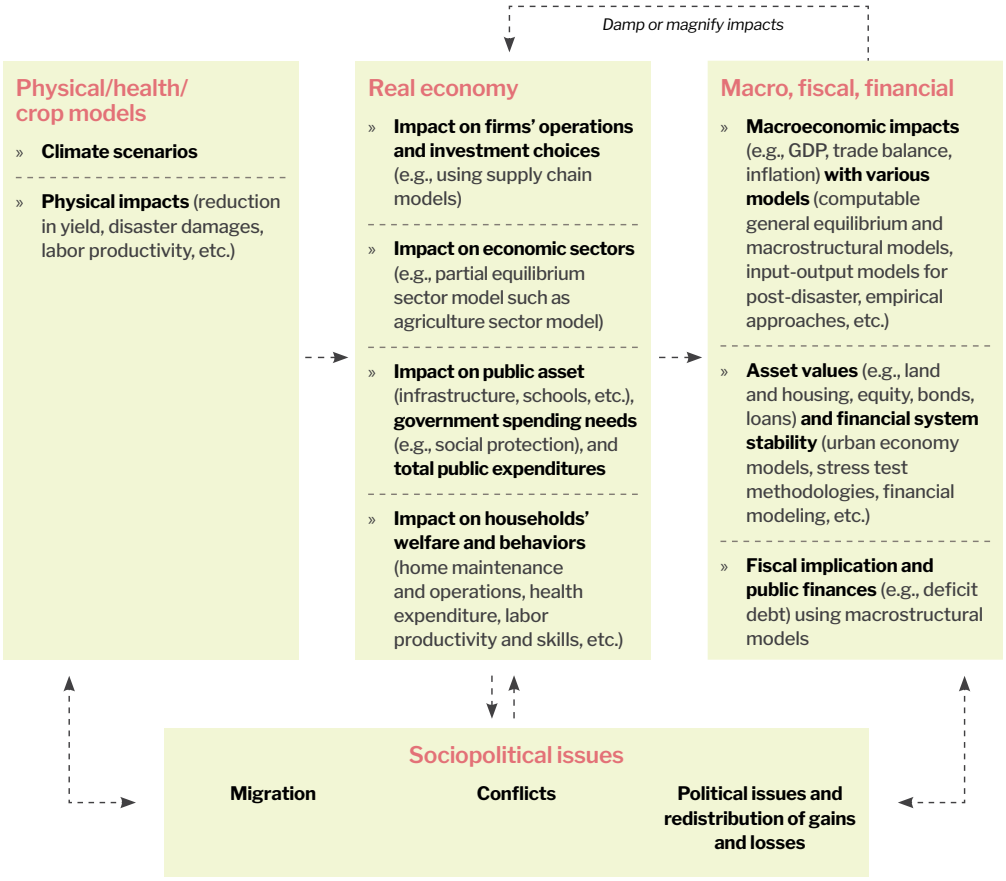
The following sections review the historical impacts of shocks on GDP, public finance, and debt in the Caribbean. To study the macroeconomic impacts of natural disasters, the economic literature has mostly relied on econometric studies that assess the short-term impacts of shocks on GDP growth or other aggregate variables like debt.

Impact of natural hazards on GDP and public finances

Natural disasters and shocks affect macroeconomic stability through many channels (*figure 4.5*), and macrofiscal and financial stability in turn support the readiness for and lessen the impact of disasters. The impact of climate change on the economy will affect activity and tax revenues, while strong impacts on major sectors (especially exporting ones) can affect a country's trade balance and capital flows. The combination of these factors may result in new risks for macroeconomic stability, public finances, and debt sustainability. Governments will need to manage these risks, considering the many channels involved (*figure 4.5*). However, the macro-level impacts of climate change are extremely uncertain, and all quantified assessments should be considered as a partial approximation and used in a way that considers both this uncertainty and the possibility of surprises (Hallegatte, Rentschler and Rozenberg 2020).

FIGURE 4.5 >>

Shocks affect macroeconomic stability through many channels



Source: Hallegatte, Rentschler and Rozenberg 2020

Econometric assessments of the impact of hazards on GDP growth

Natural hazards can have negative impacts on GDP[5] and GDP growth by destroying human and/or physical capital. Between 2000 and 2019, Caribbean countries lost an average of 3.6 percent of aggregate GDP per year to damages related to natural hazards, compared to 0.3 percent in all emerging market and developing economies (World Bank 2021). If destruction is large enough, it can push economies away from their

growth path. The uncertainty around such a negative impact is whether it will manifest over the short-term, allowing economies to recover quickly back to their equilibrium growth trajectory, or if recovery will be gradual. Conversely, a positive effect is feasible if the loss of capital results in the replacement of more productive and modern technologies that push the economy to a newer, higher growth path. This is the "building back better" concept. From a theoretical modeling perspective, predictions rest in part—and crucially—on the choice of economic growth model. Models based on neoclassical growth theory can generally only predict a negative impact since they assume rather than try to model technical change. Whether this effect is short or long term will depend on whether the disaster event permanently changes savings, depreciation, or productivity growth.

A review of empirical studies on the macroeconomic impacts of disasters in the Caribbean finds that, on average, natural disasters have a negative impact on GDP and GDP growth, but the effect is relatively short-lived—at most, a few years (Strobl 2021). The magnitude of the effect, however, depends on the data and methods, and the type of events considered (*table 4.1*). Using subnational data on economic activity can bring additional insights: Miranda et al. (2021) find that, on average, locations hit by a Category 3 hurricane (wind speed of 203 kph), experienced a 2.9 percent reduction in nightlight intensity (which can be a proxy for economic activity) for one year after the hurricane, but negative impacts were much stronger in low elevation coastal zones that are prone to storm surge, which had a 16.1 percent decrease in nightlights after a Category 3 hurricane. The study also finds that the negative association between nightlights and hurricane damage is short-lived, possibly due to the implementation of rehabilitation and reconstruction stages following a disaster shock. There are, however, exceptions to the short-lived impacts—for example, Best and Burke (2019) find that losses in Haiti still amounted to an average of 12 percent of annual GDP up to six years after the 2010 earthquake.

TABLE 4.1 >>

Impact of natural disasters on GDP and GDP growth in Caribbean and Latin American countries

Author(s)	Study/sample description	Results
Hsiang (2010)	» Sample of 28 Caribbean basin countries (including several Central American nations), 1970–2006 » Modeled hurricane destruction using a tropical storm wind field model	» No aggregate effect on total country-level production (GDP)
Strobl (2012)	» Sample of Caribbean and Central American nations, 1950–2004 » Locally (within country) constructed destruction proxy derived from a tropical wind field model	» Overall negative impact on GDP growth. However, the effect was short lived, lasting up to a year after the storm » Average hurricane reduced GDP growth rate by about 0.8 but the largest event pushed economies up to 8.5 percentage points off their equilibrium growth path
Bello (2017) **Cashin and Sosa (2013)**	» Sample including Latin American countries » Eastern Caribbean countries	» Short-lived negative effect of tropical storms on GDP growth
Moore et al. (2017)	» Sample including only Caribbean countries » Proxied total hurricane destruction by using a storm-specific power dissipation index	» Negative; slightly larger effect on GDP growth than Strobl 2012
Acevedo Mejia (2014)	» Sample including only Caribbean economies	» Negative but insignificant effect on GDP
Best and Burke (2019)	» Impact of the 2010 earthquake on macroeconomic losses in Haiti	» Up to six years after the event, losses still amounted to an average of 12 percent of annual GDP
Bello (2017)	» Floods, droughts, and extreme temperatures in a sample that includes Latin American countries	» Small short-lived negative impact on GDP growth but no implications following geological disasters

Source: Strobl 2021

There are several possible, not necessarily mutually exclusive, reasons for the negative but short-lived impact of natural disasters on GDP (Strobl 2021). The easiest answer is that Caribbean economies manage to readjust rather quickly even after a large negative shock. Although natural disasters are rare, their occurrence is not new to the region, so countries may already have buffering or adjustment mechanisms—such as remittances—in place. According to Yang (2008), after hurricanes, the monetary value of remittances to developing countries constituted nearly three-quarters of total damages, while Ebeke and Combes (2013) show that remittances have a nonlinear buffering effect, further destabilizing countries affected by natural disasters when they go above a certain level (17 percent of GDP). While Caribbean-specific evidence is scarce, a few studies show that remittances play a non-negligible role. For example, Clarke and Wallsten (2003) find that remittances to Jamaica after Hurricane Gilbert in 1988 covered 25 percent of losses, while Henry, Spencer and Strobl (2019) show that remittances can reduce the fall in consumption expenditure in Jamaica after a hurricane by approximately 75 percent. Preemptive saving is another potential buffering mechanism. Strobl (2021) finds that households in the Caribbean may be preemptively saving to deal with natural disasters when they occur, although this is likely limited for the poorest households. Henry, Spencer and Strobl (2019) find evidence that Jamaican households with savings have used these to buffer hurricane-associated losses. It is worth bearing in mind, however, that, while this mechanism can reduce the GDP impacts of disasters, it also reduces well-being.

Given the scarcity of evidence, it is difficult to conclude that these informal buffering mechanisms are the primary reason for the lack of evidence of long-lasting, macro-level effects of natural disasters in the Caribbean (Strobl 2021). Indeed, most of the reasons why empirical studies cannot detect significant or long-lasting impacts of disasters on GDP might be methodological.

Limitations of econometric approaches

One important note of caution on using empirical studies based on historical GDP timeseries is that they are likely to underestimate the impact of disasters on economic output.

First, damages from natural disasters are poorly modeled, and so econometric analyses often underestimate their effect. There may also be a problem with the way economic impact is generally measured in empirical literature. It tends to look at impact on GDP growth, implicitly isolating the marginal effect of natural disasters. Examining the impact of natural disasters on marginal productivity may substantially underestimate the true output losses, and it is preferable to focus on consequences for average productivity (Hallegatte and Vogt-Schilb 2019). However, doing so would mean looking at the impact of GDP levels rather than growth rates, and it is well known that GDP is generally not stationary. Thus, the standard approach of transforming data into first differences only allows for isolating marginal effects. A final, more conceptual reason, still related to modeling challenges, is that economies are not generally stagnant over long periods and thus may not return to their pre-event trajectories. However, to identify long-term impacts of natural disasters, it is necessary to predict what the effect would have been had the event not occurred. Although some studies—like Best and Burke (2019)—use similar non-affected islands as control groups, the explicit modeling of long-term growth dynamics can be challenging (Strobl 2021).

There are also important issues related to the way statistical agencies measure GDP, which is problematic when measuring the impact of shocks. The data that are used to measure GDP mostly rely on economic transactions—for example, the sales of goods and services. To calculate real GDP, however, statistical agencies have to include economic outputs that cannot be measured through transactions, such as public service provision, the value of public education and public road use, and housing services provided by owner-occupied dwellings. For example, most developing countries use household surveys to estimate the economic value of the services provided by owner-occupied dwellings, even if there is no transaction associated to them. But these surveys are infrequent, so when a hurricane damages a large share of the

housing stock, the value of housing services drops, but updated household surveys are rarely available to measure this impact.

Eastern Caribbean Central Bank data suggests that services from owner-occupied dwellings in Dominica dropped by 21 percent in 2017. It is unclear whether this is a good measure for the impacts of Hurricane Maria: of the 31,348 homes comprising the Dominican housing stock, approximately 4,700 (15 percent) were identified as destroyed, some 23,500 (75 percent) were estimated to have incurred partial damage, and 3,135 (10 percent) were considered unaffected. Similarly, road transport outputs were estimated to have remained stable (rising from EC$78 to EC$79 million), in spite of EC$380 million in damage to roads and bridges (Government of the Commonwealth of Dominica 2017).

Impact of natural disasters on public finances and debt

Postdisaster management, including reconstruction, can put considerable financial burden on affected economies and requires large amounts of government expenditure. The recurrent use of government expenditure to absorb the impact of natural disasters is likely to lead to higher debt levels and interest rates, accompanied by lower credit scores. This then results in higher budget deficits, causing debt to increase and creating a vicious cycle that threatens debt sustainability (Koetsier 2017; Borensztein, Cavallo and Valenzuela 2009). High debt also keeps borrowing costs high, discouraging private investment and constraining fiscal flexibility (Strobl 2021).

There is no clear consensus in the literature on the impact of different types of natural disaster on debt levels in the Caribbean region (*table 4.2*). Rasmussen's (2004) study of the Eastern Caribbean finds that the median public debt increases by 6.5 percentage points following a disaster, mainly because of an increase in spending and a small reduction in revenue. In contrast, Acevedo Mejia's (2016) study of the effect of storms and floods on public debt for the region finds that debt only increases with floods, while Ouattara and Strobl (2013) demonstrate that hurricane strikes cause no significant increase in government deficit. A more recent study (Cevik and Jalles 2021) finds that climate change vulnerability impacts bond spreads, adding to the cost of borrowing. A 10 percentage-point increase in climate change vulnerability is associated with an increase of over 150 basis points in long-term government bond spreads of emerging markets and developing economies, while a 10 percentage-point improvement in climate change resilience is associated with a 37.5 basis-point decrease in bond spreads.

TABLE 4.2 >>

Impact of natural disasters on debt in the Caribbean

Author(s)	Study/sample description	Results
Rasmussen (2004)	» Eastern Caribbean countries	» Median public debt increase, lasting up to three years
Lugay and Ronald (2014)	» Eastern Caribbean countries	» Rise in public debt after natural disasters
Ouattara et al. (2018)		» Fiscal deficit occurs only in the month of the event
Mohan and Strobl (2020)	» Eastern Caribbean countries	» Debt increases only up to six months after an island suffers damage from a hurricane
Heger, Julca and Paddison (2008)	» Caribbean economies	» Debt decreases after natural disasters, possibly due to inflow of foreign aid

Source: Strobl 2021

There are two other noteworthy aspects that arise from the literature looking at the impact on debt for the Caribbean. First, the effect seems relatively short-lived, although not all studies explicitly investigate medium or long-term effects. Second, there is mixed evidence about what is driving the increase in debt.

More specifically, according to Ouattara and Strobl (2013), the rise is due to more fiscal spending, though Ouattara et al. (2018) use monthly data and find that debt increase is driven by a fall in revenue; Rasmussen (2004) shows that both play a role.

Part of the short-lived effect of debt may be because foreign aid allows countries to avoid borrowing as much as they otherwise would to finance postdisaster management. While no study explicitly investigates this, Heger, Julca and Paddison (2008) suggest that the inflow of foreign aid and grants is a likely explanation for their finding that debt decreases after natural disasters in the Caribbean (Strobl 2021).

Impact of other shocks on GDP and debt

Caribbean countries were strongly affected by the 2008–09 global financial crisis. The collapse of the Trinidad and Tobago-based CL Financial Group reflected a weak insurance regulatory environment and the rapid deterioration in the global economy left Caribbean countries with a deficit of roughly 3.5 percent of GDP on average, and as high as 12 percent in Trinidad and Tobago and 10 percent of GDP in ECCU countries (IMF 2013). Antigua and Barbuda suffered one of the sharpest contractions in growth globally after the crisis, with GDP contracting to -12.1 percent in 2009, and only rebounding to positive levels in 2012. Grenada recorded -6.61 percent GDP growth in 2009, while Barbados recorded -5.1 percent. Trinidad and Tobago's economy shrank by 4.4 percent in 2009, recovered in 2010, and then contracted again in 2010 and 2013. Net foreign direct investment to the region, traditionally the largest source of external financing, declined from an average of $5.1 billion over 2007–08 to $2.9 billion in 2009, with particularly large contractions in Trinidad and Tobago, Barbados, and Jamaica.

The 2008–09 global financial crisis had long-term effects on public debt in the region. The already high debt burdens in the Caribbean were worsened by the 2008–09 global financial crisis as the public debt-to-GDP ratio increased by approximately 15 percentage points between 2008 and 2010 (IMF 2013). The crisis and subsequent slow recovery in advanced economies had a significant adverse effect on the Caribbean countries that are more dependent on tourism, undermining growth and exposing balance sheet vulnerabilities accumulated over many years. These originated from a strategy of increasing public spending to counteract declining trade performance (partly due to the erosion of trade preferences), and the rebuilding costs after frequent natural disasters. Commodity exporters, on the other hand, rebounded rapidly after the crisis, buoyed by high commodity prices, and their debt ratios stabilized at relatively low levels (IMF 2013).

The 2008–09 crisis caused some countries to increase public expenditure to slow job losses and safeguard vulnerable demographic groups, while in other economies, it had medium- to long-term negative effects on public debt (ECLAC 2018). For instance, Barbados expanded its fiscal deficit and increased its public debt by more than 20 percent of GDP between 2008 and 2011. In 2013, Grenada announced its difficulty in meeting its debt service commitments due March 15, because of the adverse effect of the crisis on its economy. As a result, it defaulted on its debt and Grenada's sovereign credit rating was immediately downgraded from CCC+ to C (ECLAC 2018).

COVID-19 >>

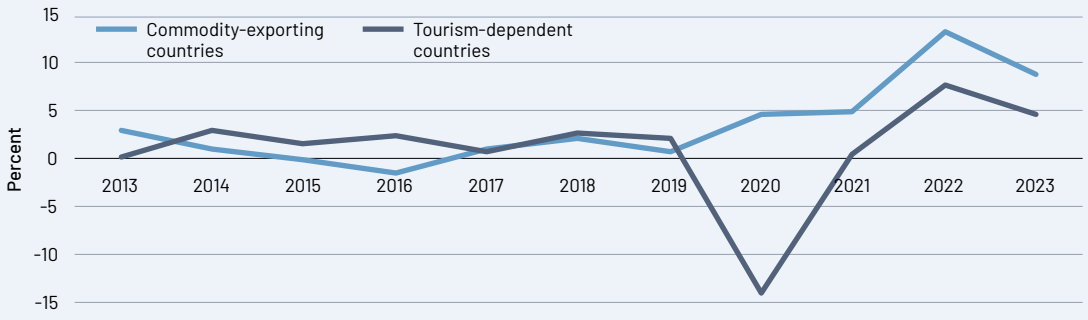
Impacts of the COVID-19 pandemic on GDP growth and debt in the Caribbean

Social and economic outcomes in Caribbean countries were severely affected by the COVID-19 crisis. The impact on GDP has been particularly detrimental for countries that are highly reliant on tourism, as international travel saw an unprecedented collapse during the pandemic. The latest estimates show that real GDP in tourism-dependent Caribbean countries contracted by more than 10 percent in 2020 (***figure 4.6***). And although commodity-exporting countries fared better in terms of GDP growth, their overall GDP may be masking significant differences in the performance of commodity and noncommodity sectors that have important social implications. A recovery is projected for 2021, as both tourism-dependent and commodity-exporting countries expect positive growth rates, but uncertainty remains in terms of the speed of recovery, which depends on multiple factors, such as the vaccine rollout, both in key tourism source countries and the Caribbean. Of the developing world regions, Latin America and the Caribbean was hardest hit by the COVID-19 pandemic. Already on a low growth trajectory in the decade before the pandemic, the unprecedented combination of negative supply and demand shocks in 2020 translated into the worst economic crisis in the last 120 years (ECLAC 2020).

The pandemic has also had an adverse impact on Caribbean countries' debt-to-GDP ratio (***figure 4.7***). All countries with available data, except Guyana, saw an increase in their debt-to-GDP ratio between 2019 and 2020. The increase in debt-to-GDP ratio is also affected by decreasing revenues and increased expenditure associated with the pandemic, as well as the contraction in GDP observed in most countries in 2020. For Guyana, 2020 was an unusual year, due to the start of oil production and exports as well as COVID-19.

FIGURE 4.6 >>

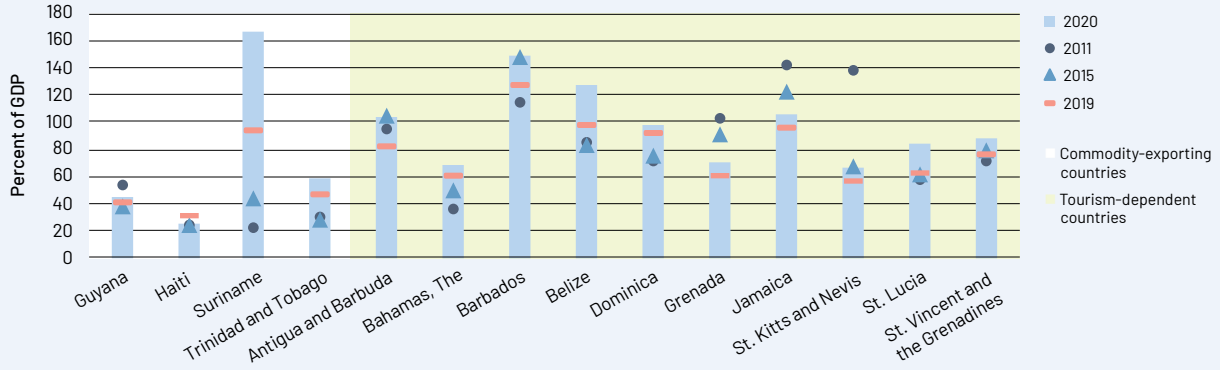
Real GDP growth in the Caribbean: COVID-19 impact and recovery



Source: Based on data from IMF's World Economic Outlook database (accessed April 2021)[4]

FIGURE 4.7 >>

General government gross debt in the Caribbean



Source: Based on data from IMF's World Economic Outlook database (accessed April 2021)[4]

Forward-looking assessments using macroeconomic models

A wide range of empirical studies have studied the direct economic impacts of natural disasters and concur on the negative short-term economic impacts of disasters. However, the longer-term macroeconomic implications for economic growth and indirect impacts are still debated. Building on sector-level assessments and analyses of physical risks, forward-looking modeling exercises can estimate climate and disaster risk on macroeconomic variables, such as GDP, debt level, or trade balance, allowing governments to consider and plan for these longer-term effects. By their very nature, macroeconomic models simplify the representation of sectoral impacts, and as such, government should only use them to inform macroeconomic decisions, such as long-term debt sustainability. Considering the many channels through which climate shocks can affect macroeconomic variables, results will always be highly uncertain. Many of the factors that can affect these variables are difficult to model, and there is often little consensus on how best to do it. Results should therefore be treated with caution and never be used as forecasts (Hallegatte, Rentschler and Rozenberg 2020). The next section presents forward-looking shock impact assessments using different macroeconomic models.

Impacts of the compound risks of pandemic and hurricanes using the EIRIN Stock-Flow Consistent (SFC) and Agent-Based Models

This analysis uses the EIRIN macrofinancial model (Monasterolo and Raberto 2018, 2019) to assess the macroeconomic and financial risk of compounding impacts such as the COVID-19 pandemic and hurricanes in the Caribbean (Dunz et al. 2021). EIRIN assesses the impacts of climate shocks on agents and sectors of the economy and finance, and considers feedbacks from financial risk assessments on economic decisions and policy effectiveness. It can provide a complementary perspective on short- and long-term disaster impacts, considering endogenous investment and consumption decisions of agents in the economy and finance.

The model can capture the richness of transmitting climate risk to the economy and finance in a rigorous accounting framework, where balance sheet accounting identities replace the model's equilibrium conditions (and related assumptions of the linearity of shocks' transmission). In particular, it considers the direct and indirect risk transmission channels to the economy and finance, and the drivers of amplification of the original shock that generate cascading impacts. This analysis is particularly relevant for the Caribbean, which is affected by growing climate change, and where disaster risks do not occur in isolation but could compound socioeconomic vulnerabilities, such as the COVID-19 pandemic and financial risk (Battiston, Billio and Monasterolo 2020).

Applying the EIRIN model to Jamaica, this analysis considers the macroeconomic and public finance impacts of hurricane risk, both individually and compounded with the COVID-19 pandemic risk. The analysis considers three scenarios, where COVID-19 and a hurricane occur as individual shocks or as subsequent events, and a business-as-usual scenario, where none of the shocks occur (*table 4.3*). For COVID-19 alone, the model simulation shows GDP growth of -11 percent in Jamaica in 2020 (pink line in *figure 4.8*), in line with IMF (2021) estimates of about -10.2 percent and the Economist Intelligence Unit's estimate of -10.3 percent.[6] In case of hurricane occurrence with no COVID-19 shock (light blue line in *figure 4.8*), simulations show that real GDP is affected in the short term by the loss in firms' production capacity due to capital stock destruction. However, when compounding COVID-19 with a hurricane (light gray line in *figure 4.8*), it nonlinearly amplifies the magnitude of the economic shock.

TABLE 4.3 >>

Compound risk of COVID-19 and natural disaster in Jamaica

Scenario	COVID-19 lockdown and policy response measures	Natural hazard occurrence	Graphical representation
1. Strong hazard (hurricane)	No	Timing: Q3 2020 Impact size: 5.35%	
2. COVID-19 emergency	**Impact from rest of the world:** » Aluminium revenues: 20% price decrease » Remittances: 20% decrease » Tourism: 67% decrease **Impact from domestic economy:** » Lockdown: 34% consumption decrease **Government response measures:** ***Fiscal:*** » Targeted measures: 0.5% of GDP » Tax cuts: 0.6% of GDP ***Monetary:*** » J$57 billion liquidity injection: 3% of GDP	No	
3. Compound COVID-19 and strong hazard		Timing: Q3 2020 Impact size: 5.35%	

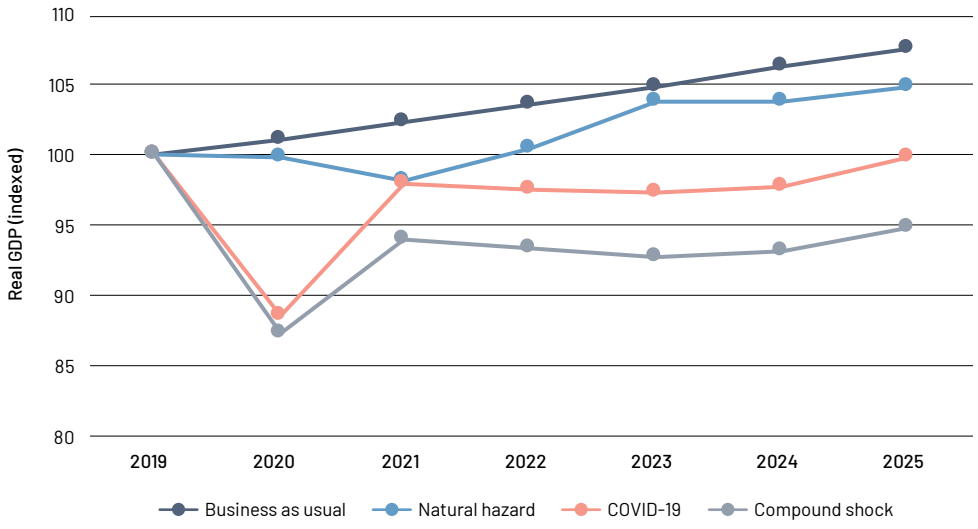
Sources: Dunz et al. 2021, using data from World Bank 2020; Dukharan 2020; World Bank commodity price data[7]; UNWTO Tourism Data Dashboard[8]; IMF policy tracker: policy responses to COVID-19[9]; Ishizawa, Miranda and Strobl 2019; Statistical Institute of Jamaica, Consumer Price Index[10]

FIGURE 4.9 >>

Real GDP in Jamaica (2019–25)

Source: Dunz et al. 2021

Notes: The x axis shows the timeline of the simulation until the 2025 on an annual basis. The y axis shows real GDP for Jamaica indexed against 2019 GDP (2019 GDP = 100).



The analysis reveals two important insights. First, the country's economic structure and financial characteristics before the shocks impact both shock duration and ability to recover quickly. Second, compounding shocks lead to nonlinear amplification effects that prolong the shock duration, due to endogenous expectations and interactions of firms, banks, households, and the government.

For practitioners, the analysis suggests that neglecting the potential for compound risk impacts could lead to an underestimation of risk, both in magnitude and persistence, and therefore, an undervaluing of the benefits of investing in resilience. As disasters often compound with other socioeconomic vulnerabilities (Battiston, Billio and Monasterolo 2020), compound risk impacts would need to be included in financial risk assessment. Understanding the drivers of amplification and corresponding transmission channels is crucial for designing policies for a fast, environmentally and financially sustainable recovery from COVID-19, and for building resilience to future compounding events.

Impacts of hurricanes in Jamaica using the World Bank's macroeconomic and fiscal model (MFMOD)

This section presents a structural model of the Jamaican economy with an explicit modeling of hurricane damages developed in Burns, Jooste and Schwerhoff (2021). The authors model damages from hurricanes as physical capital destruction and compare the GDP outcomes under four risk management strategies: investment in hurricane-resilient infrastructure; commercial disaster insurance for the government; forming a contingency fund; and lower debt via higher future primary balances to create fiscal space for disaster recovery. These strategies are run as four different scenarios, compared to the business-as-usual scenario, which has no additional risk management.

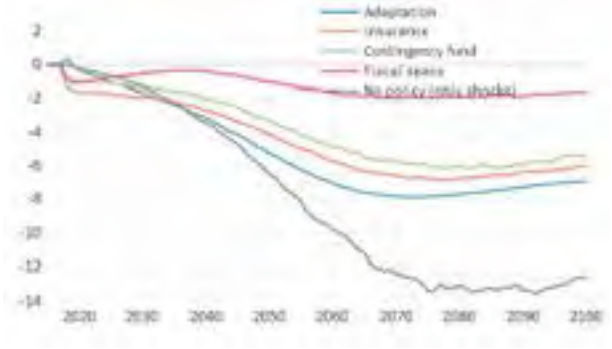
Figure 4.10 shows the median value of macroeconomic variables when the economy is subject to random hurricane shocks every year. Without fiscal resilience instruments, hurricanes inflict serious damages in the short term. But more importantly, losses accumulate in the long term, leading to unsustainable debt levels and pushing down potential output. Evidently, all four risk management strategies achieve a level of income and consumption that is permanently higher than the no risk management scenario. These results point to the importance of considering the long-term benefits of fiscal resilience against the actual costs of natural disasters rather than comparing the cost of fiscal resilience against a baseline with no shocks.

According to MFMOD, the fiscal space creation scheme (***figure 4.10***) generates the best results. This is because lower debt levels reduce the interest rate paid on debt, thus reducing the debt level in the periods between hurricanes and further reducing the interest rate. Over time, these lower interest payments mean the opportunity cost of the program (lower government spending and investment) is also reduced. Governments, however, need to implement layered risk management approaches for resilience, with different instruments against frequent shocks and large infrequent ones. These approaches and instruments are discussed in ***Part 2***.

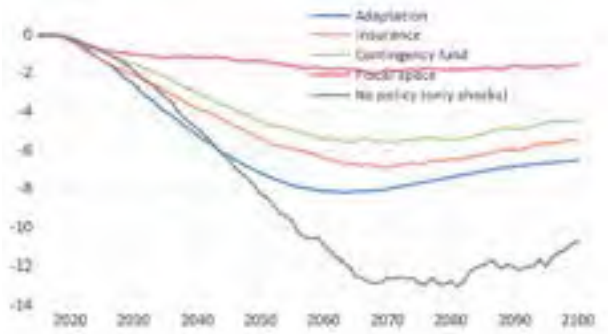
FIGURE 4.10 >>

Comparing different risk management options: probabilistic shocks

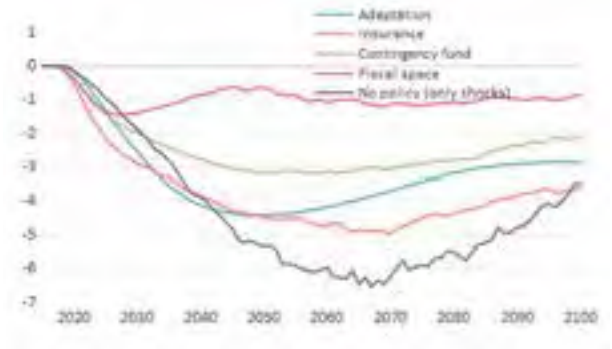
a) GDP change (%)



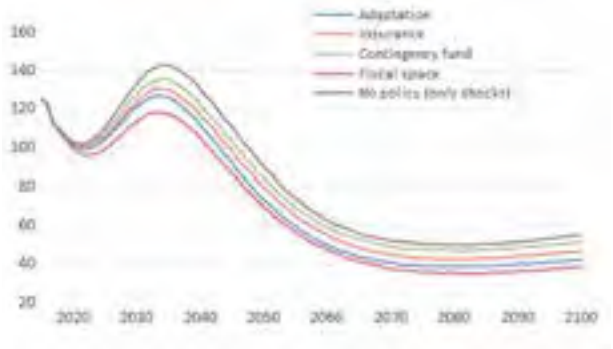
b) Potential GDP change (%)



c) Consumption change (%)



d) Debt/GDP ratio



Source: Burns, Jooste and Schwerhoff 2021

Note: The charts compare the median values of impacts of adaptation, insurance, a contingency fund, and fiscal consolidation—financed by a reduction in government investment—to the case with no form of hurricane risk management.

Summary

Caribbean countries are vulnerable to shocks at the macroeconomic level. This is because they depend on a few vulnerable sectors and rely heavily on trade. Some countries lack independent monetary policy to smooth shocks, and some have accumulated high debts, limiting their fiscal space and reducing their capacity to implement counter-cyclical fiscal policies. The consequence is a high volatility of economic growth that might, in the long term, deter investments and reduce growth. Empirical assessments of the impact of disasters on GDP growth show that impacts are often short lived, possibly thanks to buffering mechanisms that are already in place, such as remittances and savings, possibly because of methodological issues that prevent accurate assessments.

Endnotes

1. https://databank.worldbank.org/source/world-development-indicators.
2. The use of macroeconomic policy tools to build resilience is discussed in more detail in Chapter 11.
3. IMF (2018) defines fiscal space as the room for undertaking discretionary fiscal policy relative to existing plans without endangering market access and debt sustainability.
4. https://www.imf.org/en/Publications/WEO/weo-database/2021/April.
5. GDP is the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period. As a flow rather than a stock measure, it will not capture destruction of physical, natural, or human capital. Rather, it is only through the indirect effects of such destruction—such as reductions in output due to business interruptions and/or gains in output due to restructuring, relief, or investment to replace destroyed capital—that GDP can be affected by natural disasters.
6. Country Economic Database—Jamaica. https://country.eiu.com/jamaica.
7. https://www.worldbank.org/en/research/commodity-markets.
8. https://www.unwto.org/unwto-tourism-dashboard (accessed March 2021).
9. Based on IMF tracked policy responses to COVID-19. https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19#J.
10. https://statinja.gov.jm/Trade-Econ%20Statistics/CPI/NewCPI.aspx.
11. https://preview.grid.unep.ch/ (accessed April 2020).

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5

CHAPTER 5 >>

Human capital and well-being

The previous chapters described the effect of external shocks on physical assets, economic sectors, and the macroeconomy. This chapter looks at the impact of natural disasters at household level.

It begins by describing the impact of natural disasters on poverty and well-being, including recent results from microsimulations that highlight the long-lasting impacts of shocks on the poorest, and then details how shocks affect education, health, and migration. It is primarily based on background papers by written by Beazley and Williams (2021), Bellony and Powers (2021), and Harnam and Khan (2021).

Impact of shocks on poverty and well-being

Recent global research has demonstrated the disproportionate vulnerability, and sometimes exposure, of poor people to natural disasters (Hallegatte et al. 2017). Land and housing markets often push poor households to settle in riskier areas, especially urban areas, where land is scarce. Even where they are not disproportionately exposed, poor households depend on fewer and more vulnerable assets. So, when disasters occur, they struggle to recover. Small losses can have lasting impacts, including leading to chronic poverty.

Recent disasters

According to the most recent available data, one in five people in the Caribbean lives in poverty (*chapter 7*). Global evidence suggests that some of these people live in poverty because of past shocks, including natural disasters (Hallegatte et al. 2017). The scarcity of household-level data in Caribbean countries, however, limits the number of case studies that can quantify the impact of past shocks on people's income and livelihoods.

Evidence from postdisaster needs assessments in the Caribbean shows that natural disasters have had severe impacts on poverty, while the lack of coping mechanisms available to the region's poor suggest these impacts continue to accumulate long after storms pass and flood waters recede.

In Dominica, a postdisaster needs assessment after Hurricane Maria estimated a 14 percentage point increase in poverty—some 2,800 individuals—if consumption impacts were left unaddressed. Similarly, the number of impoverished individuals was expected to double from 2,253 to 4,731 (World Bank 2020a; Government of the Commonwealth of Dominica 2017a). The 2010 earthquake in Haiti is estimated to have wiped out 10 years of progress in poverty reduction (Government of the Republic of Haiti 2010). During this shock, poorer households were more dependent than wealthier households on temporary employment and other forms of public assistance (Williams, Lamanna and Jones 2016).

In Jamaica, fewer than 5 percent of those in the poorest quintile have home insurance, compared to 60 percent in the richest quintile. In St. Lucia, only 30 percent of people in the poorest quintile have bank accounts, compared to 80 percent among the wealthy. Uninsured losses and informal savings mechanisms can lead to difficult tradeoffs among food, health care, and education expenditure, and selling or pawning of livelihoods and homes (World Bank 2020c). Severely affected households may never recover, meaning natural hazards create long-lasting consequences for human and economic development, reinforcing and perpetuating inter-generational cycles of poverty.

Microsimulation modeling tools

The exposure analyses described in *chapter 1* can be disaggregated by household income when poverty maps are available. A recent analysis by the World Bank finds that a high share of the population is both poor and exposed to flooding in several Caribbean countries. For example, in Suriname, 18 percent of the population living with less than $5.50 a day is exposed to a 1-in-100-year flood. The share of the poor population exposed to flooding tells a more dire story. The percentage of poor persons who are exposed to flooding ranges from 9.4 percent in St. Lucia to as high as 42.4 percent in Suriname (*figure 5.1*).

To go further, microsimulations informed by household surveys and well-being economics can help identify vulnerability hotspots and opportunities for high-return interventions like small business loans, wage support, homeowners' insurance subsidies, or cash transfers. These tools use the risk assessments based on asset losses described in *chapter 1*, and disaggregate them at household level to simulate the impacts of asset destruction on consumption and well-being over time, as households work to rebuild their assets.

COVID-19 >>

Impacts of the COVID-19 pandemic on poverty in the Caribbean

Although it began as a public health crisis, the COVID-19 pandemic has had severe economic consequences throughout the Caribbean. The IMF estimates that growth in the region would have contracted by 6.2 percent in 2020, signifying the deepest recession in more than half a century (Werner 2020). The global collapse of tourism, which in several countries accounts for 50–90 percent of GDP and employment, has had a severe effect. Other countries, including Guyana, Suriname, and Trinidad and Tobago, have lost exports and fiscal revenues due to steep drops in commodity prices. Remittance inflows, which account for about 7 percent of the Caribbean region's GDP and exceed 15 percent of GDP in Haiti and Jamaica, are expected to fall sharply (IMF 2020). In Caribbean countries with projections, the crisis is estimated to have increased poverty by 10—25 percent (***table 5.1***).

Without emergency social spending, the costs of the global pandemic would have been much higher than these estimates. Small business loans, wage support, unemployment insurance subsidies, and cash transfers have proven highly effective for alleviating the human costs of acute shocks. Throughout the Caribbean, these programs mitigated widespread layoffs and evictions, offset wage and family losses, and underwrote education and health care. In this way, the pandemic holds lessons for more familiar crises.

TABLE 5.1 >>

COVID-19 poverty outlook in Caribbean countries

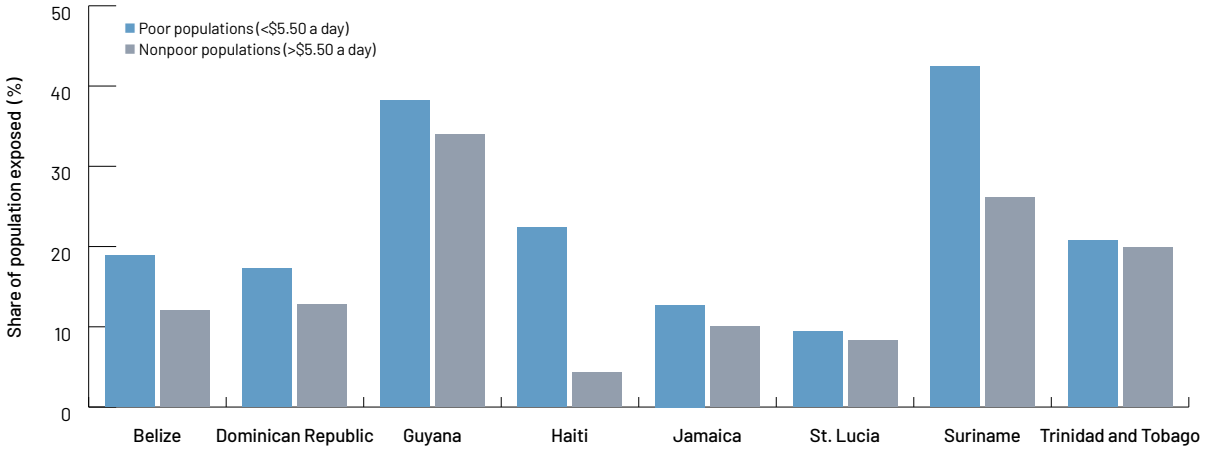
Country	Poverty rate 2019 (%)	Projected poverty rate 2020 (%)
Dominican Republic	12.9	14.2
Haiti	25.9 (2018/9)	28.7 (2020/21)
Jamaica	19.3 (2017)	23 (2020)
St. Lucia	18.4	22.8

Source: World Bank 2020a

Notes: Estimates are based on the upper-middle income international poverty rate ($5.5 in 2011 purchasing power parity, or PPP). For the Dominican Republic, the Ministry of Economy, Planning and Development (Ministerio de Economía, Planificación y Desarrollo, MEPyD) estimates that monetary poverty could increase by 13.4 percent points if the tourism and construction sectors contract by 90 percent, the inflow of family remittances decreases by 30 percent, and COVID-19 benefits are extended over time. For Jamaica, estimates are based on the national poverty line. For Haiti, estimates use the international poverty rate ($1.9 in 2011 PPP) and data are for 2018/9 and 2020/21.

FIGURE 5.1 >>

Exposure of poor and nonpoor populations in Caribbean countries to >15cm flooding



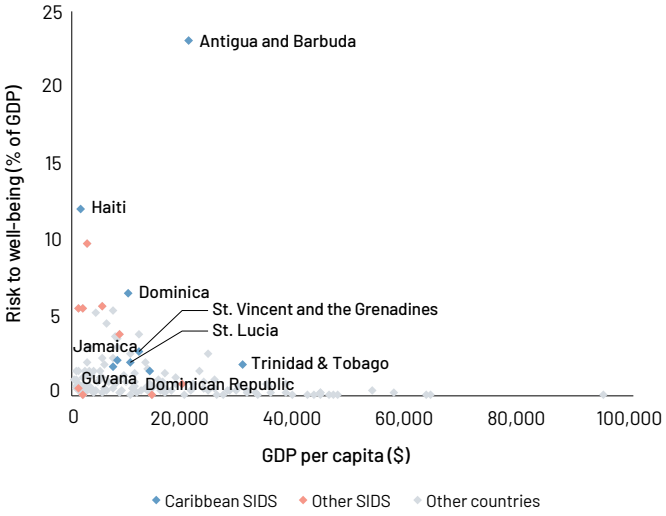
Source: Rentschler and Salha 2020

Note: Figure shows exposure to 1-in-100-year pluvial, fluvial, and coastal floods.

The *Unbreakable* report measures the impact of disasters on well-being, accounting for the fact that small losses are very impactful to poor families. The report finds that natural disasters pose an elevated risk to well-being in Caribbean states due to frequent shocks, broad exposure, geographical isolation, and undiversified economies (***figure 5.2***; Hallegatte et al. 2017; Hallegatte, Rentschler and Walsh 2018). Results from Hallegatte et al. (2017) show that well-being impacts of disasters can far exceed asset losses in the region, as high poverty levels and limited access to coping strategies lead to prolonged deprivation.

FIGURE 5.2 >>

Risk to well-being in Caribbean countries



Source: Hallegatte, Rentschler and Walsh 2018

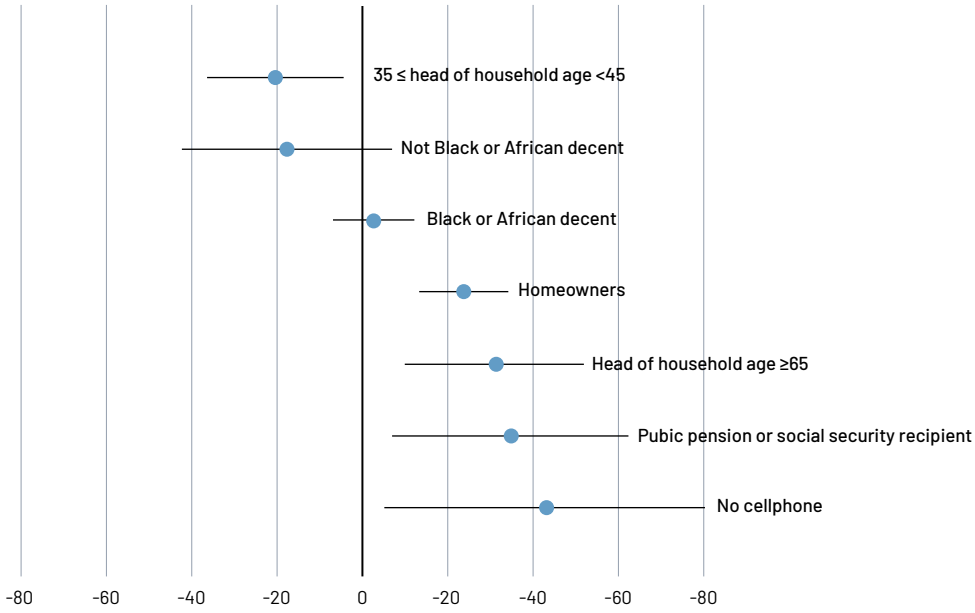
An extension of this work finds that households just above the poverty line in St. Lucia are several times more likely than wealthier households (income >EC$20/cap/day) to experience poverty for at least six months when their homes are affected by earthquakes (Walsh and Jagdeo, forthcoming). It also finds that the most needful households can be identified through characteristics that are easier to measure than well-being or income. ***Figure 5.3*** identifies a few of the characteristics found to correlate with risk of impoverishment by earthquakes in St. Lucia. For example, heads of household who are under 45 years old or non-Black have a 20 percent lower chance of impoverishment than the average St. Lucian. On the other hand, older homeowners, pensioners, social security recipients, and those without cellphones face elevated risk of impoverishment. These characteristics are correlative, not causative, and can be used to scope and distribute social expenditures efficiently when disasters cannot be prevented.

FIGURE 5.3 >>

Probability of being in poverty in St. Lucia for at least six months after a 1-in-100-year earthquake, due to housing asset and service losses

Source: Walsh and Jagdeo, forthcoming

Note: For each population segment, the mean value is shown (circle), plus or minus one standard deviation (bar).

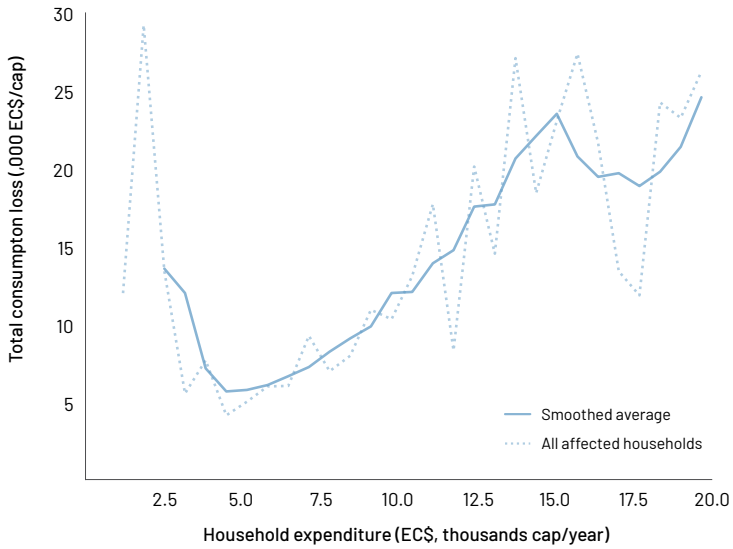


Walsh and Jagdeo (forthcoming) also show that, while asset losses vary widely for wealthy households, they fall within a narrow band for poor households of approximately EC$6,000 per capita. They do not, however, represent the largest share of losses experienced by the poor. The very poor accrue indirect losses, which far exceeds their annual income, over years and decades. These losses are as high as ES$25,000–35,000 for households with an annual expenditure of EC$2,000 per year (***figure 5.4***). But they are not visible to the market, as only a small portion of the population of St. Lucia incurs losses over many years after a shock. The net present value of consumption losses is significant for wealthy households whereas losses for poor and near-poor households are minimal.

FIGURE 5.4 >>

Exposure of poor and nonpoor populations to >15cm flooding

Source: Walsh and Jagdeo, forthcoming

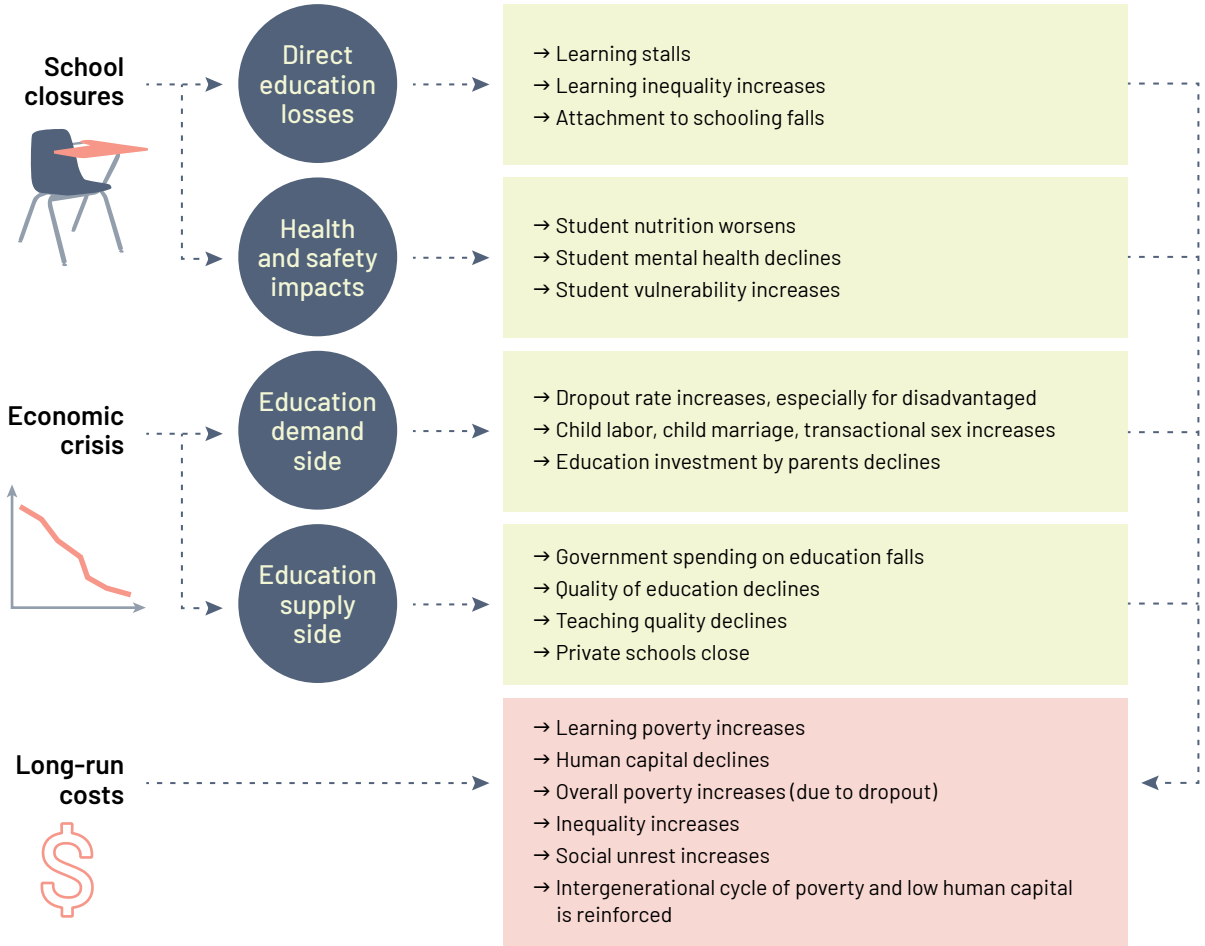


Impact of shocks on education

External shocks—including natural disasters, pandemics, and economic shocks—affect education systems through two main channels: the effects of school closures and the outcomes of the resultant economic crises (*figure 5.5*). When inadequately addressed, these shocks can cause long-term costs to students, families, and society, increasing both learning and monetary poverty, decreasing human capital, and expanding education inequality. School closures directly impact education, as a reduction in face-to-face instruction robs students of teaching and learning, widens achievement gaps, and has the potential to reduce attachment to schooling. There are health and safety impacts on student nutrition, vulnerability, mental health, and well-being. By causing a downturn in economic activity, shocks also put significant pressure on both education supply—for example, by causing a decrease in government education spending—and demand, when a decrease in household income increases the opportunity costs of schooling, leading to a higher dropout rate (World Bank 2020b; Bellony and Powers 2021).

FIGURE 5.5 >>

How shocks affect the education system



Source: World Bank 2020b

TABLE 5.2 >>

Economic and educational losses from natural disasters in Caribbean countries (2004–2019)

Event	Country affected	Economic losses (% of GDP)	Damage to education infrastructure (number of schools or $ damages)	Children affected	School closure impacts
Hurricane Ivan September 2004	Grenada	148	» 73/75 schools destroyed		» School-aged children were displaced for several months to makeshift schools or placed temporarily in schools of different countries until the education system recovered
Earthquake January 2010	Haiti	100	» 4268/17,800 schools and Ministry of Education headquarters damaged » Total damage: $626.7 million	» More than 50% of students (over 1.1 million) were still out of school a year after the earthquake, either because of the disaster or due to prior system challenges	» Access loss to schooling after the earthquake was more acute for those in displacement camps » 600 schools and 225 temporary learning spaces reopened on April 5, 2010
Tropical Storm Erika August 2015	Dominica	90	» 23 schools affected (13 damaged; 2 destroyed) » Total damage: $4 million	» 3,420 students were affected (25.8% of all primary and secondary students)	» 60% of schools reopened on September 14, 2015, two weeks after the official start date for the new academic year » Damaged schools and the three used as shelters did not reopen
Hurricane Irma September 2017	Sint Maarten	797	» Total damage: $56.4 million » 17% of early care and education facilities destroyed and 37% damaged	» 700 children in early childhood facilities	» Public schools were closed for 4–6 weeks; private schools for two weeks » Migration of students to other countries was widespread
Hurricane Irma September 2017	Antigua and Barbuda	11	» 4/4 schools damaged on Barbuda	» 410 students affected (100%)	» Students from Barbuda relocated to Antigua and enrolled in schools there
Hurricane Maria September 2017	Dominica	259	» 136/163 buildings damaged (62 needed minor repairs; 52 partially damaged; 67 highly damaged	» One month after the hurricane, 95% of students had no access to schooling	» 36% of schools had reopened by mid-November » Three years on (September 2020), some schools had not been rebuilt, sharing space with other schools instead, reducing instruction hours for both schools sharing the facility » Some students were displaced to other territories, including Antigua and Barbuda and St. Kitts and Nevis
Hurricane Dorian September 2019	Bahamas, The	25	» 45/175 buildings damaged (7 destroyed) » Total damage: $72.4 million	» 10,546/57,235 primary and secondary level students affected	» 7 weeks closure on Grand Bahama; over 8 weeks' closure on Abaco

Sources: Based on data from Deopersad et al. 2020; EM-DAT;[1] Government of the Commonwealth of Dominica 2015 and 2017b; Government of Haiti 2020; World Bank 2018

Natural disasters

Natural disasters cause severe impacts on school infrastructure and learning outcomes, through school closures and discontinuity in learning. A stocktake of historical school disruptions due to natural disasters in different Caribbean countries shows that a significant number of education buildings are damaged or destroyed (*table 5.2*). For example, in The Bahamas, Hurricane Dorian damaged 45 of 175 schools, destroying seven of them; in Dominica, Hurricane Maria damaged 136 of 163 schools, about half of them severely; and in 2010, the Haiti earthquake damaged 4,268 of 17,800 schools and the Ministry of

Education headquarters. These disruptions have forced school closures—lasting anything from a few weeks to several months—affecting many students. In Dominica, one month after Hurricane Maria hit the island, 95 percent of the students had no access to schooling, and after the 2010 Haiti earthquake, half of the countries' students were left without access to education, with some schools taking more than a year to reopen (Government of the Commonwealth of Dominica 2015 and 2017b; Government of Haiti 2020). During reconstruction, students are often displaced to makeshift schools or temporarily placed in schools in different countries (where they are temporarily relocated with their family) until the disrupted education system recovers (UNICEF 2019).

Using schools as shelters prolongs educational losses from disasters. Caribbean schools often have a dual use, serving education purposes in normal times, and used as emergency shelters during disasters. This adds to the delay in returning school buildings to substantive use in the aftermath of disasters, prolonging educational losses. For example, Hurricanes Irma and Maria destroyed more than 60 percent of the housing stock, forcing homeowners to remain in shelters for extended periods, which delayed the resumption of teaching and learning. Likewise, months after Hurricane Dorian hit The Bahamas in 2019 and Hurricane Maria hit Dominica in 2017, temporary shelters were still in use by displaced residents. Some countries have started finding alternative solutions, building standalone emergency shelters and improving housing stock. This is urgent as the use of schools as temporary shelters impinges on basic priorities for the education sector in the aftermath of emergencies, which are to minimize disruption to teaching and learning by promptly and safely returning schools to educational functions.

COVID-19 >>

Impacts of COVID-19 pandemic on educational outcomes in the Caribbean

As with natural disasters, social distancing measures undertaken during the COVID-19 pandemic led to school closures. In countries and households where adequate solutions for distance learning were not in place, this also meant discontinuity in learning. To slow the spread of the virus, temporary school closures were instituted across the region by mid-March 2020, leaving more than 1 million students out of school. In most jurisdictions, remote learning started within 2–4 weeks. In September 2020, some systems reopened with limited capacity, while others continued to offer education primarily through distance modalities. The long-term effects of COVID-19 on education are still uncertain, but evidence from past remote learning experiences—even with adequate measures in place—is mixed at best (Allen et al. 2004; Bernard et al. 2004). The scale of current disruptions suggest that the effects will be large and lasting (Azevedo et al. 2020b).

Modeling shows that COVID-19-induced school closures can translate into large learning gaps. To quantify the impact of school closure on education, a novel study by Azevedo et al. (2020b) simulates the impact of three, five, and seven months of school closure and different levels of mitigation effectiveness on school outcomes. In an optimistic scenario, schools are closed for three months and the effectiveness of enacted mitigation is high, while in the intermediate and pessimistic scenarios, schools are closed for five and seven months, respectively, and mitigation measures return intermediate and low levels of effectiveness (Azevedo et al. 2020a). Simulations indicate that five months of school closure with intermediate mitigation measures will lead to a loss of 0.4 years of schooling with respect to the baseline in Guyana, Haiti, and Jamaica. In the pessimistic and optimistic scenarios, the loss of learning is estimated at 0.6 and 0.2 years, respectively. In the Dominican Republic and Trinidad and Tobago, school closures are estimated to reduce students' test scores, resulting in 8 and 7 PISA[2] point losses, respectively, in an intermediate scenario. A longer shut down of schools and ineffective mitigation measures worsens test scores to a 10 PISA point loss in both countries.

Learning gaps can quantify into significant income losses in the long term. In the absence of remedial actions that lead to the resumption of face-to-face learning or better and more targeted remote learning, learning losses quantify into significant reductions in annual incomes (***table 5.3***). Estimates of future earning losses range from $100 per year (Haiti) to $902 (Jamaica)[3] in an intermediate scenario. This amounts to 3.5 percent (Haiti) and 6.2 percent (Jamaica) loss in yearly earnings per student. A more pessimistic scenario with seven months of school closures will cost students between $147 (Haiti) and $1,422 (Jamaica) in lifetime earnings.

TABLE 5.3 >>

Lifetime earning reductions in Caribbean countries due to school disruption (%)

Country	Optimistic	Intermediate	Pessimistic
Dominican Republic	-0.7	-1.4	-2.2
Guyana	-2.0	-4.1	-6.5
Haiti	-1.9	-3.5	-5.2
Jamaica	-3.0	-6.2	-9.7
Trinidad and Tobago	-2.3	-4.6	-8.1

Source: Generated using the simulation tool from Azevedo et al. 2020a

Notes: In an optimistic scenario, schools are closed for three months and the effectiveness of enacted mitigation is high. In an intermediate or pessimistic scenario, schools are closed for five or seven months, respectively, and government-imposed mitigation measures return intermediate or low levels of effectiveness.

Impact of shocks on health and health systems

While natural disasters have direct impacts on people's health through injury and death, they also have many indirect health impacts. First, they can divert health system services to respond to the shock, which may impact routine health services, such as immunizations and cancer screenings, and negatively impact health outcomes in the short and/or long term. Second, climate-related shocks can have short-term impacts through the deterioration of water quality, and longer-term impacts through changes to the pattern of vector-, food-, and water-borne diseases.

Accordingly, disease outbreaks also have direct health impacts due to increased infections (which can worsen pre-existing conditions, or vice versa), injuries, and mental health disorders. The COVID-19 pandemic was an extreme example of how such diseases can disrupt health care systems and human capital outcomes.

Finally, any shock can have indirect impacts on health by exacerbating poverty. As already discussed, a notable proportion of the Caribbean population experiences high levels of poverty, with one in five individuals living below the poverty line, and poverty often increases after a shock. Higher poverty can lead to worse health outcomes through various mechanisms, including reduced access to health care services, malnutrition, chronic stress, and unsafe housing conditions.

Natural disasters

Tropical storms and hurricanes have devastating impacts on human life (*table 5.4*). From 2000 to 2019, tropical storms and hurricanes in Latin America and the Caribbean resulted in roughly 8,500 deaths. Cuba, Mexico, and Haiti were most impacted, with 110 storms affecting 29 million people and causing 5,000 deaths, more than 85 percent of which were recorded in Haiti (OCHA 2019). Within the same timeframe, there were 75 earthquakes across the region, resulting in 226,000 deaths and 339,000 injured—with Haiti again accounting for the majority of deaths (98 percent) and injuries (89 percent)—and 66 landslides, which caused almost 3,000 deaths. As comparison, between 1925 and 2015, Dominica—which is extremely vulnerable to landslides and mudslides—only had 35 deaths as a result of landslides (OCHA 2018).

TABLE 5.4 >>

Deaths and injuries caused by selected natural disasters in Caribbean countries

Disaster	Earthquake	Tropical Storm Erika	Hurricane Maria	Hurricane Dorian
Date	January 12, 2010	August 27, 2015	September 18, 2017	September 1, 2019
Country	Haiti	Dominica	Dominica	Bahamas, The
Deaths/injuries	222,570 deaths 300,000 injuries	20 deaths	64 deaths	67 deaths

Source: Based on data from OCHA 2019

Research on the impacts of natural disasters on health systems is limited. However, Shultz et al.'s (2019) study of the health impacts of the 2017 Atlantic Basin hurricane season on SIDS (not only in the Caribbean region) notes significant disruptions of health services related to damaged facilities, power outages, and fuel shortages. This exacerbated chronic health problems, as populations experienced unrelieved heat exposure, inability to refrigerate medications, and reduced availability of kidney dialysis and cancer therapies. They also found that almost all SIDS populations who were exposed to hurricanes in 2017 experienced psychological distress and predicted an increase in the onset of post-traumatic stress disorder and depression. Further, after the 2017 hurricanes, some water treatment and sewage systems

were disabled due to damage to infrastructure or power outages, resulting in cross-contamination of the water supply with wastewater and other pollutants. Climate-related shocks can also have longer-term health impacts through water-, food- and vector-borne diseases. A systematic review of human health following disasters around the world between 1985 and 2014 found that gastrointestinal illness and leptospirosis generally increased following flooding and storms (Saulnier, Brolin Ribacke and von Schreeb 2017).

The 2017 events brought to light the limited resilience of some health care facilities or systems in the Caribbean. For example, Hurricane Irma moved through the Caribbean region affecting many islands from September 5–7, 2017. Barbuda was one of the most critically affected islands, with total losses to Antigua and Barbuda approximating $18.9 million (GFDRR 2017). All of the island's critical infrastructure was damaged, including the water system, electricity generation and distribution network, roadways, main cargo and ferry pier, and airport, rendering the island uninhabitable (GFDRR 2017). The hurricane damaged 85 percent of the roof of the country's only hospital, the Hanna Thomas Hospital and Health Center on Barbuda, obstructed road access, and made utility services inoperable (Thomas 2017). Apart from the roof, the hospital building was structurally sound, but the lack of access to clean water or health services, combined with the presence of stagnant water and dead animals, represented environmental health risks due to the increase in vectors, such as mosquitos and rodents. With 95 percent of housing damaged and no local access to clean water, electricity or health services, the government issued a mandatory evacuation of Barbuda's population to shelters in Antigua.

Health systems on the U.S. Virgin Islands were also impacted by Hurricane Irma. Chowdhury et al. (2019) note that the Schneider Regional Medical Center—the only hospital on the most populated island—experienced partial infrastructure damage, loss of their emergency medical record system, and flooding of their emergency department. Emergency department information also showed an increase in older patients with less severe complaints, reflecting a possible breakdown in routine service provision, such as prescription management. The federal U.S. government and its contracting companies evacuated patients who were unable to receive adequate care in the hospital to St. Croix, Puerto Rico, and the continental United States (Chowdhury et al. 2019).

Hurricane Maria became a Category 5 hurricane on September 18, 2017, causing severe damage when it made landfall in Dominica and continuing to wreak havoc on several countries in the region until September 20, 2017. Heavy infrastructure damage left thousands of Dominicans homeless and requiring daily water and food assistance (United Nations 2017). Water supply and sanitation infrastructure were damaged, with one city's population exposed to raw sewage, posing several health risks. One month after the hurricane, 40–45 percent of the population still had no access to clean water (International Medical Corps 2017). Such sustained infrastructure damage impedes the functioning of health systems and reflects low resilience capacity.

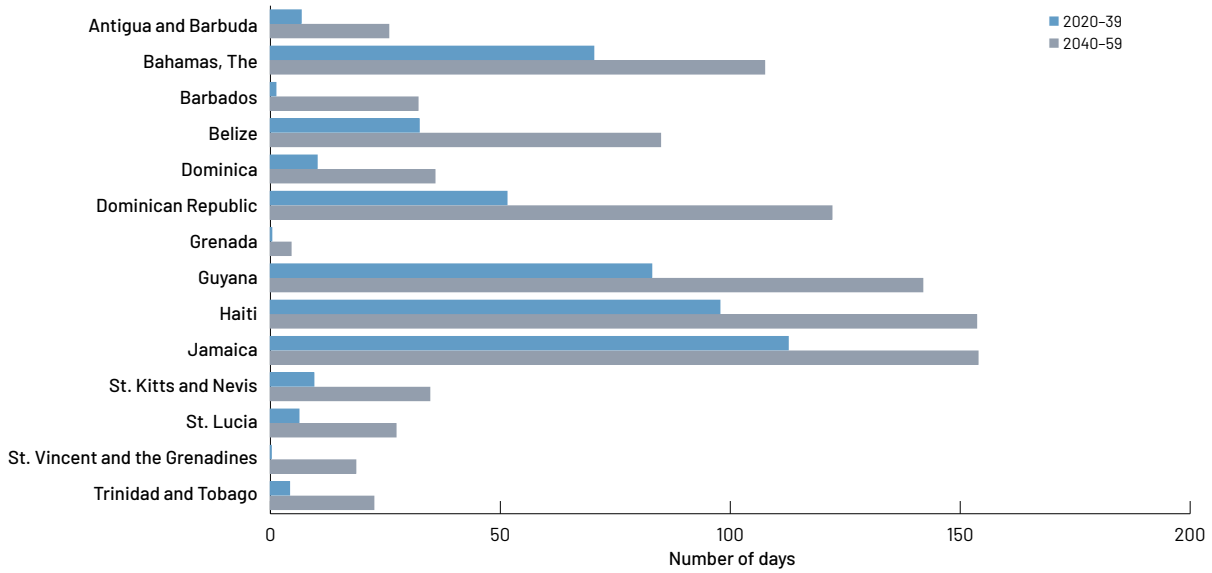
Princess Margaret Hospital, the only referral hospital in Dominica's health care system, was severely damaged and left with an estimated 53 percent ability to function. Most of its medical supplies, except medicines, were lost as a result of water damage (Government of the Commonwealth of Dominica 2017a). Medical equipment—including the portable x-ray machine and all blood bank equipment—was also lost. All health centers on the island were impacted, by direct damage (with some clinics sustaining severe damage) and/or blocked road access, which reduced overall access to health care. However, primary health services continued to be provided, either in buildings that had emergency repairs or alternative locations (Government of the Commonwealth of Dominica 2017a), reflecting a level of adaptive capacity (Harnam and Khan 2021).

Future climate change

Climate change poses human health risks such as food and water insecurity, spread of water and vector-borne diseases, population displacement and heat stress. Climate change is expected to increase the average annual temperature and intensity and frequency of heat waves, resulting in a greater number of people at risk of heat-related medical conditions. While there is high uncertainty on the impacts of climate change on extreme heat, an analysis of extreme scenarios (90th percentiles of models ensemble for RCP 4.5) shows that this impact is also very heterogenous in the region: the annual increase in number of extreme heat days (>35°C) from 2020 to 2039 could range from 0.15 days in St. Vincent and the Grenadines to 113 days in Jamaica (*figure 5.6*), with an average of 63 days for the region. From 2040 to 2059, the average number of days with extreme heat in each year increase by 103 days, ranging from four days in Grenada to as many as 154 days in Jamaica and Haiti. Continued exposure to high temperatures poses human health risks such as heat rash, dehydration, heat exhaustion, heatstroke, and death (WHO 2020).

FIGURE 5.6 >>

Annual number of days with dangerous heat (>35°C) in extreme climate change scenarios in Caribbean countries



Source: Based on data from the World Bank Climate Change Knowledge Portal[4]

Note: The annual number of extreme heat days is calculated taking the 90th percentile estimates of all models under RCP4.5, it thus represents a pessimistic scenario.

Some of the world's most virulent infections are also highly sensitive to climate, making SIDS extremely vulnerable to disease outbreaks. Climate change could affect the seasonality of such outbreaks as well as the transmission of vector-borne diseases. Modeling the potential risk of dengue fever transmission under low and high greenhouse gas emission scenarios, the WHO shows that seasonality and prevalence of dengue transmission may change with future climate change (WHO 2020). Based on the models, Trinidad and Tobago, St. Lucia, Guyana, Grenada, and Dominica are consistently highly suitable for dengue transmission under all scenarios and thus vulnerable to outbreaks.

Infectious diseases

In the past decade, multiple viruses—including chikungunya and Zika—were introduced in the region for the first time, contributing to increased disease burdens. The dengue virus transmitted by mosquito vectors was first isolated in the Caribbean region in the 1940s and has since been responsible for many dengue fever outbreaks on Caribbean islands, including more severe recent outbreaks in Dominica, St.

Vincent and the Grenadines, and Jamaica. Other diseases—such as AIDS, cholera, Zika, and tuberculosis—also persist. Considering that new pathogens are more likely to necessitate higher health system resilience and capacities, this section examines how the region has responded to outbreaks of some of these newer viruses over the past two decades.

2013–14 chikungunya virus outbreak. The first laboratory-confirmed native cases of chikungunya occurred in December 2013 on the French part of the Caribbean island of St. Martin (van Bortel et al. 2014). This was followed by a rapid spread of the virus throughout the Caribbean, rising to a total of 103,018 suspected and 4,406 laboratory-confirmed cases by the end of May 2014 (Fischer and Staples 2014). At that time, the Dominican Republic, Martinique, Guadeloupe, Haiti, and St. Martin reported the highest number of cases. While the mortality rate associated with chikungunya virus is low (4 percent), the large percentage of symptomatic infections put a strain on health care resources, especially since there was no specific treatment beyond symptomatic relief or vaccine for the virus (Gutierrez-Saravia and Gutierrez 2015). The Caribbean Public Health Agency laboratory in Trinidad conducted testing for many countries using a realtime polymerase chain reaction method developed by the United States Centers for Disease Control and Prevention (Ahmed et al. 2015). However, these laboratory services were quickly overwhelmed as case numbers grew, indicating low absorptive capacity of the health system's laboratory component. Countries instead relied mainly on the WHO clinical case definition of chikungunya to identify cases. National public health responses to local outbreaks focused mainly on vector control efforts and encouraging personal protection efforts to reduce mosquito-to-human contact (Gutierrez-Saravia and Gutierrez 2015).

In 2014, Jamaica's first native case was reported in early August and by the end of the year, the Ministry of Health had been notified of 4,447 chikungunya infections. One study suggested that officially reported cases were likely only a small portion of actual cases, noting that 87 percent of families in Jamaica reported having household members affected by the virus (Christie et al. 2016). Freitas et. al (2019) also suggest that chikungunya-related deaths were likely under-reported, noting that while Jamaica reported no chikungunya-associated deaths, there were 2,499 deaths during the epidemic period. The peak of the outbreak in October 2014 placed a significant strain on hospital resources, as reflected by a fivefold increase in emergency room visits by children at two public hospitals, compared to a similar time period in 2013 (Christie et al. 2016).

2015–2016 Zika virus outbreak. At the end of 2015 into 2016, the Zika virus spread quickly throughout the region, with peak cases reported in August 2016 after the start of the rainy season. By December 2016, non-Latin Caribbean countries[5] had reported more than 16,000 locally transmitted suspected cases and over 4,000 confirmed cases. The highest number of confirmed cases were in the U.S. Virgin Islands, Curaçao, Suriname, and Trinidad and Tobago.[6]

The Caribbean bore the brunt of the Zika outbreak across the Latin America and Caribbean region. The UNDP (2017) noted that the Caribbean was the most affected subregion, with a negative impact five times greater South America's. Limited research has examined the impact of Zika specifically within the Caribbean. While the direct medical costs for treating Zika patients' symptoms are low, as hospitalizations are rare, the indirect lifetime costs of treating associated congenital and neurological conditions are high. The national projected tangible costs of the consequences of the Zika virus in Suriname, which had a high number of cases, were estimated at $10–22 million (UNDP 2017). Based on previous experiences with chikungunya, Suriname quickly implemented a laboratory-based surveillance system for Zika infections (Codrington et al. 2018). This could reflect Suriname's stronger anticipatory capacities following a previous shock, which allowed them to adapt more quickly to a new but similar threat.

COVID-19 >>

Impacts of the COVID-19 pandemic on health in the Caribbean

As of October 15, 2020, PAHO reported that within the Americas region, the highest increase in COVID-19 cases was observed in the Caribbean and Atlantic Ocean Islands subregion,[7] with a 20 percent increase in cases and an 18 percent increase in deaths (PAHO and WHO 2020). *Table 5.5* shows COVID-19 related data provided by governments on confirmed cases, deaths, recovery, and vaccination.

In general, Caribbean countries' early response to the COVID-19 pandemic garnered global praise, with some noting that most Caribbean islands experienced a less steep outbreak growth in the early months compared to their Central and South American counterparts (Hambleton, Jeyaseelan and Murphy 2020). However, as *table 5.5* shows, the spread of the virus and testing within the region has varied greatly. The Dominican Republic has a notably high number of cases, despite taking early measures—such as a national lockdown when they had only 21 cases and one death—and there have been reports of inadequate personal protective equipment (PPE) in hospital settings, including designated COVID-19 response sites, due to market shortages and increased costs. The country has also struggled with health communication, with media misinformation leading to national shortages of drugs such as hydroxychloroquine (preventing some patients from accessing necessary treatments) and grocery shortages (Tapia 2020).

TABLE 5.5 >>

COVID-19 cases, deaths, recovery, and vaccination in Caribbean countries

Country	Total confirmed cases	Confirmed cases per 100,000	Total deaths	Deaths per 100,000	Persons recovered	Vaccine doses administered
Antigua and Barbuda	1,263	1,276	42	42	1,214	
Bahamas, The	12,225	3,079	239	60	11,174	146,567
Barbados	4,038	1,392	47	16	3,971	23,087
Belize	12,989	3,207	326	80	12,490	
Dominica	189	263	0	0	188	32,415
Dominican Republic	310,391	2,931	3,717	35	253,272	
Grenada	161	142	1	1	160	
Guyana	18,530	2,346	437	55	16,401	59,582
Haiti	16,662	140	358	3	12,568	
Jamaica	49,379	1,661	1,012	34	27,919	
St. Kitts and Nevis	209	387	0	0	64	
St. Lucia	5,186	2,818	80	43	5,018	6,473,104
St. Vincent and the Grenadines	2,158	1,944	12	11	1,900	185,533
Suriname	18,825	3,180	418	71	14,423	93,451
Trinidad and Tobago	29,309	2,089	686	49	19,667	152,293

Source: Based on data from the World Bank high frequency database[8] (accessed June 2021)

Impact of shocks on displacement and migration

Economic shocks, natural disasters, and climate change impact a country's human capital by displacing people. Displacement can be induced by both slow-onset events, such as sea level rise or more extreme temperatures, and sudden-onset events such as natural disasters. The former can induce migration and planned relocation as forms of adaptation (in anticipation of the event) or cause displacement when stresses reach a tipping point (as a reactive strategy). Similarly, sudden-onset events can cause displacement in their aftermath—as people lose their homes, jobs, neighborhoods or any other component of their daily life that provides them with stability (Chase-Dunn and Grimes 1995)—or in advance of the forecast event as a risk reduction strategy. Displacement generates impacts on health, sense of place, and community cohesion, that are not captured by conventional economic damage and loss measures and yet can cause significant indirect economic losses (UNFCCC 2013).

In the Caribbean, displacement is higher than in the rest of the world relative to population size. The six countries and territories with the world's highest average per capita annual internal displacement are located in the Caribbean (Francis 2019). But although displacement of residents due to extreme events including hurricanes, floods, and tropical storms has long been an issue in the region, there is little research on it before 2017 (Kaenzig and Piguet 2014).

The three major hurricanes of the 2017 season—Harvey, Irma, and Maria—displaced approximately 3 million people from 16 countries and territories (Francis 2019; Thomas and Benjamin 2020). This included the unprecedented displacement of entire island populations in both Antigua and Barbuda and The Bahamas, which resulted in two islands becoming completely uninhabited (IDMC 2018a). In 2019, the Internal Displacement Monitoring Centre (IDMC 2018b) reported that 5.9 percent of The Bahamas' population would be displaced by hurricanes every year.

Displacement can lead to migration as people look for stability elsewhere, within their own country or abroad. Andrade Afonso (2011) estimates a 16.5 percent increase in the number of immigrants to the United States, per year, after a storm in Central America or the Caribbean. Similarly, Spencer and Urquhart (2018) find that destructive hurricanes increase migration from Central America and the Caribbean to the United States by roughly 6 percent. Mahajan and Yang (2017) find that hurricanes cause immediate increases in U.S. immigration on average and that this effect is magnified among origin countries with larger numbers of U.S. immigrants.

The cost of emigration for Caribbean countries is magnified as highly skilled people are the first to leave. In their study of the impact of natural disasters on migration according to level of education, Drabo and Mbaye (2015) find that only individuals with a high level of education migrate in the case of an increased incidence in number of natural disasters, suggesting that this amplifies brain drain in developing countries at a time when they need the most skilled and qualified people to deal with the damage caused by natural disaster. They also observe increased migration rates of highly educated people from the Latin America and Caribbean region. Baez et al. (2017) measure the impact of drought and hurricanes on internal mobility in eight Latin American and Caribbean countries and find that younger individuals are more likely to migrate in response to natural disasters, particularly droughts. The authors note that young persons are more inclined to relocate to rural and small towns, motivated by opportunities for off-farm employment as well as financing limitations for urban transport and living expenses.

Remittances—one of the benefits of emigration—mitigate but do not cancel the negative impacts of emigration. Mishra (2006) finds that the Latin America and Caribbean region is the largest recipient of remittances and has the fastest growth in receipts. Emigration has large impacts on trade and foreign direct

investment networks, and, if biased towards the highly skilled, can raise relative wages and returns to higher education in receiving countries, and induce human capital formation. However, Mishra also finds that Caribbean countries have lost 10–40 percent of their labor force due to emigration to Organisation for Economic Co-operation and Development (OECD) member countries, with higher migration rates among high-skilled workers. According to Mishra, many countries have lost more than 70 percent of their labor force with more than 12 years of completed schooling—among the highest emigration rates in the world. Despite the added benefit of remittances flowing from migrant to their home country, Mishra's well-being calculations show that losses due to high-skill migration outweigh official remittances to the Caribbean region.

Summary

This chapter demonstrates that the impacts of natural disasters, disease outbreaks, and economic shocks on human capital could be much higher than traditional DaLAs capture. As well as affecting poor people more severely and keeping vulnerable populations in poverty, natural disasters displace people and break social cohesion, lead to emigration of the high-skill labor force, reduce lifelong earnings through school disruptions, and worsen the health of the population. Although difficult to measure, these compounding effects weaken human capital in Caribbean countries and thereby limit long-term growth and well-being prospects.

Endnotes

1. https://www.emdat.be/.
2. PISA = Programme for International Student Assessment. PISA and PISA for Development (PISA-D) measures 15-year-olds' ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges.
3. In 2017 PPP$.
4. https://climateknowledgeportal.worldbank.org/.
5. These include: Anguilla, Antigua and Barbuda, Aruba, The Bahamas, Barbados, Bonaire, British Virgin Islands, Cayman Islands, Curaçao, Dominica, Grenada, Guyana, Jamaica, Montserrat, Sint Maarten, St. Eustatius and Saba, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos, and U.S. Virgin Islands.
6. PAHO and WHO. Zika Cases and Congenital Syndrome Associated with Zika Virus Reported by Countries and Territories in the Americas, 2015-2016 Cumulative Cases, Data as of 29 December 2016. https://www.paho.org/hq/dmdocuments/2016/2016-dec-29-phe-ZIKV-cases.pdf.
7. Anguilla, Antigua and Barbuda, Aruba, The Bahamas, Barbados, Bermuda, Bonaire, British Virgin Islands, Cayman Islands, Cuba, Curaçao, Dominica, the Dominican Republic, Falkland Islands, French Guiana, Grenada, Guadeloupe, Guyana, Haiti, Jamaica, Martinique, Montserrat, Puerto Rico, Sint Maarten, St. Barthélemy, St. Eustatius and Saba, St. Kitts and Nevis, St. Lucia, St. Martin, St. Pierre and Miquelon, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos, and U.S. Virgin Islands.
8. https://mtimodelling.worldbank.org/highfreqmonitor/dashboard.html.

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6

CHAPTER 6 >>

Summary and conclusions

The chapters in Part 1 assess the risks and vulnerabilities of Caribbean countries, each focusing on different aspects and sources of vulnerability and shocks.

Chapter 1 looks at historic records and analyzes exposure trends to show that a large share of physical capital (buildings, infrastructure) and natural capital (agriculture land) in Caribbean countries is exposed to natural hazards. It also shows that, although the level of exposure varies across countries, climate change is exacerbating Caribbean countries' exposure to natural hazards. A review of damages from past disasters provides evidence that risks to physical capital in the Caribbean region are high and represent a threat for its people and economies. The analysis shows that in most countries, new infrastructure and low-density residential areas have expanded into flood plains, most likely due to geographical constraints. This trend increases the value of capital that will need repairs in case of damage by hazards, thus increasing contingent liabilities for governments.

Chapter 2 highlights the high exposure of lifeline infrastructure and networks to natural hazards, in terms of direct damages and losses related to service disruptions, including to their vital role in postdisaster response and recovery. While power and water outages are frequent in the region, most firms own backup infrastructure that help them cope with short-term disruptions. In the event of big disasters that interrupt water and power services for more than a few days, however, firms would not be able to cope. The transport network plays a key role during disasters, since disruptions can affect countries' ability to receive international support (if ports and airports are damaged), and to access health care and other lifeline networks, including energy supply (due to their reliance on petroleum transported by road) and backup water supply.

Chapter 3 discusses Caribbean countries' high reliance on the tourism, commodities, and agriculture and fisheries sectors, which are vulnerable to both climate shocks and shocks to external demand. It shows that tourism, agriculture, and fisheries are particularly vulnerable to climate and disaster shocks, and have experienced large losses in the past. And while the financial sector could act as a risk mitigation tool through risk-sharing mechanisms like insurance, in practice it is quite vulnerable in most countries and might amplify—rather than alleviate—some shocks.

Chapter 4 examines countries' vulnerability to macroeconomic shocks, including natural disasters, financial crises, and the COVID-19 pandemic. Their economies are highly reliant on a few sectors that are vulnerable to external shocks and many governments have limited capacity to respond to shocks due to monetary and fiscal policy constraints. For example, export-oriented economies require a stable exchange rate environment, which leaves little room for governments to develop other monetary policies to effectively respond to shocks. Many countries' fiscal space is also limited by prevailing high debt levels, compromising their creditworthiness and hindering their ability to borrow. The chapter describes the macroeconomic impacts of these shocks and explores why empirical assessments of the impact of disasters on GDP growth show that these are often short-lived. Although this may be due to buffering mechanisms such as remittances and savings, it is more plausible that methodological issues prevent accurate assessments.

Chapter 5 demonstrates that the impacts of natural hazards, disease, or economic shocks on human capital could be much higher than traditional assessments of damages and losses capture. As well as affecting the poor more severely and keeping vulnerable populations in poverty, natural disasters displace people and break social cohesion. This increases high-skilled labor migration, reduces lifelong earnings through school disruptions, and worsens health conditions. Although incredibly difficult to measure, these compounding effects help weaken human capital in Caribbean countries, limiting long-term growth and welfare prospects.

The individual chapters provide a thorough description and analysis of different dimensions of risk and vulnerability, but the consequences of shocks on Caribbean countries depend on a complex mix of these vulnerabilities. For example, the impact of a potential hurricane on the population's well-being is determined not only by the number of people and built-up areas that are exposed to intense flooding and wind, but also by the shape and condition of transport networks that are crucial for an efficient disbursement of postcrisis international support, the development of risk-sharing mechanisms in the financial sector, and governments' ability and space to use monetary and fiscal policy to respond to shocks. Therefore, a holistic approach spanning these different sources of vulnerability is essential for understanding risks and building resilience in Caribbean countries.

These chapters also demonstrate that it is impossible to quantitatively capture the full impact of shocks on welfare through one model or analysis. The most common assessments of the impacts of disasters,

which focus on physical capital destruction, paint only a partial picture of total impacts on an economy. And while numbers on capital destruction are often used to sound the alarm—indeed, Caribbean countries like Dominica and Sint Maarten have seen storms destroy capital value equivalent or higher than to their annual GDP—these assessments say very little about impacts on well-being. Similarly, macroeconomic assessments, which capture only the short-term impact of shocks on GDP growth, are not methodologically adapted to paint an accurate picture of the true impacts of shocks on people and livelihoods. Shocks have long-term impacts in the Caribbean, including the following:

- Destruction of human capital through impacts on health and education and increased high-skilled labor migration
- Reduction in external demand for some productive sectors—for example, by reducing the influx of tourists
- Slowing down of development—not only financial but also in terms of tying up human resources with the recovery and reconstruction process, and putting activities that were underway prior to the impact on hold
- Ripple effects via the financial sector—for example, deteriorating households' debt service ability, which in turn affect banks' health
- Ripple effects via macroeconomic and fiscal vulnerabilities, which decrease governments' capacity to respond

Various feedback mechanisms reinforce or reduce the impact of shocks; and these are difficult to capture. For example, when natural hazards lead to port disruptions, they interrupt supply chains in the region. And as Caribbean states that rely heavily on maritime transport for trade, the negative impacts propagate through the entire economic system. In the tourism industry, firms have built buffering mechanisms against smaller infrastructure disruptions, by increasing their number of suppliers or inventories and investing in backup infrastructure. Macroeconomic policy also plays an important role in either exacerbating or buffering impacts. Frequent occurrence of natural disasters requires large amounts of government expenditure for emergency management, recovery, and reconstruction, putting considerable financial burden on affected economies. The recurrent use of government expenditure can lead to higher debt levels and interest rates alongside lower credit scores. This results in higher budget deficits and further increases debt, creating a vicious cycle. Similarly, macroeconomic shocks—such as the global financial crisis in 2008–2009—worsen the high debt burdens of Caribbean countries, reducing governments' ability to respond in the event of natural disasters.

To conclude, Part 1 has shown that natural, financial, and biological shocks affect the Caribbean through different sectors and channels and have detrimental short- and long-term effects on societies. The occurrence of natural disasters in the Caribbean is not rare and countries have learned to adapt, readjusting and keeping buffering mechanisms in place to bounce back when hit by a shock. However, scattered sectoral efforts are yet to become a comprehensive and cross-sectoral approach to resilience. Building on *The Adaptation Principles* (Hallegatte, Rentschler and Rozenberg 2020), Part 2 presents a comprehensive framework that allows for assessing the state of resilience in the Caribbean, highlighting the region's strengths and priorities and providing the means to approach resilience to shocks in a holistic and context-specific way.

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2

Chapter 7 >>
Foundations for rapid, robust, and inclusive growth

Chapter 8 >>
Facilitate risk reduction decisions by firms and households

Chapter 9 >>
Design resilient infrastructure systems, urban and coastal plans

Chapter 10 >>
Build resilient health and education systems

Chapter 11 >>
Help firms and people manage residual risks and natural disasters

Chapter 12 >>
Anticipate and manage macrofiscal and financial issues

I.2

INTRODUCTION TO PART 2 >>

A progress assessment: an analysis of resilience levels in the Caribbean using a traffic light approach

Part 1 of this report gave an overview of the risks faced by Caribbean countries, historically and in the future with climate change. Because of all the shocks that these countries have had to manage over their history, they have built some levels of resilience.

But their limited capacity and the new challenges they will face—in terms of reduced tourism demand in the wake of the COVID-19 pandemic and with climate change worsening natural shocks—call for a new generation of resilience building that considers the social, micro, and macroeconomic aspects in an integrated framework.

Part 2 follows the framework developed in *The Adaptation Principles* (Hallegatte, Rentschler and Rozenberg 2020) to systematically assess the progress that Caribbean countries have made towards greater resilience, and the gaps that need to be filled using a traffic light approach (*box I2.1*). It is based on sector assessments—for which detailed background papers are available—and on a long list of indicators that countries can use to set targets and monitor progress. Those indicators are summarized in the country-level traffic light systems provided in *Appendix B*.

The traffic light system and *Part 2* are organized into the following sections (*figure BI2.1.1*).

Chapter 7. Foundations for rapid, robust, and inclusive growth

Poverty and the lack of access to basic services—such as critical infrastructure, financial services, health care, and social protection—are strong predictors of vulnerability to climate change. No resilience strategy can be successful without eradicating extreme poverty and ensuring the high-vulnerability population have the financial, technical, and institutional resources they need to adapt. This chapter reviews the gaps for achieving inclusive economic growth in the Caribbean, which is the foundation for resilience.

Chapter 8. Facilitate risk reduction decisions by firms and households

Private actors are aware of the threats posed by natural and economic shocks and want to build their own resilience. However, they face a range of obstacles, including a lack of actionable information barriers to access some technologies, a lack of appropriate skills, or financial constraints. Governments need to minimize these obstacles to maximize the economy's adaptive capacity.

Chapter 9. Design resilient infrastructure systems, urban and coastal plans

Beyond direct support to households and businesses, governments have a transformative role to play by ensuring the reliability and resilience of lifeline infrastructure systems, such as power systems, roads and bridges, ports and airports, and water and sanitation. Urban and coastal land use plans also influence private investments in housing and productive assets, so these must adapt to evolving long-term climate risks to avoid locking people into high-risk areas. Finally, participative and adaptative coastal management plans that build on natural protection will be crucial for adapting to sea level rise.

Chapter 10. Build resilient health and education systems

In addition to critical lifeline infrastructure, critical public services like health care and education need thorough climate risk assessment and management. Not only do they need to keep functioning properly during shocks; they also provide crucial services that people's well-being depends on during and after a shock. Even relatively short disruptions in health care or education can have long-term adverse consequences, especially for vulnerable groups.

Chapter 11. Help firms and people manage residual risks and natural disasters

No matter how much private actors and governments try to reduce exposure to shocks or make their assets and networks more resistant to natural hazards and climate change, risk cannot be reduced to zero, particularly not in a region that is as prone to extreme events as the Caribbean. Shocks will continue to inflict damage, so it is vital to supplement risk reduction measures with improvements in people's ability to cope with and minimize the impact of unavoidable shocks. Governments need to help the population better prepare for residual risk and natural disasters through preparedness and response systems and business continuity plans, and enable them to bounce back through insurance markets and adaptive social protection. Finally, given the frequency of shocks in the Caribbean, governments must prepare to build back better, using reconstruction as an opportunity to reduce pre-shock levels of exposure and vulnerability.

Chapter 12. Anticipate and manage macrofiscal and financial issues

Managing macrofiscal and financial issues is key for building resilience in the Caribbean. Natural and economic shocks directly affect economic activity and tax revenues, while strong impacts on major sectors (especially exporting ones) can affect a country's trade balance and capital flows. The combination of these factors may result in new risks for macroeconomic stability, public finances, debt sustainability and the financial sector, which in turn affects the country's ability to respond to natural disasters and external shocks. In addition, constrained institutional capacity and resources affect how efficiently and effectively resources are mobilized post-shock and can further worsen the impact of natural and economic shocks.

BOX I2.1 >>

The traffic light system used in this report

The traffic light system (TLS) is based on the conceptual framework proposed by Hallegatte, Rentschler and Rozenberg (2020) and is organized around actors and responsibilities within governments, grouping actions under "foundations" for rapid and inclusive development, which offers protection against shocks, and five priority areas[a] to build resilience and adapt to shocks (***figure BI2.1.1***). The TLS conceptual framework covers the five pillars outlined in the *Caribbean Pathway for Building Resilience*,[b] namely (i) Social protection for the marginal and most vulnerable, (ii) Safeguarding infrastructure, (iii) Enhancing economic opportunity, (iv) Environmental protection, and (v) Operational readiness, but it also covers more extensively the role of the Ministry of Finance through macro-fiscal policy and financial sector regulation for resilience. The goal is to identify gaps, facilitate target setting, and monitor progress across all sectors and aspects of resilience.

Under each priority area lie several actions with indicators to monitor progress towards implementing these actions. According to criteria defined by World Bank experts, the framework defines three maturity levels and classifies the indicator as:

- **Nascent** (red) when the country does not meet the standard or includes areas that are only starting to or do not address the standard at all
- **Emerging** (yellow) when the country partly meets the standard and has progressed beyond the initiation point but has not reached the final point
- **Established** (blue) when the country meets the standard

The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. It is intended to serve as a starting point for discussion, and the indicators and ratings can be modified, based on additional country-level information. The TLS can also be used as a complement to other resilience tools already available in the region, such as CDEMA's Comprehensive Disaster Management (CDM) Audit Tool.[c] While the CDM Audit Tool provides more depth when analyzing the traditional disaster risk management (DRM) cycle, the TLS proposed here is broader and includes actions that are the responsibility of the Ministries of Finance or Economy, Health, Education, or Social Protection. As such, the TLS can first be used to identify areas that require attention, while CDEMA's framework can be used to identify and monitor more specific actions.

[a] In this report, the *Adaptation Principles*' priority area 2—*Adapt land use plans and protect critical public assets and services*—has been split into two: *Design resilient infrastructure systems, urban and coastal plans* and *Build resilient health and education systems*. *The Adaptation Principles*' framework also proposes a sixth priority area for institutions, legal frameworks, planning and monitoring. In this report, the actions in this area are included in each of the five presented priority areas.

[b] https://www.cdema.org/Building_A_Caribbean_Pathway_For_Disaster_Resilience_In_The_Caribbean_Community_(CARICOM).pdf

[c] https://www.cdema.org/cdm

FIGURE BI2.1.1 >>

Conceptual framework applied to the TLS and used in Part 2 of this report

PRIORITY AREA 1	PRIORITY AREA 2	PRIORITY AREA 3	PRIORITY AREA 4	PRIORITY AREA 5
Facilitate risk reduction decisions by firms and households	Design resilient infrastructure systems, urban and coastal plans	Build resilient health and education systems	Help people and firms manage residual risks and natural disasters	Anticipate and manage macrofiscal and financial issues

FOUNDATIONS

Rapid, robust, and inclusive development

Source: Adapted from Hallegatte, Rentschler and Rozenberg 2020

Note: Foundations are the actions, systems and processes that enable rapid, robust, and inclusive development and form the basis of the conceptual framework, while the five priority areas identify actions governments can take to strengthen resilience.

References

Hallegatte, S, Rentschler, J, and Rozenberg, J. 2020. *Adaptation Principles: A Guide for Designing Strategies for Climate Change Adaptation and Resilience*. Washington DC: World Bank.

7

CHAPTER 7 >>

Foundations for rapid, robust, and inclusive growth

Poverty reduction and sustainable economic development are essential for reducing vulnerability to shocks. Any resilience strategy must start with solid foundations that focus on eradicating extreme poverty and ensuring that everyone has access to basic services, including infrastructure, health, education, and financial services. This chapter draws on sectoral background notes prepared for this report, including Beazley and Williams (2021), Bellony and Powers (2021), Harnam and Khan (2021), Li (2021), Masetti (2021), and Medina, Kullmann and Felter (2021).

Economic opportunity and growth

Economic development and GDP growth are heterogenous across the Caribbean. The World Bank classifies most Caribbean islands as upper middle-income economies, and some as high-income economies. Haiti is the only low-income country in the region. Despite the differences in economic structures, several common development challenges emerge, including high debt, a lack of fiscal buffers, a sluggish, undiversified private sector, and a lack of policies that facilitate "doing business". Emigration of skilled persons, high crime and violence levels, and other structural impediments further curtail growth and development in the region. Altogether, these factors have resulted in a complex and challenging environment for promoting sustainable growth and development (Beuermann and Schwartz 2018).

As seen in *Part 1*, Caribbean countries have shown persistently weak economic growth. Since 2000, real GDP growth of their economies has been half that of other emerging market and developing economies and two-thirds that of non-Caribbean small states (Srinivasan et al. 2017). While commodity exporters saw faster growth in the 2000s due to largely positive effects from the commodity price boom, their growth has also slowed or turned negative (Srinivasan et al. 2017). Annual GDP growth rates averaged only 1 percent, compared with 1.7 per cent (in 2019) for all small states (OECD et al. 2019). Most of the Caribbean islands also exhibit high levels of growth volatility, creating uncertainty, hindering economic growth, and negatively affecting public finances (Beuermann and Schwartz 2018). This low growth and high volatility could be partially explained by the high levels of debt accumulated after the 2008 global financial crisis, which prevents countries from implementing counter-cyclical fiscal policies after shocks.

The COVID-19 pandemic further depressed growth in Latin America and the Caribbean, with the economy contracting by an estimated 6.9 per cent in 2020 as a result of control measures, risk aversion by households and firms, and spillovers from a shrinking global economy (World Bank 2021). This contraction was bigger than any other emerging market and developing economy regions. More specifically, Caribbean economies were among the most affected by the pandemic, with annual hotel stays plummeting by 70 percent and cruise ship travel stopping completely (Srinivasan, Muñoz and Ding 2021). Tourism-dependent countries contracted by 9.8 percent in 2020, while commodity exporters (Trinidad and Tobago, Suriname, and Guyana) were less affected, seeing a mild contraction of 0.2 percent (Srinivasan, Muñoz and Ding 2021). However, growth in the Caribbean is projected to rebound to 4.5 percent in 2021, boosted by a partial recovery of tourism to prepandemic levels and with it, employment (World Bank 2021).

The size of Caribbean economies is a limiting factor for growth. Structurally, SIDS have small populations and small land areas, which translates into small markets and limited resources. Lacking economies of scale, Caribbean countries are less diversified and heavily depend on one or two major sectors, which are also the main exporters and mostly driven by external demand. This exposes them to sector-specific shocks and global business cycles. However, they have also specialized in their comparative advantage, and Easterly and Kraay (2000) find that, once location is controlled for, small states grow faster than larger ones. Ruprah, Melgarejo and Sierra (2014) also find that size does not account for the documented underperformance, suggesting that rent-seeking and state capture by private elites hold back growth.

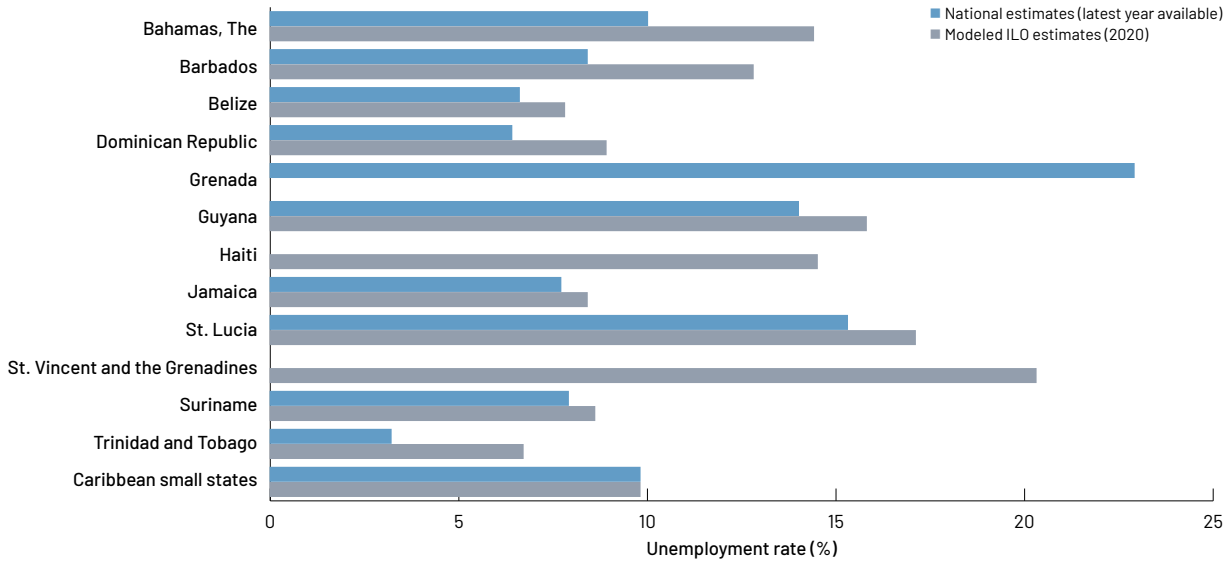
A defining feature of Caribbean growth compared with other regions has been the weak contribution of total factor productivity, which measures the overall productivity of both labor and capital and reflects elements like technology and innovation. Srinivasan et al. (2017) suggest that, in contrast with other small states, emerging markets, and developing economies, total factor productivity growth in the Caribbean has been near zero or negative since 2000. The region in general has not caught up with OECD member countries in terms of $ per capita or controlling for price differences between countries, at per capita PPP$. The exception is Trinidad and Tobago, which saw improvements up until 2008 (Ruprah, Melgarejo and Sierra 2014).

Another limiting factor has been persistently high energy costs over the past two decades. Oil is a key energy source, and diversification has been limited. Combined with inefficiencies in the power sector and dependence on expensive petroleum imports, this has eroded competitiveness (Mcintyre and Ashram 2017).

The region's prolonged and sustained weak economic and fiscal performance poses significant challenges for their public and private sector debt burden, raising wages, improving social conditions, and creating jobs. In many countries—Guyana, Haiti, Trinidad and Tobago, and The Bahamas are notable exceptions—debt-to-GDP ratios remained above the 60 percent threshold, potentially harming growth prospects (Ruprah, Melgarejo and Sierra 2014). In some cases, debt-to-GDP ratios have remained significantly higher, including Antigua and Barbuda and Dominica (over 80 percent), and Barbados, Belize, and Jamaica (over 90 percent). But in a few countries, such as Jamaica, Grenada, and St. Kitts and Nevis, the ratio has decreased in the past decade. Low growth also contributes to high unemployment, with rates in Grenada, St. Lucia, and St. Vincent and the Grenadines recently topping 15 percent (*figure 7.1*).

FIGURE 7.1 >>

Unemployment rates in Caribbean countries



Source: Based on data from World Bank, World Development Indicators[1]
Note: National estimates for latest year available between 2015–2020.

Governance

Good governance is essential for an economic system to function properly and be resilient, and policies are needed that allow for a quick injection of financing into the economy after a crisis to mitigate the short-term impacts of a shock. However, without good public governance—including accountable policy design, clear targeted groups, transparency, and following appropriate regulatory frameworks—the effectiveness of such policies would be seriously compromised. Moreover, the credibility of public governance is crucial for guiding private sector responses and accessing international assistance.

Extensive literature has shown that quality of public governance is positively correlated with economic growth, while increasing research has focused on this result under the context of external shocks. Kaufmann and Kraay (2002) argue that governance quality and long-term economic growth are positively associated. In their evaluation of the Worldwide Governance Indicators (WGI) from 1996 to 2002, they found that "per

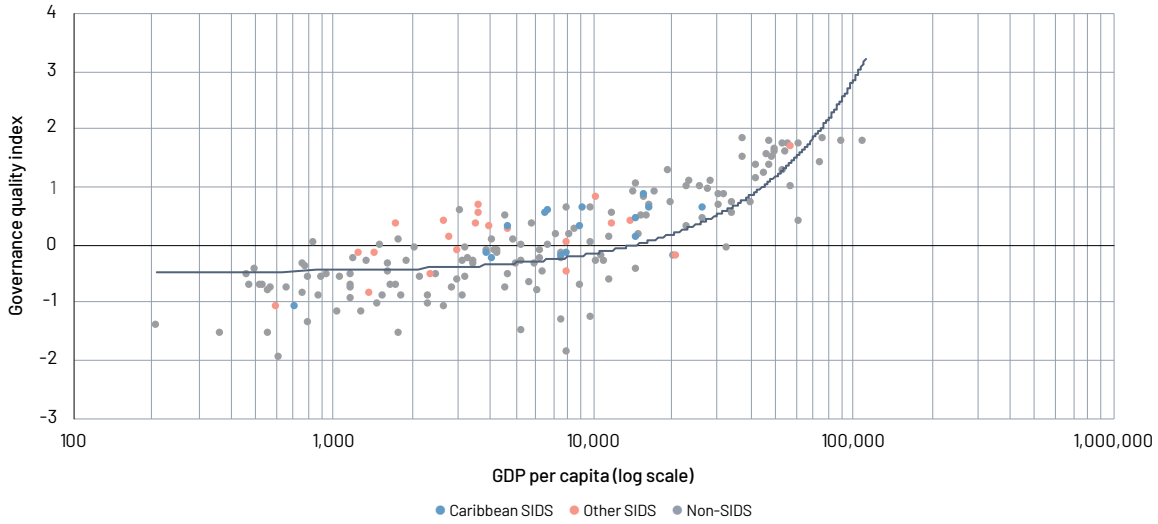
capita incomes and the quality of governance are strongly positively correlated across countries". However, the causality between good governance and higher economic growth is still subject to debate.

Meanwhile, a growing volume of literature focuses specifically on good governance and economic performance in the context of external shocks. In terms of the macro-level responses to crisis, Noy (2009) concludes that institutions affect the direct efficiency of postdisaster public interventions or have an indirect impact by shaping the private sector response. At the micro level, the literature mostly emphasizes the positive impacts of good governance on human development, which enhances the capacity to mitigate and recover from external shocks at the individual level. For example, Alkire (2010) concludes that human development requires both economic growth and good governance, which supports an economy's productivity and resilience by providing healthy, highly trained individuals.

Good and effective governance is particularly important for the Caribbean, where external shocks are normally large and affect the whole economy, and the private sector is less developed in terms of protection. This implies a more critical role for the government. However, the quality of governance in the Caribbean—especially in tourism-dependent economies—is relatively low compared with countries of similar income level (measured by the WGIs; *figure 7.2*). Considering the importance of the public sector and the high levels of vulnerability in the Caribbean, there is a significant need to improve public governance.

FIGURE 7.2 >>

Governance quality and income levels



Source: Based on data from the WGI 2019 Update;[2] World Bank, World Development Indicators[1]

Inclusion and access to basic services

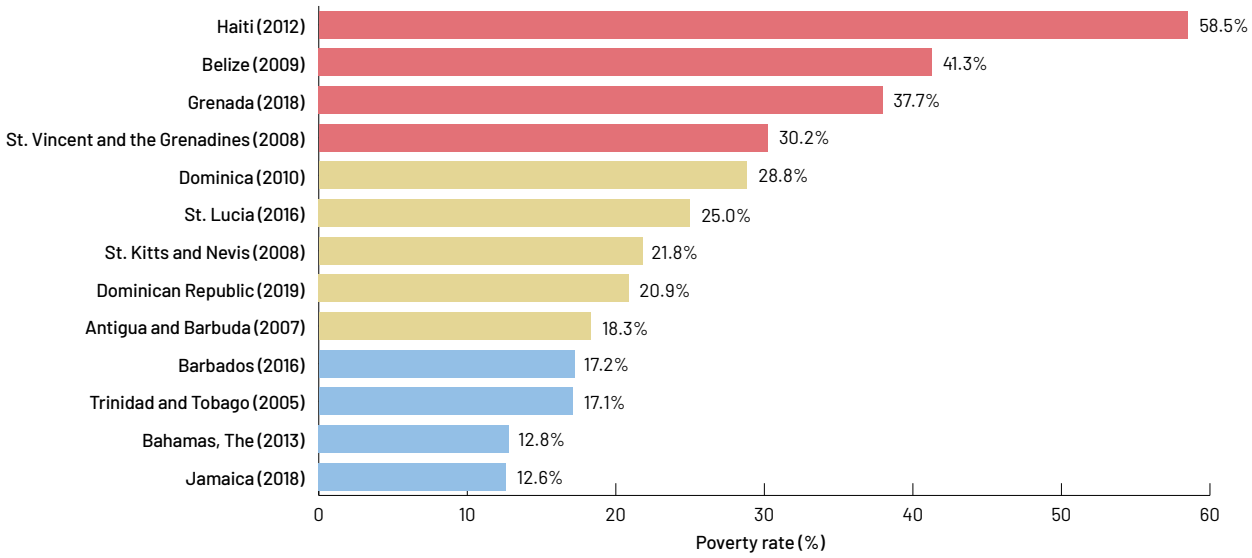
Poverty and a lack of access to basic services—such as critical infrastructure, financial services, health care, and social protection—are strong predictors of vulnerability to disasters and climate change. No resilience strategy can be successful without eradicating extreme poverty and ensuring high-vulnerability populations have the financial, technical, and institutional resources they need to bounce back from shocks and adapt to climate change.

Poverty

Poverty in the Caribbean remains high; in most countries, at least one-fifth of the population lives in poverty (*figure 7.3*). The most recent estimates show that 38 percent of Grenada's population was poor in 2018, 17.5 percent in Barbados (2016), 28.8 percent in Dominica, (2010), 22.8 percent in the Dominican Republic (2019), and 25 percent in St. Lucia (2016). At the other end of the scale, Jamaica recorded a poverty rate of 12.6 percent in 2018, a considerable improvement from 19.3 percent in 2017. However, the overall lack of frequent and periodic household surveys in the region is a constraint on measuring poverty, resilience, and other well-being dimensions. Although some countries—including Belize, the Dominican Republic, Jamaica, and St. Lucia—undertake periodic surveys, others have not collected household data for more than 10 years, limiting their ability to implement evidence-informed policy and program decisions.

FIGURE 7.3 >>

Poverty rates in Caribbean countries



Sources: Based on data from country poverty assessment reports and living conditions surveys 2005–2018

Notes: Poverty headcount rates are compiled from most recent available data for each country (shown in parenthesis). Countries in red (nascent) are in the lowest third; those in yellow (emerging) are in the middle third; and those in blue (established) are in the top third.

Social protection

Countries have made significant progress in developing social protection systems (Beazley and Williams 2021). Social protection helps facilitate equity, build resilience, and promote opportunity through benefits and services, including noncontributory social assistance or social safety nets, active labor market programs, social care services, and contributory social insurance (World Bank 2012). Driven by substantial spending, social protection is increasingly visible in the region. Most countries have a mix of programs to support the main social protection objectives of equity/protection, opportunity/promotion, and resilience/prevention (*table 7.1*). These include:

- Cash transfer programs and social pensions for smoothing consumption
- School feeding programs for improving food security, nutrition outcomes, and school attendance
- Active labor market programs for improving employability and increasing earnings
- Social insurance for protecting against disability, old age, and other risks

TABLE 7.1 >>

Social protection programs in Caribbean countries

Country	Social safety nets *Equity/protection*							Labor markets *Opportunity/ promotion*		Social insurance *Resilience/prevention*		
	UCT	CCT	Social pension	ECT/ RG	SFP	Public works	US	ST	ES	Pensions	UI	OSI
Antigua and Barbuda	✓		✓		✓		✓	✓	✓	✓		✓
Belize		✓	✓		✓			✓	✓	✓		✓
Dominica	✓		✓		✓	✓		✓		✓	✓	✓
Dominican Republic		✓			✓		✓	✓		✓		✓
Grenada		✓		✓	✓	✓		✓		✓		✓
Guyana	✓		✓		✓			✓		✓		✓
Haiti				✓	✓	✓				✓		
Jamaica		✓		✓	✓			✓	✓	✓		✓
Sint Maarten	✓		✓					✓	✓	✓		
St. Kitts and Nevis	✓			✓	✓			✓		✓		✓
St. Lucia	✓				✓	✓		✓		✓		✓
St. Vincent and the Grenadines	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓
Trinidad and Tobago	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

Source: Beazley and Williams 2021

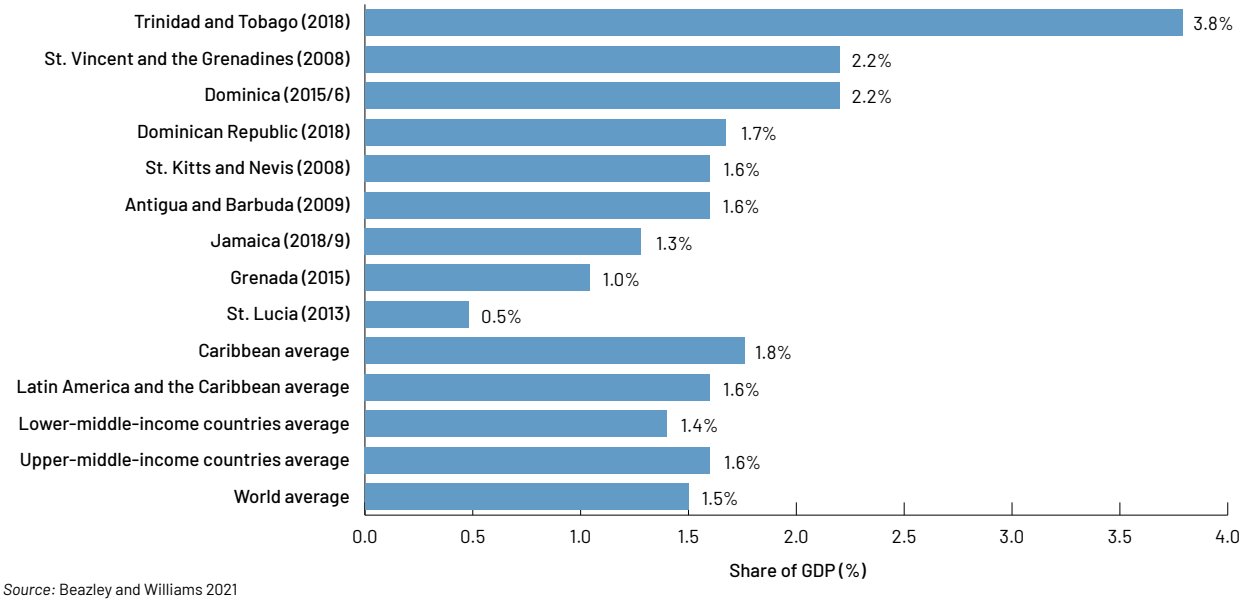
Notes: UCT = unconditional cash transfer (poverty-targeted to households); CCT = conditional cash transfer (poverty-targeted to households); ECT/RG: emergency cash transfer or relief grant (one-off or temporary cash or in-kind transfers for emergencies that are an established part of the social protection system); SFP = school feeding program; US = utility subsidies or waivers; ST = publicly funded skills training programs; ES = employment services; UI = unemployment insurance; OSI = other social insurance (short- and long-term benefits, including maternity, workplace injury, etc.).

Progress has been driven by substantial public spending. On average, social spending in the Caribbean is similar to Latin American countries and the world's average (***figure 7.4***), but higher than East Asia and the Pacific, the Middle East and North Africa, South Asia, and Sub-Saharan Africa (World Bank 2018). In the Caribbean, foundational social protection programs, which form the basis for adaptive social protection programs, are mostly financed annually by recurrent budget expenditures and maintaining beneficiary quotas without disruptions. Haiti is an exception, as the vast majority cash transfer programs are financed by external donors and implemented through humanitarian agencies.

Gaps remain in terms of coverage and adequacy. In Jamaica, one of the countries with the highest social protection coverage in the Caribbean, almost 20 percent of the population has no access to social protection, while in St. Lucia, more than half of the population is excluded (53 percent). Social insurance coverage in the region remains low and pro-rich due to the predominantly high levels of informality. In Jamaica, only approximately 40 percent of those in the poorest quintile have access to social insurance (***figure 7.5a***). This proportion goes down to less than 20 percent in St. Lucia (***figure 7.5b***). Social assistance is pro-poor, but with substantial room for improvement in terms of reaching the poorest. For example, in Jamaica, 36 percent of those in the poorest quintile are excluded from social assistance, while in St. Lucia, this proportion is 47 percent.

FIGURE 7.4 >>

Social protection spending as percentage of GDP

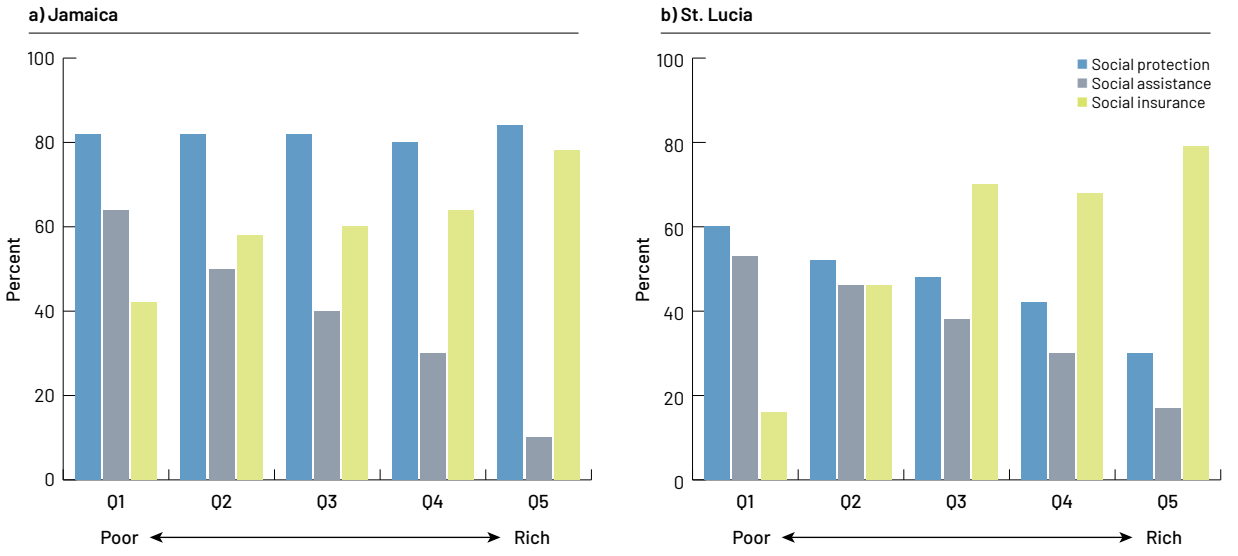


Source: Beazley and Williams 2021

Note: Social protection spending figures are compiled from most recent available data for each country (shown in parenthesis after each country on the vertical axis).

FIGURE 7.5 >>

Share of Jamaican and St. Lucian populations receiving social protection benefits, by wealth quintile



Source: Beazley and Williams 2021

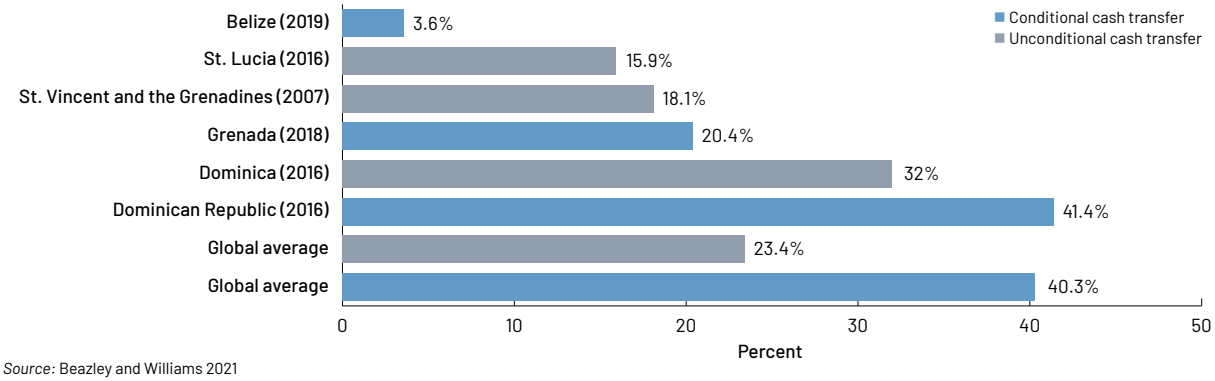
Notes: Social protection includes social assistance and social insurance. Panel a: *social assistance* includes the Program of Advancement Through Health and Education and the Poor Relief and School Feeding Program; *social insurance* includes National Insurance Scheme and government pension beneficiaries. Panel b: *social assistance* includes Koudmen Ste Lisi and the Public Assistance, Housing Assistance, Education Assistance, School Feeding, and School Transportation Programs; *social insurance* includes National Insurance Corporation beneficiaries. Coverage also includes indirect beneficiaries (other members of a household with a direct beneficiary, but for whom no specific benefit is assigned).

Coverage of flagship cash transfer programs in most Caribbean countries remains low compared with global averages. In several countries, close to 80 percent of the poorest quintile receive no benefits from programs that are intended to be the main social protection intervention (***figure 7.6***). Only the Dominican

Republic's conditional cash transfer (CCT) program slightly exceeds global averages, while coverage in Belize, Dominica, Grenada, and St. Vincent and the Grenadines is likely to be lower than this figure suggests. These countries lack recent household surveys, so in coverage calculations perfect targeting (or identification of the poor) is assumed (Beazley and Williams 2021). Most countries have a social pension system and, while some (such as Trinidad and Tobago) reach universal coverage, in others, there is room for improvement. For example, in Dominica, some 40 percent of the elderly population does not receive a pension. School feeding programs exist in all examined countries except Sint Maarten. Indeed, in some countries, such as St. Lucia, school feeding is the main social safety net. Targeting varies across countries: in Dominica and Haiti, school feeding programs are offered in selected public schools only, in Trinidad and Tobago, they only target children in need, while in Grenada, they are offered universally (Barca et al. 2019).

FIGURE 7.6 >>

Cash transfer coverage rates in the Caribbean vs global averages



Source: Beazley and Williams 2021

Notes: Accounts for coverage of direct beneficiaries; for the Dominican Republic, St. Lucia and Jamaica, coverage is estimated as a share of the poorest quintile; for Belize, St. Vincent and the Grenadines, Grenada, and Dominica, coverage is estimated as a share of households below the poverty line, with the most recent poverty rate applied to the current population; program coverage for countries without household survey data assume perfect targeting, so actual coverage is lower; global UCTs cover 23.4 percent of the poorest quintile (ASPIRE); CCTs cover 40.3 percent of the poorest quintile (ASPIRE).

TABLE 7.2 >>

Benefit adequacy of select cash transfer programs in Caribbean countries

Country	Program name	Program type	Adequacy (%)	Year
Belize	Building Opportunities for Our Social Transformation (BOOST)	CCT	60.1	2019
Dominican Republic	Progresando con Solidaridad (PROSOLI)	CCT	2.8	2016
Jamaica	Program of Advancement Through Health and Education (PATH)	CCT	15.3	2017
St. Lucia	Public Assistance Program	UCT	45.6	2016
St. Vincent and the Grenadines	National Assistance Fund	UCT	33.6	2019
Latin America and Caribbean average		CCTs	21	2019
Global average		CCTs	15.6	2018
Global average		UCTs	18.6	2018

Source: Beazley and Williams 2021

Notes: CCT = conditional cash transfer; UCT = unconditional cash transfer. For Belize, Jamaica, St. Lucia, and St. Vincent and the Grenadines, adequacy is estimated by using the last available average annual benefit as a share of the food poverty line. Where the food poverty line is outdated, it is adjusted to current prices using official Consumer Price Index data. For the Dominican Republic, adequacy refers to adequacy of CCT benefits in the poorest quintile. The global averages measure the cash transfer value captured in household surveys, as a share of beneficiaries' post-transfer well-being among the poorest quintile.

Benefit adequacy is an important performance indicator to help assess the potential impact of social protection benefits on consumption smoothing and ultimately, poverty reduction, particularly assuming that the poor use most of their income on consumption. For most Caribbean countries, assessing benefit adequacy is difficult, given the absence of recent household surveys for some countries. And where recent household surveys are available, the relevant variables are not structured to effectively assess benefit adequacy of specific noncontributory transfers. Nevertheless, a rapid assessment of some countries' programs shows that benefit adequacy is mixed (*table 7.2*). Programs in Belize, St. Lucia, and St. Vincent and the Grenadines perform better than regional and global averages, while programs in Jamaica and the Dominican Republic perform poorly. However, it is important to note that for both the Dominican Republic and Jamaica, CCT transfers are complemented by other benefits; and while they have lower adequacy, both countries demonstrate higher coverage than those with more adequate benefits. While indicative, this demonstrates the trade-offs countries face between expanding coverage and increasing benefits.

Health

Health care provision is improving, but challenges remain. While each Caribbean country's health situation and system is unique, there are common regional[3] trends and, overall, the scope and quality of health care provision has improved in the last decades. For example, life expectancy has increased from 70.2 years in 1990 to 73.6 years in 2017; maternal mortality rates have decreased steadily from 112 to 88 per 100,000 live births since the turn of the century; and under-five mortality has fallen from 3.5 percent in 1990 to 1.7 percent in 2019. At the same time, government health spending as a percentage of GDP is increasing, albeit slowly, rising from 2.1 percent in 2000 to 3.3 percent in 2017.

National health ministries provide oversight to health systems and are responsible for health policy development and implementation. In some countries, health services are delivered by one or several national authorities. There is a strong presence of regional organizations—such as CARICOM, CARPHA, and the OECS—that play varying roles to support the functioning of their member states' health systems. Health financing systems vary between countries—for example, Guyana, Jamaica, and Trinidad and Tobago are more reliant on government-funded public systems, while Suriname and the Dominican Republic rely more on social or mandatory insurance schemes with public or private administrators. Like most countries, Suriname, Guyana, and the Dominican Republic have policies or programs in place to ensure low-income and high-risk groups have access to health care. Others, including Jamaica and Trinidad and Tobago, have specific programs targeting high-risk groups. Coverage of essential health services in the region ranges from 47 percent (Haiti) to 77 percent (Barbados) but in most CARICOM states, it is around 70 percent (*table 7.3*). Still, for all countries, patients' out-of-pocket payments at the point of care remain relatively high—around 33 percent of health costs are paid out of pocket, rising to 52 percent in Grenada, 48 percent in St. Kitts and Nevis, and 45 percent in St. Lucia—contributing to income-based inequities in health care access (WHO 2020).

Health capacity is low in the region. The WHO recommends 4.45 doctors, nurses, and midwives per 1,000 population for operational routine services, plus a 30 percent surge capacity (WHO 2019). However, only four of the countries included in this analysis—Antigua and Barbuda, Dominica, Grenada, and St. Vincent and the Grenadines—meet the standard nurse and midwife capacity for operational routine services and none has enough physicians to meet WHO standards (*table 7.3*).

TABLE 7.3 >>

Selected health indicators for Caribbean countries

	Income level	Government health expenditure (2017, % of GDP)	Out of pocket expenditure (2017, % of total health expenditure)	Universal health coverage index	Hospital beds per 1,000 (2014*)	Physicians per 1,000 (2017**)	Nurses and midwives per 1,000 (2018***)	Life expectancy at birth (2018)	Under 5 mortality per 1,000 live births (2018)
Antigua and Barbuda	High	2.5	35	73	3.8	3	4.5	77	6
Belize	Upper-middle	4.7	24	64	1.3	1.1	2.3	74	13
Dominica	Upper-middle	3.5	31		3.8	1.1	6.4		36
Dominican Republic	Upper-middle	2.8	45	74	1.6	1.6	1.4	74	29
Grenada	Upper-middle	2.0	52	72	3.7	1.4	6.3	72	15
Guyana	Upper-middle	2.8	32	72	1.6	0.8	1	70	30
Haiti	Low	1.0	40	49	0.7	0.2	0.7	64	65
Jamaica	Upper-middle	3.7	17	65	1.7	1.3	0.8	74	14
St. Kitts and Nevis	High	2.6	48		2.3	2.7	4.2		12
St. Lucia	Upper-middle	2.2	45	68	1.3	0.6	3.2	76	17
St. Vincent and the Grenadines	Upper-middle	2.8	31	71	2.6	0.7	7	72	16
Suriname	Upper-middle	3.5	26	71	3.1	1.2	2.8	72	19
Trinidad and Tobago	High	4.3	40	74	3	4.2	4.1	73	18

Source: Based on World Bank Open Data.[4]

Notes: *For Dominica, data were from 2012; Haiti, 2013; Jamaica, 2013; St. Kitts and Nevis, 2012; St. Lucia, 2013; Suriname, 2010. **For Guyana, data were from 2018; Haiti, 2018; St. Kitts and Nevis, 2015; St. Vincent and the Grenadines, 2010. ***For St. Kitts and Nevis, data come from 2015; St. Lucia, 2017. Countries in red (nascent) are in the lowest third for that indicator; those in yellow (emerging) are in the middle third; and those blue (established) are in the top third. For universal health coverage index, countries in red (nascent) have less than 64% coverage; those in yellow (emerging) have between 64% and 80% coverage; and those in blue (established) have greater than 80% coverage.

Disease prevalence in the Caribbean

Noncommunicable diseases (NCDs), mortality, and morbidity in Caribbean states are higher than Latin American and Caribbean averages. In 2016, NCDs—particularly cardiovascular diseases, cancer, and diabetes (PAHO 2019)—were responsible for almost 80 percent of all deaths and the main cause of premature deaths among 30–69 year-olds (more so than for any other subregion of the Americas) (PAHO 2015). As a result of the toll exerted by NCDs, life expectancy at birth is now lower in the CARICOM countries than the rest of Latin America, a stark reversal of the situation 30 to 40 years ago.[4]

While the major burden of disease stems from the rising prevalence of NCDs, certain communicable diseases also remain detrimental (CARPHA 2018). Despite important advancements, including the elimination of vaccine-preventable diseases such as polio, measles, and rubella (CARPHA 2018), challenges remain around viruses such as HIV, tuberculosis, and dengue (Chattu and Knight 2019). Mosquito-borne viral disease outbreaks are common, historically including dengue (Dick et al. 2012) and more recently, chikungunya in 2013 and Zika in 2015 (CARPHA 2018). Haiti is an exception to the Caribbean's general trends of disease burden, with communicable diseases outstripping NCDs and low vaccine coverage. Poor health outcomes in Haiti are related to high national poverty levels, low access to basic health care, and political unrest (Talbot and Shevy 2017).

Education

School dropout is a persistent problem in Caribbean countries, with 8.5 percent of students dropping by the last grade of primary school. The problem continues throughout the education cycle: by the end of lower secondary in some countries, cumulative dropout rates have doubled (Suriname), tripled (St. Vincent

and the Grenadines), or increased sevenfold (Belize) (Bellony and Powers 2021). The largest out-of-school rates are observed in The Bahamas, Belize, and Suriname, which all have upper secondary dropout rates well above 30 percent (*table 7.4*). One factor increasing the risk of dropout is being over the age range for a specific grade level. Although most countries register less than 5 percent of over-age students, in those that have rates above 5 percent, common sociodemographics include having: a (partially) indigenous population, migrants whose main language is different from the host country language, and classroom instruction in a different language from that spoken in sections of the population. Countries with large numbers of over-age students include Suriname (16 percent), Sint Maarten (15 percent), Dominica (11 percent), and Belize (9 percent) (*table 7.4*). Over-age students represent a significant proportion of the population with less than optimal educational attainment.

TABLE 7.4 >>

Foundational problems in Caribbean countries' education systems

	Out of school (%)			Over-age students (%)	Trained teachers (%)		Educational attainment (%)			Education years lost
	Primary	Lower secondary	Upper secondary	Primary	Primary	Secondary	Primary	Lower secondary	Upper secondary	
Antigua and Barbuda	0.7	1.4	12.8	3.6	52.8	47.7				4.6
Bahamas, The	23.5	29.5	32.5	8.5	89.8	83.1	95.1	89.1	81.9	
Barbados	1.1	3.8	5.6	1.9	75.1	51.9	86.4	78.1	24.2	
Belize	0.5	10.1	38.8	8.7	17.7	33.3	99.8	83.9	36.8	
Dominica	4.0	2.0	16.0	11.1	94.9	82.8	71.2	67.2	48.6	4.4
Dominican Republic	3.7	10.7	24.6	6.7	62.9	45.0	89.4	26.6	10.8	5.3
Grenada	0.8		3.2	4.1	62.9	46.3		10.0		4.8
Guyana	1.8			1.2	69.6	57.4	67.5	31.2	31.2	5.4
Haiti							7.8	10.0	2.3	5.3
Jamaica	17.2	17.9	24.5	5.3	100.0	100.0	99.2	60.7		4.3
Sint Maarten				15.3						
St. Kitts and Nevis	1.1		4.5	1.7	72.0	61.7		69.6		4.5
St. Lucia	1.7	11.9	19.7	2.7	88.1	72.3		45.9	40.4	4.2
St. Vincent and Grenadines	0.5	1.5	15.1	2.4	61.1	58.4	91.3	9.6	41.8	4.6
Suriname	12.3	15.0	37.9	16.0	99.0	71.3	90.4	61.8	24.7	
Trinidad and Tobago	1.2			8.0	88.0		94.6	67.5	56.7	3.3
Turks and Caicos	27.8			6.5	42.8	97.6		24.5		

Source: Based on World Bank, World Development Indicators 2020;[1] World Bank 2019.

Notes: Data shown are latest year available (year might vary by country). Countries in red (nascent) are in the bottom third for educational attainment and trained teachers or the top third for dropout, out-of-school, and over-age rates; those in yellow (emerging) are in the middle third; and those in blue (established) are in the top third for educational attainment and trained teachers or the lowest for dropout, out-of-school, and over-age rates. Gray cells show that there are not enough available data to make a rating. "Education years lost" shows the gap between expected years of schooling and learning adjusted years of schooling, or the years of learning students are expected to attain against the benchmark of top-performing education systems (Filmer et al. 2018).

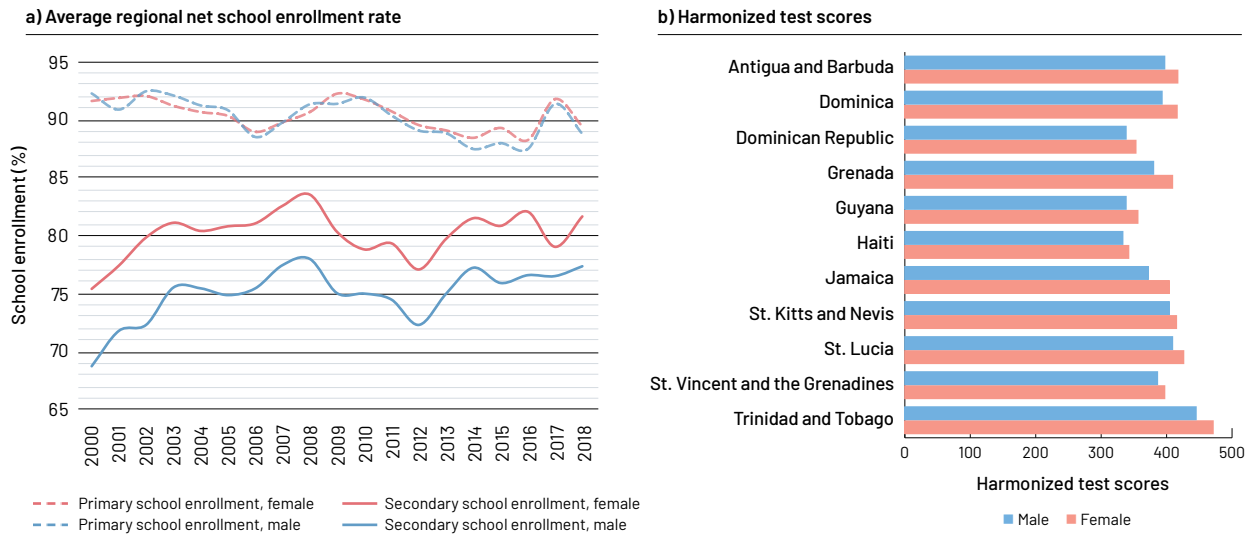
Poor quality education decreases the amount of human capital students can acquire during school. The difference between expected years of schooling and learning adjusted years of schooling gives an indication of school years lost to poor quality education. *Table 7.4* shows that this gap is largest in the

Dominican Republic (5.3 years), Guyana (5.4 years), and Haiti (5.3 years). Recent regional examination results reveal that learning outcomes are low and inequitable; in 2019, only half of all students had the required proficiencies in mathematics and two-thirds in language by the end of primary school (Caribbean Examination Council 2020). Similar results are observed for secondary school outcomes on these subjects. Low performance in mathematics is a persisting regional problem, with attainment rates varying from 33.1 percent in St. Vincent and the Grenadines to 38.6 percent in Grenada, 39.7 percent in Antigua and Barbuda, 43 percent in Guyana, 46.7 percent in Dominica, 51.1 percent in St. Kitts and Nevis, 54.6 percent in Jamaica, and 61.6 percent in Barbados. Few students continue formal education beyond secondary school, likely due to inability to meet entry requirements, enrollment in other education programs, or labor market entry (Bellony and Powers 2021). Consequently, secondary education is the highest level of educational attainment in many Caribbean countries. In Antigua and Barbuda, 76.7 percent of the population record secondary or lower as their highest educational attainment; in Grenada, 83.3 percent; in Jamaica, 55.3 percent; and in St. Lucia, 76.9 percent (Caribbean Examination Council 2020).

Girls are more likely to be in school, and when in school, they score better. Learning in the Caribbean favors girls and there are two effects at play. Regionally, girls are more likely to be in school: over the last two decades, they were 0.2 percentage points more likely to be enrolled in primary school education and 5.2 percentage points more likely to be attending secondary school than boys (***figure 7.7a***). However, the gap in primary school enrollment is small and there are some intercountry differences. In Aruba, Belize, Cuba, the Dominican Republic, Grenada, Guyana, St. Kitts and Nevis, St. Lucia, Trinidad and Tobago, and St. Vincent and the Grenadines, girls are, on average, less likely to be in school than boys, with the largest difference observed in St. Kitts and Nevis (5.8 percentage points). Regionally, girls are more likely to be enrolled in secondary school than boys, with the largest differences observed in Dominica (8 percentage points), the Dominican Republic (9 percentage points), and Suriname (10 percentage points). When they are in school, girls also tend to perform better than boys. Regionally, girls' learning poverty index is lower, they obtain 0.6 more years of schooling on average, and they get higher test scores, resulting in up to 32 points difference in harmonized test scores, as observed in Jamaica (***figure 7.7b***).

FIGURE 7.7 >>

School enrollment and performance in the Caribbean, by gender



Sources: Panel a: Based on World Development Indicators[1]; panel b: Based on World Bank 2020

Notes: Panel a: The net enrollment rate is the ratio of children of official school age who are enrolled in school to the population of the corresponding official school age. The following are included in the regional average: Aruba, Antigua and Barbuda, The Bahamas, Belize, Barbados, the British Virgin Islands, Cuba, Dominica, the Dominican Republic, Grenada, Guyana, Jamaica, St. Kitts and Nevis, St. Lucia, Puerto Rico, Suriname, Turks and Caicos, Trinidad and Tobago, and St. Vincent and the Grenadines.

Water and sanitation

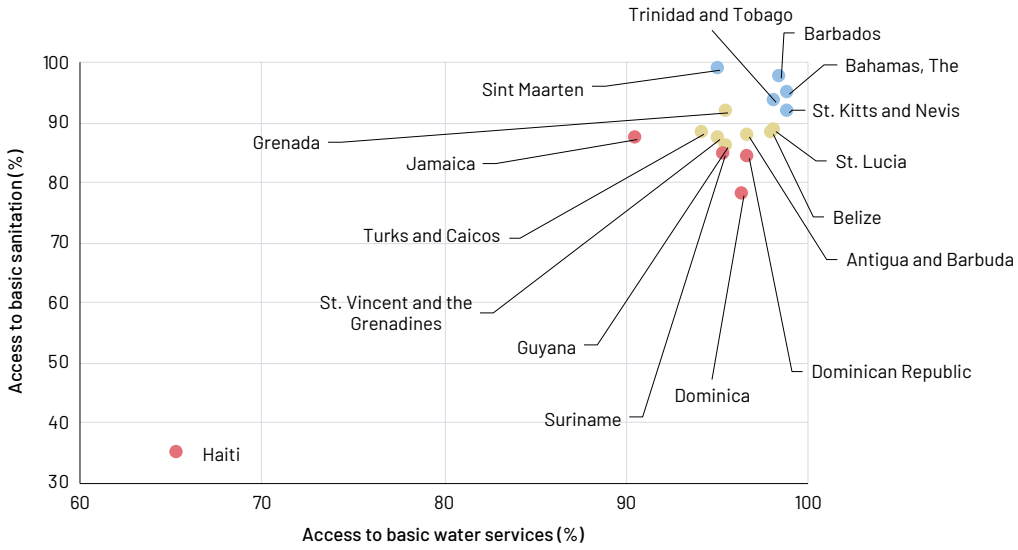
Although water levels are worrying in many Caribbean countries (*chapter 9*), access to basic water and sanitation services is generally relatively high, with most countries ranking above 80 percent for both services.[5] When considering only access to basic water supply, all countries rank over 90 percent, except Haiti (65.5 percent). Access to basic sanitation is slightly lower, but still over 85 percent for most countries, except Dominica (77.9 percent) and Haiti (34.7 percent) (*figure 7.8*). Caribbean countries are on a similar level to the rest of Latin America, which has a regional average of 91.7 percent for basic sanitation and 97.7 percent for basic water supply. Except for Grenada, which reports that 87 percent of their water supply is safely managed,[6] there are no data available on the quality of services (measured as "safely managed" by the Sustainable Development Goal (SDG) guidelines). At subnational level, there are differences in the accessibility of water supply and sanitation between rural and urban areas. While data are scarce in the Caribbean, when they exist, they demonstrate that rural residents generally have lower accessibility compared to urban areas—for example, in urban Haiti, more than 80 percent of households report access to basic water supply, compared with just over 40 percent in rural areas—and within rural areas, access to basic water services is higher than sanitation (Medina, Kullmann and Felter 2021).

FIGURE 7.8 >>

Access to basic water and sanitation services in Caribbean countries

Source: Medina, Kullmann and Felter 2021

Notes: Countries in red (nascent) are in the lowest third for combined water and sanitation access; those in yellow (emerging) are in the middle third; and those in blue (established) are in the top third.



While basic water supply and sanitation services reach a large proportion of the population across the Caribbean, there is some variation in how services are provided. Although a large percentage of the urban population can access basic water services, those without access to piped services receive lower-quality services. Likewise, piped sewerage services generally provide a higher quality of service than pit latrines or septic tanks. Breaking down the types of infrastructure that households have access to provides insight into the resilience of water infrastructure. However, only a small share of urban households can access sanitation services through sewerage connections, and even in Jamaica and the Dominican Republic—the two countries with the highest percentage of sewerage services—less than 25 percent of households are connected.

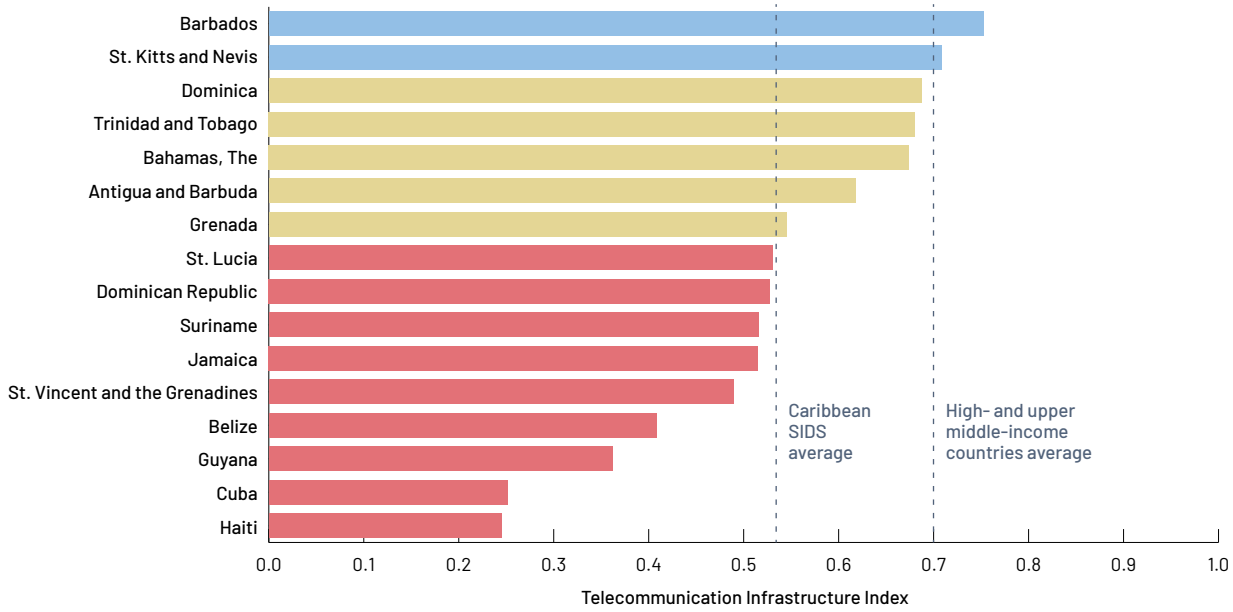
Information and communications technology

In many Caribbean countries, levels of information and communications technology (ICT) development, adoption, and use are relatively low. According to the UN's 2020 Telecommunications Infrastructure Index—which measures accessibility of telecommunications infrastructure based on the share of active mobile broadband subscriptions, internet users, mobile subscribers, and fixed broadband subscriptions—

accessibility to and adoption of this type of infrastructure in the Caribbean can be improved. Many countries are below the Caribbean average, and only St. Kitts and Nevis and Barbados are above average for upper-middle and high-income countries (*figure 7.9*). Many still have relatively low mobile penetration rates and broadband subscriptions, and face challenges in adopting it into their public administration.

FIGURE 7.9 >>

Access to ICT in Caribbean countries



Source: Based on data from United Nations 2020

Notes: Countries in red (nascent) are below the Caribbean SIDS average of 0.53; those in blue (established) are over the upper middle- and high-income countries' average of 0.7; those in yellow (emerging) are in between the two averages.

Endnotes

1. https://databank.worldbank.org/reports.aspx?source=world-development-indicators.
2. http://info.worldbank.org/governance/wgi/.
3. The presented regional numbers concern Caribbean small states, including Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Monserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.
4. Healthy Caribbean Coalition. 2017. NCDs in the Caribbean, 25 January. https://www.healthycaribbean.org/ncds-in-the-caribbean/.
5. Drinking water from an improved source, provided collection time is not more than 30 minutes for a roundtrip, including waiting in line (https://washdata.org/monitoring/drinking-water).
6. Drinking water from an improved water source that is located on premises, available when needed, and free from fecal and priority chemical contamination (https://washdata.org/monitoring/drinking-water).

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8

CHAPTER 8 >>

Facilitate risk reduction decisions by firms and households

Private actors have an incentive to increase their resilience and adapt to climate change. However, they face a range of obstacles, from the lack of information and behavioral biases to imperfect markets and financial constraints.

Governments need to minimize these obstacles to maximize the economy's adaptive capacity, support households to reduce their risk, and prevent climate change impacts and natural disasters.

This chapter explores what countries are doing to facilitate risk reduction by firms and households and identifies what they should do to incentivize the private sector to increase resilience and adapt to climate change. Among other sources, it draws on sectoral background papers prepared for this report, including Beazley and Williams (2021), Bellony and Powers (2021), Johnson, Caroca Fernandez and Restrepo Cadavid (2021), Makara (2021), and Masetti (2021).

Assess disaster and climate change risks, and make this information available

Understanding disaster risk is the top priority of the 2015 Sendai Framework for Action,[1] which was signed by all Caribbean countries. It is also the basis for informing the adaptation of firms and people, adapting land use, protecting critical public assets and services, and managing both residual risk and financial and macrofiscal issues. In the absence of clear land use plans, private actors can use publicly available risk information to locate their home or activity away from hazard-prone areas or make the necessary adaptation investments.

But to understand disaster risk, governments must develop or have access to relevant baseline data and knowledge to ensure they can assess the impacts of hazards and climate change. They must also make this information available to all actors to use for decision making. Effective data use requires enforced policies that promote universal access to data services, a legal and regulatory environment that outlines rules for data use and sharing, data-literate end users, and institutions that are can use data to their full potential (World Bank 2021). DRM data come from a wide range of public and private sector agencies and include both sensitive and freely available information. So, what is needed to ensure good quality data that are easily understandable and freely available to all?

Baseline information

Modeling risk and future climate impacts requires many datasets. Some of these base products are vital, and guidelines are available, such as the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA's) Common and Fundamental Operational Datasets (McDonald 2010) and GFDRR's Open Data for Resilience Initiative (Crowley et al. 2014). Essential information for managing most hazards and determining potential climate change impacts include: disaster impacts, administrative boundaries, population data, land mapping, structure and asset locations, hydromet data, and seismic data. The existence and availability of different resilience-relevant data are shown in ***table 8.1***; the scoring criteria in ***table 8.2***.

Disaster impact record

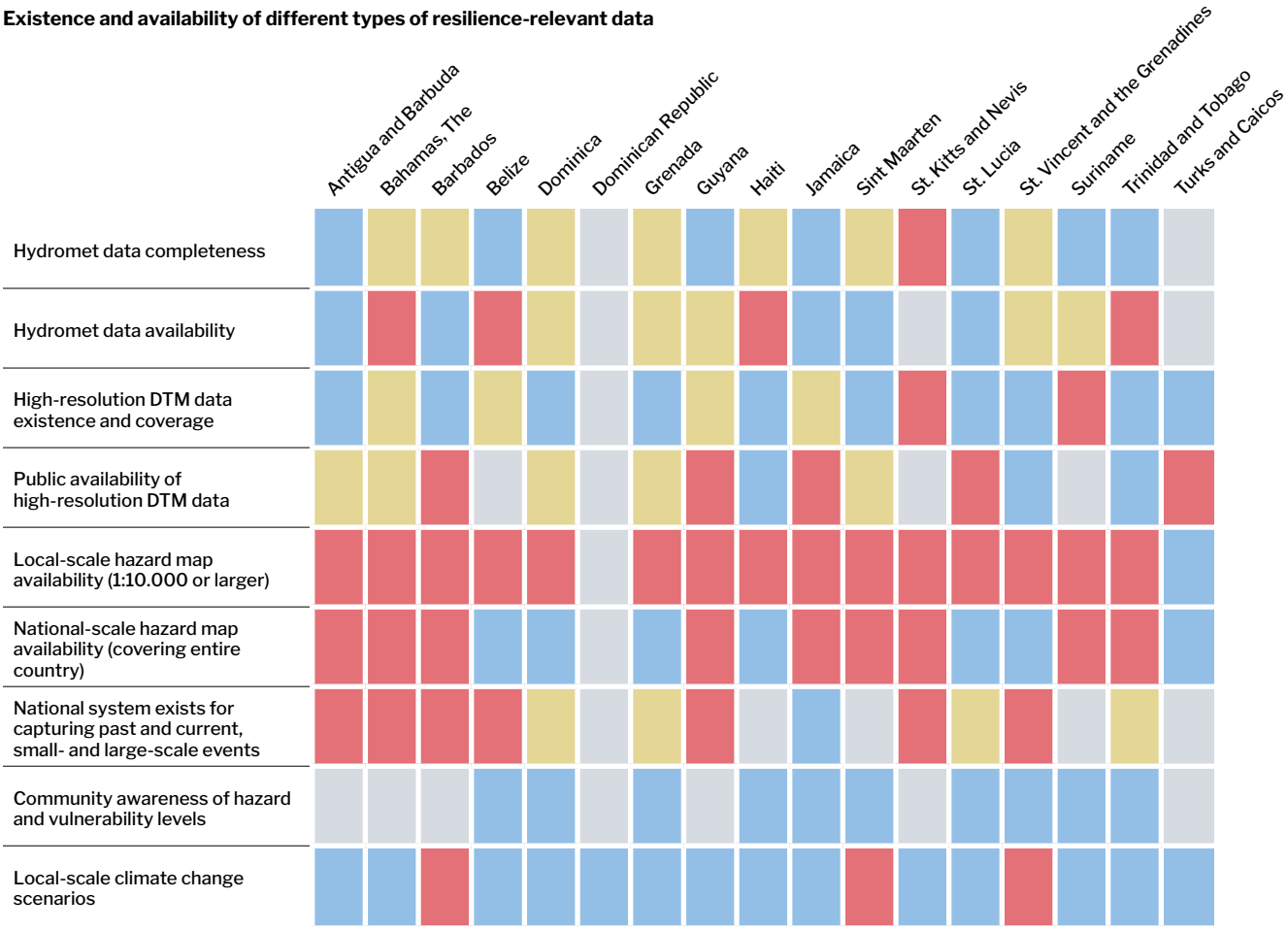
An up-to-date, national-level record of disaster impacts is essential. However, there is no defined standard set of data variables for capturing disaster impacts and no single definition of what constitutes an event worth documenting. Caribbean countries' capacity to assess and report on disaster impacts also varies widely, depending on the resources available to National Disaster Management Offices (NDMOs). Some countries, like Jamaica, Trinidad and Tobago, and Turks and Caicos, have dedicated ICT and geographic information systems (GIS) staff, and Jamaica's National Emergency Response Geographic Information System Team uses mobile devices to map and document disaster impacts. Less well-resourced NDMOs, on the other hand, use paper forms to collect information on impacts, and these are seldom digitized or mapped.

Regionally, CDEMA's Caribbean Risk Information System (CRIS) Virtual Library (***box 8.1***) contains information on historical disaster impacts in the Caribbean, including records of disaster impacts, information notes, and situation reports from CARICOM member states.

Globally, the Sendai Framework and associated portal[6] use a standard set of data variables to provide a record of past disasters for many countries, including those in the Caribbean. The Emergency Events Database (EM-DAT)[7] is another global public database that contains information on subnational jurisdictions and overseas countries and territories in the Caribbean (***chapter 1*** for an overview of the data).

TABLE 8.1 >>

Existence and availability of different types of resilience-relevant data



Sources: Based on data from multiple sources, including government and other websites,[2] news articles,[3] journal articles and research publications,[4] government publications,[5] and personal communications with persons in the countries.

Notes: Countries in red (nascent) do not meet the standard (table 8.2) and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; countries in blue (established) meet the standard entirely. The gray cells show that there are not enough data available to make a rating.

TABLE 8.2 >>

Defining terms: nascent, emerging, and established data indicators

Nascent	Emerging	Established
» **Hydromet data** do not exist	» **Hydromet data** are available in limited locations, representative of limited rainfall regimes, and available on request/at a fee	» **Hydromet data** are available in multiple locations, representative of different rainfall regimes, and publicly and freely available on a web platform
» **Digital Terrain Model (DTM) data** do not exist	» **DTM data** cover less than 60 percent of the country and are available on request/for a fee	» **DTM data** cover over 60 percent of the country and are publicly and freely available on a web platform
» **Hazard data** do not exist	» **Local and national-scale hazard data** are available on request/for a fee	» **Local and national-scale hazard data** are publicly and freely available on a web platform
» **System for capturing past and current events** does not exist	» **System for capturing past and current events** is available but not up to date	» **System for capturing past and current events** is available, applied, and up to date
» There is little **community awareness of hazard and vulnerability levels**, and local hazard maps have not been validated with community members	» There is some **community awareness of hazard and vulnerability levels**, and local hazard maps have been validated to an extent with community members	» **Community awareness of hazard and vulnerability levels** is high, and local hazard maps have been validated with community members
» **Downscaled climate change scenarios** do not exist	» **Downscaled climate change scenarios** exist but are not available to the public	» **Downscaled climate change scenarios** exist and are available to the public

BOX 8.1 >>

The Caribbean Risk Information System

CDEMA is a regional intergovernmental agency for disaster management in CARICOM with 19 participating states. Established in 1991, its primary responsibility is mobilizing and coordinating emergency response and relief efforts in participating states that require assistance. Its other functions include:

- Mitigating or eliminating, as far as practicable, the immediate consequences of disasters in participating states
- Providing immediate and coordinated emergency disaster relief to any affected participating state
- Securing, coordinating, and providing reliable and comprehensive information on disasters affecting any participating state to interested intergovernmental and nongovernmental organizations (NGOs)
- Encouraging participating states to adopt disaster loss reduction and mitigation policies and practices at national and regional levels
- Encouraging cooperative arrangements and mechanisms to facilitate the development of a culture of disaster loss reduction
- Coordinating the establishment, enhancement, and maintenance of adequate emergency disaster response capabilities among participating states

CDEMA established CRIS to fulfill its mandate to "provide a clearing house for relevant information and intelligence on all matters relating to disasters including current research being undertaken in all related institutions".[a] CRIS hosts risk management data and information to facilitate analysis, research, and greater awareness of risk management and climate change adaptation in the region. It contributes to the region's sustainable development efforts by enhancing and strengthening disaster risk and climate change information sharing to drive evidence-based decision making at all levels. The platform has three main components:

1. A geospatial database and web application, **GeoCRIS**, which provides access to geospatial and risk data required for DRM, preparedness, and response operations. Data from the Caribbean Handbook on Risk Information Management (CHaRIM)[b] GeoNode are integrated into the GeoCRIS to facilitate evidence-based decision making and development planning.
2. A **virtual library** of reports and technical articles. This repository of key disaster risk reduction (DRR) and climate change adaptation documents includes but is not limited to model policies, plans, procedures, guidelines, reports, and profiles. The virtual library includes the CHaRIM,[c] which aims to support the generation and application of landslide, flood hazard, and risk information to inform planning and infrastructure sector projects and programs, specifically targeted to small Caribbean countries.
3. A **database component** provides knowledge on disaster events, early warning systems (EWSs), and risk profiles.

When funding becomes available, the CRIS will also host live emergency logs with realtime information as events unfold to inform decision making.

Sources: CDEMA (https://www.cdema.org/about-us) and CRIS (https://www.cdema.org/cris/)

[a] CDEMA. 2020. "CDEMA launches new Caribbean Risk Information System Platform". Press release, November 12. https://www.cdema.org/news-centre/press-releases/2097-cdema-launches-new-caribbean-risk-information-system-platform

[b] An online handbook that supports the generation and use of hazard and risk information in the most frequent infrastructure and physical planning. https://research.utwente.nl/en/activities/caribbean-handbook-on-risk-information-management

[c] https://www.cdema.org/virtuallibrary/index.php/charim-hbook/what-is-charim

While disaster inventories focus on bigger events with significant impacts—for example, where a state of emergency is declared, and/or those with multiple fatalities—they rarely capture smaller, localized events, such as floods, landslides, and rockfalls. And although such events have limited economic impact on their own, their cumulative impact on both the economy and society can be significant. But no Caribbean country systematically keeps record of such events and their related impacts.

Administrative boundaries

Official administrative boundaries for all levels of government are crucial for several applications. Levels of government will vary by country and administrative structure, but are always numbered from Level 0, which is the national boundary. Level 1 may be the state, province, or parish boundary, Level 2 a region or municipal boundary, Level 3 an individual town boundary, and so on. The Humanitarian Data Exchange and GeoCRIS portals both contain freely available datasets of administrative boundaries for countries in the region.

Population data

Information on population count and location is also vital, ideally associated with administrative boundaries. However, managed by national statistical offices (NSOs), these data are not always provided for administrative areas. Rather, they are collected through census districts and enumeration areas, which may not line up with administrative boundaries. Census information can be used to determine the location of vulnerable populations and for details on age and housing stock construction type. As well as the census, NSOs perform or take part in surveys to determine poverty, which are crucial for locating poor and indigent populations. These surveys are often performed with external assistance—for example, the 2009 poverty mapping study in Dominica (Ballini et al. 2009) was supported by the University of Siena and the 2016 National Survey of Living Conditions in St. Lucia (Kairi Consultants Limited 2018) was funded by the Caribbean Development Bank (CDB) and executed by a private consultancy.

Land mapping

Several characteristics of the land are vital for assessing risk from natural hazards and potential climate change impacts. These baseline datasets include topography, bathymetry,[8] and land cover. Global data sources such as Landsat and the Shuttle Radar Topography Mission (SRTM) include topographic and land cover data for the entire region. Bathymetric charts also exist for all the countries. However, assessing hazards and risks requires data that allow clear and accurate delineation of assets at risk. Global datasets are not appropriate for this, especially for the relatively small and dense communities of most Caribbean countries.

Topography

Highly accurate and detailed terrain data make it possible to determine the potential impacts of natural hazards with more precision (*box 8.2*). The small size of most Caribbean countries' inhabited areas necessitates the use of highly detailed topographic datasets. For example, the sea level rise analysis described in *chapter 1* finds that using LiDAR-based terrain models significantly increases modeled flood extent in some countries compared to global SRTM terrain models, as the latter overly generalize the mountainous topography of many Caribbean countries. However, data collection costs—particularly for LiDAR—can be prohibitive and accurately processing them required highly specialized skillsets that are not commonly available in the Caribbean region. Countries also need high computing power and storage infrastructure. Working on a project with USAID to increase LiDAR capacity in the region, the Caribbean Community Climate Change Center has procured a LiDAR unit and plans to conduct regular surveys across the region.[9]

BOX 8.2 >>

Topographic mapping

Topography is the relief of the landscape, which can be represented by contour lines derived from topographic surveys conducted with highly precise instruments measuring the elevation of the earth at regular intervals. National-scale mapping usually uses aerial and space-based sensors. Before digital mapping software and hardware were available, topographic mapping predominantly used photogrammetry with stereo image pairs captured by film cameras mounted on aircraft. The official national topographic maps of many Caribbean countries were created using this technique.

However, digital mapping technologies like LiDAR, structure from motion photogrammetry, and synthetic aperture radar (SAR) have made it possible to produce digital terrain and surface models that far exceed the level of detail and accuracy of traditional photogrammetry. These methods also require less personnel time for processing and data capture. Because of LiDAR's data density and the ability to classify individual "returns", it is possible to separate the topography of the "bare ground" from surface features like vegetation and buildings, something impossible to do using photogrammetry. Although SAR also allows the sensors' combination of wavelengths to separate bare ground from canopy cover, the resolution, positional, and height accuracies of SAR products are typically lower than LiDAR and vary significantly depending on surface cover and slope (with higher accuracy in flat areas that are free from vegetation cover).

Highly accurate topographic data also allow the exploration of the landscape's geomorphology. This can help determine the presence of seismic hazards—such as fault lines and volcanic activity—as well as flood and drought risk, by establishing soil types (in concert with laboratory testing of soil samples).[a] It is also useful for monitoring changes to the landscape due to climate change-induced sea level rise and disaster events.

When combined with other datasets, such as aerial/satellite imagery, digital terrain and surface models allow the determination of biomass and categorization of vegetation types based on canopy form and spectral characteristics (from the imagery). This is essential for modeling potential disaster impacts and assessing the impacts of disasters on the natural environment and for monitoring the effects of climate change.

[a] https://www.oas.org/pgdm/document/BITC/papers/gibbs/gibbs_02.htm.

Most Caribbean countries have high-accuracy and high-resolution terrain models (*table 8.1*). In more densely populated countries with smaller land mass—such as Antigua and Barbuda, Barbados, Dominica, Grenada, Sint Maarten, St. Lucia, St. Vincent and the Grenadines, and Turks and Caicos—these models cover the entire country. Antigua and Barbuda and St. Lucia both have terrain models derived from photogrammetry, while the others used LiDAR. Haiti, one of the region's largest countries, has also been mapped with LiDAR and these data are publicly available. Larger countries like The Bahamas, Jamaica, Suriname, Belize, and Guyana have collected high-resolution data over areas of interest. For example, Guyana and Jamaica collected LiDAR data for select coastal areas, Belize, flew LiDAR surveys for archaeological purposes, and Suriname has used aerial drones to collect topographic data for community-level hazard assessments. However, these were mostly carried out using project-based funding, and regular updates of these datasets are vital. But without regular funding, these are unlikely to happen, though improvements in technology and access in recent years does mean costs have decreased significantly. Access to these datasets has also been a major issue, with several countries not sharing the data widely. With access often contained to a few persons within government, exposure to, and use of, these vital data are reduced. Countries give various reasons for these restrictions, including national security concerns and the need to show that they are attempting to recover costs. Fundamentally, few policies and laws are in place that detail how countries should handle these data for the common good, so technical officers tend to restrict access by default.

Bathymetry

Typically collected through sonar instruments, bathymetry is important base data for assessing coastal hazards like storm surge and tsunamis. Multibeam sonar provides highly detailed and accurate bathymetric models, which are the basis of nautical charts used for navigation. In relatively shallow and calm waters, specialized aerial bathymetric LiDAR systems can also deliver data with similar levels of detail to multibeam sonar. Bathymetric LIDAR has been used in Barbados, Dominica, Grenada, St. Lucia, and Turks and Caicos to create combined bathymetric/topographic terrain models and update nautical charts. In Grenada, this model was created through a collaboration between the United Kingdom Hydrographic Office (UKHO) and the World Bank-funded Regional Disaster Vulnerability Project. The UKHO has also updated nautical charts in the Eastern Caribbean using multibeam sonar in recent years.

Land cover and use

A land cover map is typically derived from high resolution aerial/satellite imagery using fully or semiautomated methods of classifying land cover into distinct classes—such as urban, forest, and so on. Land cover maps deal with physical land types, whereas land use maps document how humans use the land. Land uses can be inferred from land cover characteristics based on prior knowledge or ancillary data. Land cover maps are useful for determining what features are exposed to hazards on a national scale and for carrying out rapid analyses of potential disaster impacts. Programs like the Copernicus Emergency Management Service use land cover maps for rapid mapping of disaster impacts.

Structure and asset locations

Knowing the location of critical assets, such as infrastructure and government facilities, is crucial for DRM. Critical infrastructure includes power, water, and transportation systems. Ideally, these should be cataloged in asset inventories or management systems, allowing users to proactively manage maintenance requirements and mitigate exposure to hazards.

The impacts of disasters on housing and commercial sectors are often assessed using geospatial datasets of building footprints. These are outlines of structures as they would be seen from above. In their most basic form, these footprints provide an idea of the location of exposed structures and their areas. Adding other information—such as construction materials, number of floors, and age of the structure—allows the assessment of the structure's vulnerability to disasters.

Hydromet data

Hydromet data are critical for the region, given that they cover floods and hurricanes, the most frequently occurring and damaging hazards.[10] A variety of international, regional, and national entities collect and manage hydrological and meteorological data in the Caribbean region, with varying levels of cooperation (*box 8.3*).

BOX 8.3 >>

Organizations in charge of hydromet data

The Caribbean Meteorological Organization (CMO), which is a CARICOM body, and the associated Caribbean Institute of Meteorology and Hydrology (CIMH) are the major regional organizations involved in collecting and managing hydromet data in the Caribbean. All the countries except Grenada, St. Kitts and Nevis, and St. Vincent and the Grenadines are members of the World Meteorological Organization (WMO). The CIMH in Barbados is the WMO regional training center for the Caribbean, providing free training for officers from meteorological offices across the region. It also operates automated climate and weather stations across the region, and individual countries have monitoring networks that serve various purposes, from providing data for early flood warnings to agricultural monitoring.

The spatial and temporal resolution of meteorological and hydrological observations in most Caribbean countries are lower than their needs, particularly for EWSs. In volcanic countries with rugged inaccessible terrain and varied hydrometeorological conditions, this leads to serious limitations in coverage, particularly in upper catchments where rainfall accumulates and results in flash flooding downstream. The river gauge network is particularly sparse, despite most islands having many rivers and creeks. For example, despite having 365 rivers, Dominica only had two functional water level stations in 2018 and no stream gauges, although it is now installing 14 water level stations.[10] Maintaining monitoring networks is expensive, requiring equipment maintenance, specialized software and hardware systems for data management and forecasting, and skilled personnel. Network maintenance is often underfunded, especially during periods of budget austerity, which results in data gaps and shortened equipment lifespan. So, although Caribbean countries need long time series from monitoring networks that can capture the diversity of hydrometeorological conditions, they rarely achieve optimal coverage and length of reliable uninterrupted observations.

Complementing ground observation from local stations, radar coverage is comprehensive, with radars in Barbados, Belize, Cayman Islands, Curaçao, French Guiana, Guadeloupe, Guyana, Martinique, Puerto Rico, Suriname, The Bahamas and Trinidad and Tobago. However, while many of those radars also cover neighboring countries, data sharing is limited for multiple reasons, including technical challenges (since the datasets are large), and willingness to share. Radars have significant potential for EWSs because they enable forecasters to follow extreme events as they approach, anticipating rainfall intensities and quantities, thus increasing the lead time for warnings. As most catchments are small and react very quickly to heavy precipitation, additional lead time is crucial to give the population enough time to react. Forecasters, such as national meteorological services, also integrate outputs from numerical models such as the Weather Research and Forecasting, which the CIMH runs regionally, as well as satellite data. This includes National Oceanic and Atmospheric Administration (NOAA) Geostationary and Polar-orbiting Operational Environmental Satellite data via NOAA and many other public websites.

Data sharing remains an issue. Although WMO members have access to the Global Telecommunications System, this only contains data from stations at airports or in regional networks. Data from other stations are often stored locally and not shared with government agencies or neighboring countries. Data for manually read instruments and older records are usually stored on paper, although CIMH and several national agencies are digitizing older records. Countries with separate national hydrological and meteorological agencies often store data in different databases and do not share them. This poses challenges for forecasters, as they can only access a portion of the data they need. Caribbean countries are exploring potential solutions, in the form of linked or unified databases and associated data quality control tools, as they replace older monitoring equipment with automatic digital stations.

Given these challenges, regional and international collaborations help fill in some of the gaps that national budgets leave and encourage best practices for data sharing and management. Well defined and actively supported agreements to collaborate at national, regional, and international levels are essential for the long-term sustainability of critical monitoring networks in the region and the continued development of the capacity of regional and national hydromet services (***box 8.4***).

Seismic data

Responsibilities for seismic monitoring are handled by a collection of regional and national entities. In the Eastern Caribbean, the University of West Indies (UWI) Seismic Research Center operates a seismic monitoring network which covers many of the OECS countries. Cuba, the Dominican Republic, Haiti, and Jamaica have their own national seismic monitoring agencies.

BOX 8.4 >>

Monitoring hydromet hazards in the region

To ascertain the local probability of a damaging **rainfall** event (also called a *return period*), a consistent, multiyear time series of data collected from rain and tide gauges needs to exist. The number of years of data required for determining return periods for rainfall events depends on a region's climatic conditions. But generally, a longer time series will allow projection of more extreme events with longer return periods.

In countries with very steep and mountainous terrain, orographic effects[a] are pronounced (Ogden 2016) and rainfall varies significantly with elevation and exposure. As such, they may need more rainfall and water level stations to accurately capture these differences. Larger countries like Guyana, Belize, and Suriname can use satellite data products as a proxy for in-situ monitoring. The government of Guyana and Columbia University's Enhancing National Climate Services project has demonstrated the use of satellite data for reconstructing rainfall records across the country over a 30-year period.[b]

The statistical process of determining rainfall probabilities from a time series of observations is known as *frequency analysis*. The Caribbean Risk Information Program[c] performed a frequency analysis on rainfall records from Grenada, Belize, Dominica, St. Vincent and the Grenadines, and St. Lucia; this led to the creation of design storms with 5 to 50-year return periods (depending on data availability), which engineers can use to design more resilient infrastructure. With climate change increasing the likelihood of extreme events, any analysis based solely on historical data must also consider guidance from climate models. And because determining potential flooding from these rainfall events requires detailed and accurate topographic information, planners need to know the geometry of channels as well as information on water levels and discharge. Hydrological and hydraulic models are frequently used at national and local levels to determine areas that are prone to flooding given rainfall events of certain return periods. These models and rainfall monitoring equipment also form the basis of flood EWSs.

Like rainfall, determining the probability of a damaging **storm surge** event requires a long time series (typically 19 years to capture a full tidal cycle) of local sea level from tide gauge observations. As with rainfall data, these monitoring stations often do not survive long enough to provide such a record due to a lack of maintenance and storm damages. Hydraulic models are also often used to model potential flooding from storm surge events. Many settlements in the region are close to sea level and at risk from combined rainfall and storm surge events, particularly during hurricanes, which bring heavy rainfall and storm surge simultaneously. Regionally, the CIMH maintains a version of the TAOS/L Storm Hazard Model,[d] but it is not run on a regular basis or used for forecasting.

Droughts are slow-onset disasters that occur in the region, particularly during the December–June dry season. Drought monitoring is especially important for national water utilities and agricultural agencies, as most islands depend on rainfall for their water supply. CIMH provides a monthly drought forecasting product[b] and national hydrological and meteorological agencies monitor drought conditions by analyzing temperature, evapotranspiration, rainfall, and streamflow datasets. Unlike other natural disasters, droughts are difficult to define, as they can be meteorological or agricultural and have context-specific timespans.

[a] *Orographic effect* occurs when air masses are forced to flow over high topography. As air rises over mountains, it cools and water vapor condenses, forming clouds and precipitation. When air moves to the other side of the mountain, it plunges, warms up and dries out. As a result, it is common for rain to be concentrated on the windward side of mountains, and for rainfall to increase with elevation in the direction of storm tracks. https://www.climate.gov/news-features/blogs/beyond-data/highs-and-lows-climate.

[b] https://rcc.cimh.edu.bb/drought-outlook/.

[c] https://www.cdema.org/virtuallibrary/index.php/charim-hbook/why-charim.

[d] https://www.oas.org/CDMP/hazmap/taos/taosdoc/taosfull.htm.

Hazard, vulnerability, and risk assessments

Hazard, vulnerability, and risk assessments use a variety of methods, depending on their purpose and geographic extent. Given the unique characteristics of the Caribbean region, these assessments need to be performed in an appropriate way for local circumstances. Ideally, there would be defined specifications and standards for the types of assessment necessary for the region. This would allow the creation of products with consistent quality that consider the impacts of climate change where applicable, whether undertaken by government staff or consultants. CDEMA and CARICOM have made some attempts to standardize this type of assessment. In 2009, they led an activity to develop a CARICOM Regional Organisation for Standards and Quality (CROSQ)-approved Standard for Disaster Risk Management for Sustainable Tourism (CDEMA 2009), which includes a risk assessment process for tourism assets. Ideally, similar standards would be developed for other economic sectors and hazards. However, the process takes time and requires clear and knowledgeable leadership to steer the technical work and build consensus from a broad set of technical and nontechnical stakeholders. The Caribbean Risk Information Program[11] provides a framework with methodologies that are tailored to the regional context for performing flood and landslide hazard assessment and mapping.[12]

These assessments will also need regular updating. Assessments are currently performed when funds become available, either from donors or public sector sources on an irregular basis. Numerous donor-funded projects have developed hazard and risk maps at different scales and for different countries and created vulnerability functions for various types of built structure. The problem, therefore, lies not in creating these products, but in how accessible, appropriate, and authoritative they are. Accessibility challenges arise not just in relation to data access, but in being able to understand the information contained within. Appropriateness concerns the end uses of the data face—for example, it is not appropriate to use a national-scale flood map to assess community-level flood hazards. Authoritativeness concerns the reliability of the data represented on a map. To effectively use the results of an assessment, end users need access to the necessary documentation and sometimes training. It is also important to consult communities who are considered at risk about assessment results in a way they can understand and give them opportunities to ask questions and contribute to the assessment process. Nevertheless, when studies are done through externally funded projects, there are often capacity issues around updates after the external support ends.

Hazard data and risk maps are particularly important for DRM in the land use planning process. In some countries, such as Haiti, these risk maps guide urban development in the absence of official plans. Sint Maarten has reasonably good risk maps—including the UNESCO-Institute for Hydraulic Engineering flood plans, some academic flood modeling reports, and updated flood maps for some local development plans—which it currently uses for planning, especially in low-lying areas. The national authorities are also working on new risk maps, based on highly detailed earthquake and tsunami modeling. In Haiti, multiple risk maps are successfully being used at different scales to guide urban growth. But their use is uncoordinated, with each authority or region using different maps. While maps and reports are available publicly for some countries, the underlying data to create these maps and reports are rarely made available. Jamaica and Trinidad and Tobago, for example, make multiple hazard maps available on their government websites, but not the underlying geospatial data used to create them. In contrast, the GeoCRIS platform has made available national and local-scale hazard mapping for Dominica, Turks and Caicos, Belize, St. Vincent and the Grenadines, Grenada, and St. Lucia, where underlying data can be downloaded and used to analyze exposure.

Community awareness of hazard and vulnerability assessments is neither regular nor standardized across the region or individual countries. The assessments are often carried out through donor-funded projects, with methodologies set by the implementing agency. The CDEMA and Red Cross Vulnerability

and Capacity Assessment methodology[13] provides some guidance on performing community vulnerability assessments, which some national Red Cross offices—for example, those in Dominica, St. Vincent and the Grenadines and Belize—use in their community vulnerability mapping projects. However, the results of these assessments are not usually shared beyond the target community, Red Cross, and the NDMO. The UNDP completed community vulnerability mapping in Dominica in 2010, as part of its Sustainable Land Management project and validated the outputs with community members, but the data from this exercise are not publicly available. Trinidad and Tobago also undertook a national vulnerability and risk assessment exercise at municipal scale, publishing its preliminary report (ODPM 2014).

Data governance and infrastructure

DRM data must not be considered as distinct from other types of information managed by agencies in the Caribbean region. The World Bank's *Data for Better Lives* flagship report (World Bank 2021) outlines four building blocks for an effective data governance framework: the necessary data infrastructure policies; a secure and enabling legal and regulatory environment for data; the ability to harness the economic value of data; and an institutional ecosystem that ensures data deliver on their potential and laws, regulations, and policies are effectively enforced (*figure 8.1*). These factors are especially important for disaster risk and climate change information in the region.

FIGURE 8.1 >>

Data governance layers at national and international levels

	National	International
Infrastructure policies	» **Universal coverage** of broadband networks » **Domestic infrastructure** to exchange, store, and process data	» **Global technical standards** for compatability of hardware and software » **Regional collaboration** on data infrastructure to achieve scale
Laws and regulations	» **Safeguards** to secure and protect data from the threat of misuse » **Enablers** to facilitate data sharing among different stakeholders	» **Cybersecurity conventions** for collaboration on tackling cybercrime » **Interoperability standards** to facilitate data exchanges across borders
Economic policies	» **Antitrust** for data platform businesses » **Trade** in data-enabled services » **Taxation** of data platform businesses	» **International tax treaties** to allocate taxation rights across countries » **Global trade agreements** on cross-border trade in data-enabled services
Institutions	» **Government** entities to oversee, regulate, and secure data » **Other stakeholders** to set standards and increase data access and reuse	» **International organizations** to support collaboration on data governance and promote standardization » **Cooperation** on cross-border regulatory spillovers and enforcement issues

Source: World Bank 2021

In the Caribbean, the foundational policy framework for data governance has gaps. Not all countries have passed freedom of information legislation into law, including Barbados, St. Lucia, Grenada, Dominica, Suriname, and Haiti. Open data and data management policies are similarly inconsistent or lacking. Cybersecurity legislation and policies are often nonexistent, resulting in a propensity to restrict all access to all data in the name of security. The International Telecommunication Union's (ITU) Global Cybersecurity Index version 3 (ITU 2019) rated all Caribbean countries but Cuba, Jamaica, and the Dominican Republic in the lowest tier of commitment to cybersecurity due to a lack of legislation, policies, and cybersecurity-trained personnel.

This lack of enabling legislation and regulations means that agency roles and responsibilities are often not defined. Multiple agencies can, and often do, claim sole ownership of all government data based on interpretations of pre-digital era enabling legislation. At the same time, neither data collection nor creation responsibilities are established. CDEMA's model Comprehensive Disaster Management (CDM) legislation clearly lays risk information responsibilities with NDMOs. With this legislation in place, NDMOs would be responsible for coordinating hazard identification and vulnerability and risk assessments. However, other government agencies—particularly physical planning, statistics, and environmental management agencies—also require this information for their work.

As most of the data discussed in this chapter also have a spatial component, countries like Jamaica, The Bahamas, and Belize are trying to set up national spatial data infrastructures, while the UN-Global Geospatial Information Management has attempted to create a regional spatial data infrastructure (Merodio Gómez, Limones García and Ramírez Santiago 2021). Such infrastructures would define policies, practices, roles, responsibilities, and standards for managing and sharing spatial information within government. These could be developed based on a data governance framework, with an additional set of unique standards around data modeling, metadata, and data exchange.

The 2020 UN E-Government Survey observes that, like many other SIDS, Caribbean countries "have highly developed human capital but are unable to realize their full potential owing to impediments to effective online services provision and infrastructure-related limitations" (UN 2020, p60). Statistical performance also lags,[14] with the best scoring Caribbean nation (the Dominican Republic) ranked 80th in the world in the combined statistical performance index score. There are qualified personnel in the region, but like many other government agencies with data management responsibility, NDMOs are often understaffed and unable to take on new responsibilities, particularly if they are not stated in their mandate (Miles et al. 2020). Staff often lack the technical capacity or availability to undertake hazard and risk data management and analysis activities—such as community vulnerability and risk assessments—and these are instead performed by consultants or NGOs like the Red Cross. Decision makers also lack the capacity to understand what information is available to them (sometimes because it exists but is not available) and how to use it. Improving communication between technical staff and decision makers would resolve both issues, but this would require defining roles and responsibilities and other improvements to the institutional ecosystem.

Sharing information about disaster and climate change-related risks is in the best interest of the public. However, significant institutional issues need to be addressed to ensure the systemic collection, management, analysis, and sharing of these data and information products in the Caribbean region. Although technology has made collecting and analyzing this information cheaper and easier than ever, it has not solved the institutional bottlenecks.

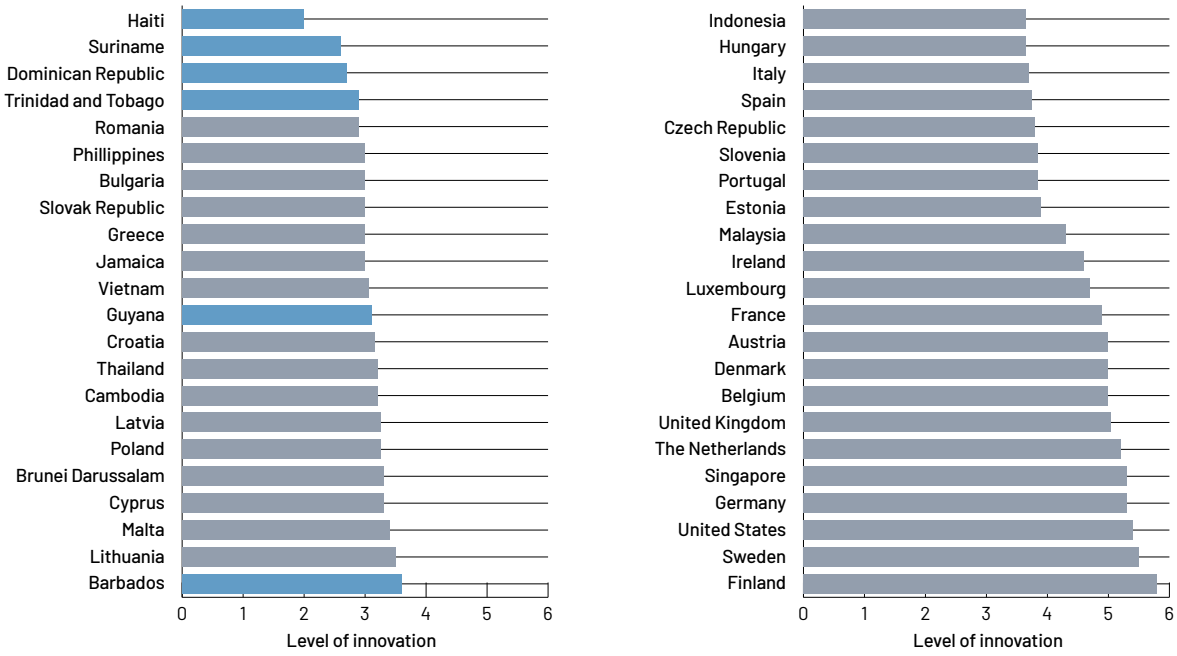
Develop and implement technical solutions for resilience

New technologies offer great opportunities for private actors in the Caribbean to better manage climate and disaster risk (Fontes de Meira and Bello 2020). This includes climate-smart agriculture, access to finance, and innovations in health and education. However, data availability is an issue, and studies indicate that innovation and productivity levels in the region remain low (*figure 8.2*). Further factors contributing to the region's low innovative performance are low levels of research and development intensity, private sector participation in innovation efforts, funding and foreign direct investment in innovation, and human capital for innovation (ECLAC 2016; Fontes de Meira and Bello 2020). At the national level, governments are largely responsible for investments in science and technology, research

and development, and driving technological adoption and adaptation. From a governance side, there have been efforts to address technology gaps since the 1980s, with several bodies and frameworks—such as the Caribbean Council for Science and Technology (1980) and CARICOM's regional science and technology policy (1988) and regional framework for science and technology (2017)—established to align efforts regionally and increase cooperation. However, the process remains fragmented and constrained by policy shifts, inadequate financial resources, and the inability to retain capable staff. To date, only Cuba, the Dominican Republic, Jamaica, and Trinidad and Tobago have developed policy frameworks or plans for technology development and innovation (ECLAC 2020; Fontes de Meira and Bello 2020).

FIGURE 8.2 >>

Global comparison of innovation in Caribbean countries



Source: Alleyne, Lorde and Weekes 2017
Note: Caribbean countries are highlighted in blue.

Agriculture

Farmers need access to awareness programs and credible, context-specific technical information on climate-smart agriculture (CSA) practices and their benefits. Lower-cost CSA practices, such as crop rotation and plant density management, are easier to adopt because investment costs are on par with conventional practices. On the other hand, adopting higher-cost CSA practices—including cover structures, drip irrigation systems, and planting native trees—presents greater challenges (CIAT 2018; Shannon and Motha 2015).

These strategies are most effective when farmers are well versed in basic risk management concepts and have the necessary tools and data to apply CSA practices, as this empowers farmers to make sound climate-adaptive decisions and retain management control of their agricultural activities. Farmers must be able to manage their risk themselves because opportunities to transfer risk from farmers to external entities, such as agricultural contractors or insurance companies, are low (Shannon and Motha 2015).

Farmer-centered monitoring and forecasting tools, early warning tools, and mitigation strategies that account for topographic and microclimate variabilities are therefore crucial. Farmers' input is vital for developing effective educational and training materials and user-friendly risk management tools, thus ensuring they get the information they need to effectively manage climate risks to agriculture (Shannon and Motha 2015).

Finance

Despite the Caribbean lagging in innovation and technology adoption, these advancements hold many potential benefits, such as improving access to financial services. Innovative, low-cost digital financial services—including transaction accounts, savings, credit, insurance, and remittances—could help vulnerable households, MSMEs, and farmers invest, smooth consumption over time, and mitigate the impacts of climate and other shocks to their livelihoods. Modernized regulation and infrastructure for payments systems would also support efficient transmission of social cash transfer funds to vulnerable households throughout the region. However, digital payment use is low across the region, preventing individuals and businesses from transacting online. High costs for opening and maintaining bank accounts, high transaction fees for "traditional" digital payment methods like credit and debit cards, and steep automatic teller machine (ATM) withdrawal fees drive a preference for cash transactions and a general avoidance of the formal banking system. These challenges help explain why many Caribbean firms struggle to obtain access to credit despite the region's large financial systems (***chapter 3***).

There is also a gap between the regulatory and infrastructure foundations that are in place and those needed to support the digital economy (World Bank 2020a). The COVID-19 pandemic has further highlighted these digital deficits, exposing the region's lack of preparedness to move government operations, education, communications, and commerce online. While recent fiber optic infrastructure upgrades have improved networks' capacity and reach, access to broadband remains a challenge for many individuals and businesses, and service quality remains unreliable. These challenges disproportionately impact the poorest individuals, MSMEs, and vulnerable or marginalized groups, which continue to be locked out of the digital economy as a result (Masetti 2021).

Education

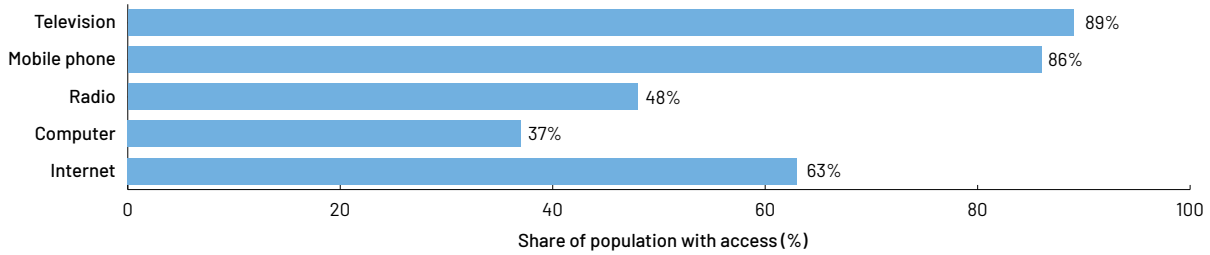
Digitalization also plays an important role in access to education services. When social distancing measures imposed during the COVID-19 pandemic forced many schools to close, disparities in access to technologies led to inequitable access to education. One in every 10 households with school-aged children in the Caribbean lack access to the tools and equipment they need to support remote learning (Bellony and Powers 2021). In Antigua and Barbuda, Belize, the Dominican Republic, Grenada, Jamaica, Haiti, St. Lucia, St. Vincent and the Grenadines, and Suriname, over one-third of the population lacks internet access, between one-fifth and two-thirds have no access to a smartphone, computer, or tablet for online learning, and about 20 percent have no access either device or internet connection (***figure 8.3***). Computer ownership is highest in Antigua and Barbuda, where seven in 10 households own a computer, and lowest in Haiti, where only 20 percent of households own a computer. Mobile phones are the most widespread device, and 70 percent of these are smart devices. Yet, their use as a tool for remote learning is limited, as only 55 percent are connected to the internet.

Lower-income households disproportionally lack access to technologies to engage in remote learning. In Jamaica, 21 percent of children from the lowest income quintile have access to both the internet and a computer, compared to 73 percent of children at the top of the income distribution; 55 percent of children from the lowest income quintile have access to smartphones and internet, compared to 86 percent from the highest quintile. Households in the lowest income quintile also have, on average, twice as many children as households in the highest income quintile, so any available resources that enable remote learning are

likely shared by multiple students. While measures such as zero-rated content, data plans, hotspots, and MiFi devices[15] remain unavailable to low-income and vulnerable households, remote learning measures will continue to aggravate equitable education outcomes (Bellony and Powers 2021). ***Box 8.5*** shows how different initiatives are promoting access to technology in education in the Caribbean.

FIGURE 8.3 >>

Access to assets that enable online learning in selected Caribbean countries



Sources: Bellony and Powers 2021

BOX 8.5 >>

Improving access to technology in education

Educational institutions are best suited to impact the digital literacy skills of children from disadvantaged households. Giga,[a] an initiative launched by UNICEF and the ITU in September 2019, is a digital public good platform to connect every school to the internet. Nine of the 11 Eastern Caribbean countries have signed up to Giga and mapped school connectivity. The OECS Commission has regional implementation oversight for this initiative on behalf of its member states.

Today, technological infrastructure is as important as physical infrastructure for education. The World Bank-financed Caribbean Digital Transformation Project (World Bank 2020a) aims to expand access to digital technologies, services, and skills in selected in the Eastern Caribbean countries and has three main components:

1. Developing an enabling environment through legal and regulatory reform in telecommunications, digital financial services, cybersecurity, data protection, and privacy
2. Creating digital government infrastructure, platforms, and services to support public sector modernization and service delivery
3. Ensuring the adoption of digital skills and technology through workforce development and training in digitally enabled professions and expanded access to digital services for students, teachers, and vulnerable groups

Telecommunications providers in the Caribbean have improved internet connectivity to benefit the education sector, expanding the high-speed, long-term evolution mobile wireless data network, and in some cases, connecting rural areas. Through partnerships with ministries of education, these companies have tailored support to the sector through subsidized data plans or free access to online learning platforms, e-libraries, and other zero-rated education websites.

Source: Bellony and Powers, 2021

[a] For more details on Giga, see https://gigaconnect.org/.

Diversify economic sectors

Diversifying away from narrow economic bases is key to reducing vulnerability to climate change and other technological or preference shocks, including those caused by decarbonizing the world economy. But it is also desirable for governments to diversify their economy, for pure short-term economic reasons. Regional policy makers have discussed digital technology, automation, creative and cultural industries, blue and green economies, and climate change adaptation as potential areas for economic diversification, growth, and job creation. In parallel, they are probing ways to add value and pivot within sectors such as agriculture, tourism, and energy to develop new revenue streams to reduce vulnerability and exposure to shocks (Bellony and Powers 2021).

The Caribbean's heavy reliance on tourism, mining and quarrying, or agriculture—all sectors that contract in response to a storm event or require a high degree of social interactions—is a threat to private sector resilience and calls for increased diversification. However, economic diversification is often hampered by a weak business environment, difficulties in obtaining credit, and slow adoption of the digital economy.

The overall business environment

Economic resilience generally benefits from a dynamic private sector that allows firms and households to adapt to risks and opportunities. But it can be difficult for entrepreneurs to start new businesses in the Caribbean and diversify the economy away from more vulnerable sectors.

TABLE 8.3 >>

Business climate in Caribbean countries: ease of doing business scores 2020

	Starting a business	Dealing with construction permits	Getting electricity	Registering property	Getting credit	Protecting minority investors	Paying taxes	Trading across borders	Enforcing contracts	Resolving insolvency	Overall score
Antigua and Barbuda	82.6	65.7	83.5	56.7	25	58	58.9	68.7	68.1	35.6	60.3
Bahamas, The	87	70.9	76.7	30.8	30	56	81.7	53.1	59.1	53.4	59.9
Barbados	86.4	56.6	66.2	58	30	38	72.3	62.8	38.9	69.8	57.9
Belize	72	64.3	73.7	52.4	20	28	79.9	68.2	50.1	46.1	55.5
Dominica	89.3	70.1	82.5	33.5	30	58	75.6	74.3	57.5	34.7	60.5
Dominican Republic	85.4	70.7	68	67.2	45	34	57.4	83.5	50.6	38	60
Guyana	85.6	52.5	45.9	55.7	55	56	65.7	58.3	57.9	22.4	55.5
Haiti	36.4	44.2	57.2	30.4	35	18	57.6	76.9	51.6		40.7
Jamaica	97.4	71.9	65	65.3	85	62	64.9	61.5	53.7	70.1	69.7
St. Kitts and Nevis	85.9	73.5	70.2	28.9	25	52	64.4	81	65.5		54.6
St. Lucia	89.4	76.4	83	59.8	25	58	75.5	73.9	59.7	35.9	63.7
St. Vincent and the Grenadines	87	74.4	71.2	43.1	25	58	71.1	77.4	63.7		57.1
Suriname	61.6	66.3	57.7	46.8	10	28	69.4	75	25.9	33.8	47.5
Trinidad and Tobago	88.6	64.1	84.3	46.7	65	64	53.5	62.6	35.6	48.4	61.3
Caribbean average	81	65.8	70.4	48.2	36.1	47.7	67.7	69.8	52.7	44.4	57.4
Latin America and Caribbean average	79.6	63.2	71.7	54.9	52	47.3	60.5	69.1	53.5	39.2	59.1

Source: Based on World Bank 2020b

Notes: An economy's ease of doing business score is reflected on a scale from 0 to 100, where 0 represents the lowest and 100 represents the best performance. For example, an ease of doing business score of 75 means an economy is 25 percentage points away from the best regulatory performance constructed across all economies and across time. Countries with scores lower than 55 are shaded red (nascent), those scoring 55–63 are shaded yellow (emerging), and those scoring over 63 are shaded blue (established). The gray cells show that there are not enough data available to make a rating.

As shown in *table 8.3*, the business environment in most Caribbean countries is challenging. The average Caribbean score in the World Bank's ease of doing business ranking is 1.7 points lower than the Latin America and Caribbean average (World Bank 2020b). Jamaica and St. Lucia are the best performing Caribbean countries, while Suriname and Haiti score lowest. Looking at the individual subcomponents of the ease of doing business ranking reveals that the region particularly lags in registering property (6.7 points below the Latin America and Caribbean average). On average, it takes 87 days to register property here, compared to 64 days in Latin America, and only 21 days in Europe and Central Asia. In Haiti and St. Kitts and Nevis, it takes up to 319 and 224 days, respectively. Registration is also expensive, costing 8.1 percent of property value on average. The key obstacles often lie in burdensome procedures and inefficient, paper-based land registries. Few countries have electronic databases for checking encumbrances (liens, mortgages, restrictions, and so on), recording boundaries, checking plans, and providing cadastral information (geographic information system) and transparent information on immovable property.

Tourism

With tourism in the Caribbean mostly driven by all-inclusive beach hotels and cruises, diversifying the sector would make it more resilient to external shocks. For example, countries could shift their focus from beach tourism towards ecotourism, gastronomy, agrotourism, and cultural heritage. This would require strategic discussions to identify each island's specific opportunities, with any strategic decisions trickling down to territorial plans and tourism circuits and followed by a series of private/public coordinated actions. The tourism season could also be expanded by supporting local or regional tourism (even across islands), and the tourist base expanded and diversified to other tourism markets. This could include targeting people in the southern hemisphere, where the weather patterns differ from those in the northern hemisphere.

Fisheries

Diversifying fisheries and aquaculture means a substantial change in production activities, responding to changes in available fish stocks (for fisheries) and/or the environmental state of the marine system, driven by climatic and other challenges (Climate Adapt 2019).

FAO (2014) and Free et al. (2020) suggest that aquaculture could compensate for losses in catch fisheries and may cope better than fisheries with the rapid rate of change and compounded effects of multiple drivers of both climate and nonclimate-related vulnerabilities. However, aquaculture has its own set of challenges, including insufficient or nonexistent regulations, legal and institutional constraints around developing export-oriented aquaculture, a lack of information systems to support farmers and investors, and poor research development (Pérez-Ramírez 2017). It can also have detrimental environmental impacts.

Offshore mariculture—or marine aquaculture—has emerged as a strategy for minimizing the potential environmental and socioeconomic impacts of aquaculture. Essentially, it is aquaculture that occurs at more than three nautical miles offshore and/or at depths greater than 100 feet (30 meters). It usually involves using submersible cages that facilitate development in areas considered unsuitable due to wave intensity and/or threat of damage from tropical storms and hurricanes. One study found that using this strategy could result in a potential yield over two orders of magnitude greater than the region's total current seafood production and roughly half of the total annual harvest from global capture fisheries (Thomas et al. 2019).

Expanding mariculture under climate change will require simplifying permits for sustainable mariculture in countries with a complex regulatory environment and where mariculture sector growth has been slow, developing better practices in countries with weak regulatory environments and rapid but less sustainable growth in the mariculture sector, and fostering access to financial assistance and resources such as credit and insurance in countries where mariculture production is developing or has yet to develop (Free et al. 2020).

Digitalization

Digitalization could pave the way towards economic diversification and the transition toward a knowledge-based economy. Competitiveness in the services sector increasingly relies on technology and digital platforms to serve the demands of consumers, a trend that is expected to accelerate in the wake of social distancing practices. For example, Jamaica has successfully developed an animation outsourcing industry, which sells animation services to studios in the United States and Canada. The priority for Caribbean countries that want to diversify through digital services is to invest in improving connectivity and in developing the digital skills needed.

In 2020 and as a reaction to the COVID-19 pandemic, Barbados started offering "digital nomad" visas for remote workers, academics, or freelancers who are not geographically bound to their workplace. Antigua and Barbuda, The Bahamas, the Dominican Republic, and Dominica also implemented similar programs. These visas last one year to 18 months, and visitors who use them are not subject to income tax in the Caribbean country. However, the schemes should be seen as a diversification of tourism rather than of the economy, since freelancers are not working for Caribbean-based companies or paying labor taxes.

Make finance for resilience accessible and provide direct support to the poorest and most vulnerable

High upfront costs or affordability issues may stop private actors from implementing effective solutions. Even if these costs are more than compensated in the long term by avoided impacts and losses, the lack of financing can be a serious obstacle for credit-constrained firms and households. And in the absence of external support, hundreds of millions of people in or close to poverty will be impacted by climate change and have limited ability to respond and adapt. Direct support through social protection or subsidies for resilience-building interventions can play a key role in reducing their vulnerability.

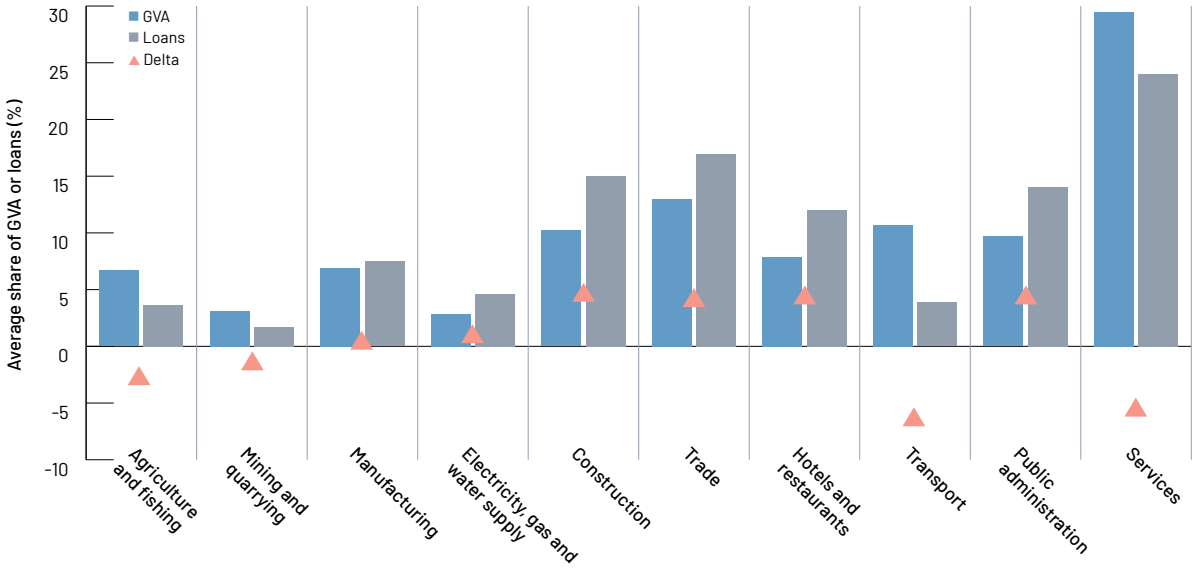
Access to finance for resilience

Access to financing services is low in the region, and there is little information on the availability of dedicated financing for resilience, such as subsidized loans or guarantees. Caribbean countries show shortcomings getting credit (15.9 points below the Latin America and Caribbean average, World Bank 2020b). Credit information infrastructure is a particular weakness, as only four countries—Trinidad and Tobago, Jamaica, the Dominican Republic, and Guyana—collect information on borrowers through a credit bureau.[16] In other countries, there is no ready access to a prospective borrower's credit history and the resulting information asymmetries make it difficult to obtain credit at affordable rates. This problem is especially acute for MSMEs and startup companies, which rarely have established banking relationships. Access to credit seems particularly limited in the service, transport, and agriculture sectors, as these receive a lower share of total credit than indicated by their share in total gross value added (*figure 8.4*). Attempts to address these issues, such as establishing a regional credit bureau in the ECCU, have stalled. The gaps in credit infrastructure are often compounded by the absence of both modern collateral registries and a dedicated framework for secured transactions, and by shortcomings in countries' legal systems.

Most Caribbean countries also score low on resolving insolvency (World Bank 2020b). Not only does this impede access to finance; by preventing a speedy rehabilitation of viable firms and liquidation of nonviable firms, it can slow economic recovery after a shock (Masetti 2021).

FIGURE 8.4 >>

Sectoral financing versus economic importance in the Caribbean



Source: Masetti 2021

Notes: GVA = gross value added. Gray bars show the average of a sector's share in total bank lending across Caribbean countries; blue bars show the average of a sectors' weight in GVA across countries. The delta (pink triangle) indicates the difference between the two series. As pointed out by Rajan and Zingales (1998), dependence on external finance differs across sectors, so the overserved differences in the share of credit and GVA cannot entirely be interpreted as credit constraints for certain sectors.

Governments can provide subsidies for farmers or the tourism sector—especially to the most vulnerable firms—to invest in resilience. Three initiatives in St. Lucia offering adaptation support are the Climate Adaptation Financing Facility (CAFF), a component of the St. Lucia Disaster Vulnerability Reduction Project,[17] which provides affordable loans to small businesses and homeowners to invest in reducing their vulnerability to natural hazards and climate change impacts (*box 8.6*); and the Sustainable Agribusiness for Laborie and Environs (SABLE) project and SmartClime loan facility, which both help farmers and fishers transition from low productivity activities to more entrepreneurial agribusiness operations, while improving their resilience to climate change.

BOX 8.6 >>

Climate Adaptation Financing Facility

The CAFF is implemented by the St. Lucia Development Bank (SLDB) and sponsored by the Ministry of Finance in partnership with the World Bank and Climate Investment Fund (CIF). CIF loans to the government of St. Lucia through the World Bank are provided to households and small agriculture, fisheries, tourism, services, and manufacturing businesses. Typical interventions include installing rainwater harvesting, drainage, and renewable energy alternatives.[a] When the St. Lucia Disaster Vulnerability Reduction Project was restructured in response to the COVID-19 pandemic in August 2020, the purposes of the CAFF were modified to:

- Allow the provision of grants as well as loans to COVID-affected enterprises with good prospects for recovery from the economic effects of the pandemic
- Expand the SLDB's ability to provide technical assistance to borrowers
- Provide business continuity training to borrowers (the Business Recovery Program, a new subprogram that blends grant and loan funds, was launched in late 2020)

[a] https://www.sldb.lc/climate-adaptation-financing-facility-caff.

Early lessons from the CAFF, SmartClime and SABLE projects include:

1. **Personnel involved in adaptation lending may need training to provide the necessary support to borrowers.** Adaptation is an emerging area of lending that differs from other types of lending. Lenders need a decent understanding of climate change, mitigation and adaptation options, and risk management in a changing environment, guidance on how to underwrite these loans, and on-call advice from technical experts.

2. **Smaller borrowers need help with loan preparation and applications.** Borrowers cannot always identify an adaptation investment that properly addresses climate impacts without technical support and facilitated permits. The SLDB and Labor Co-operative Credit Union both require borrowers to have business plans and/or business continuity plans. Such project preparation costs may make developing the correct project and applying for a loan unaffordable.

3. **Adaptation financing programs require support to generate demand.** Bankers cannot carry out the necessary activities to create demand in the private sector for adapting financing, such as educating business owners, conducting research, identifying technical solutions, and monitoring and disseminating results. Government or donors need to create these enabling conditions or give financial institutions the necessary capacity and resources to participate in these activities.

4. **Not all adaptation projects are bankable, nor all adaptation loans affordable.** Early on, the SLDB identified the need for grant funding to accompany (or in some cases, replace) CAFF lending to meet the adaptation needs of smaller and more marginal business owners. It also noted that the transaction costs of borrowing are too high. If borrowing takes too much time away from a business, the opportunity costs may put the loan out of reach. Given the economic niches filled by many marginal microenterprises and the employment they generate, new projects could work at developing adaptation financing schemes that are more suited to these businesses.

5. **Farmers and fishers are especially reticent to borrow.** The SmartClime loan facility was discontinued due to a lack of demand from agriculture or fisheries producers. This could be a combination of low returns on investment in these sectors, availability of grant funding, a lack of targeted outreach, perceptions of inadequate expertise in the financial institutions, or opportunity costs associated with the borrowing process.

It is clear that, while firms need financial support, merely helping them invest in resilience is not enough. They must first be knowledgeable about climate change and how it could affect their business, and then understand what steps they need to take to adapt (through access to data, jobs training, and education for resilience). Firms also need to be convinced of the business case for making an investment. It is only then, with the appropriate financial and technical inputs, that they may make adaptation investments.

Direct support to the most vulnerable households

To directly support resilience building at household level, governments need to know where they are located. The overall lack of frequent and periodic household surveys for measuring poverty, resilience, and other well-being dimensions is a constraint on policy design in the region. Although some countries undertake periodic labor force surveys (LFS) and/or surveys of living conditions (SLC)—for example, Belize (LFS), the Dominican Republic (LFS and SLC), Jamaica (LFS and SLC), and St. Lucia (LFS)—this remains a challenge in the region overall. Some countries have collected no household data for over 10 years, limiting their ability to implement evidence-informed policy and program decisions.

Despite this, Caribbean countries have made significant progress in developing social protection systems that enhance resilience from different angles. Most have a mix of programs that support human capital investments and enhance household resilience. The majority have conditional or unconditional cash transfer programs and social pensions for consumption smoothing, while social pensions, relief grants, and public works are also common. Virtually all countries have school feeding programs to improve food security, nutrition outcomes, and school attendance. For the labor market, most have a skills training program, and some provide employment services. Almost all the countries have a contributory old-age pension scheme and other social insurance benefits to cover work-related risks like workplace injuries. Unemployment insurance, however, is almost nonexistent.

Despite this progress and the wide range of programs implemented in most countries, significant gaps remain in terms of coverage and adequacy, and few countries have strategies to promote resilience. Social insurance coverage in the region remains low and pro-rich due to predominantly high levels of informality. For example, in Jamaica, which has one of the highest levels of social protection coverage, almost 20 percent of the population has no access to social protection, while in St. Lucia, more than half of the population is excluded. And, although social assistance is pro-poor, there is substantial room for improvement in terms of reaching the poorest. The targeting approach of school feeding programs varies, and most flagship cash transfer programs have low coverage. Also, a rapid estimation of benefit adequacy for select countries indicates that, while some Caribbean countries' cash transfer benefits are better than other Latin American and Caribbean countries, in others, they are extremely low.

Build skills for resilience through public works and training programs

Although social protection systems are increasingly visible in the region, few have complementary measures to enhance resilience. Their focus remains on delivering their core benefits and services—for example, delivering cash to reduce food insecurity or to smooth consumption—and they are rarely complemented with additional support to enhance resilience. However, if designed correctly, public works and skills training programs can enhance resilience, both through the works they build and the training they provide. But they are typically not designed to promote climate adaptation or to perform postdisaster recovery and reconstructions activities.

Public works and job training programs

Although public works programs in Dominica, Grenada, Haiti, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago all provide immediate cash support in return for labor, they tend to have low coverage and offer training in areas that are not related to resilience building (Beazley and Williams, 2021). Public works programs are typically designed to have an impact through three channels: cash, public works, and training. They can be particularly useful when used to support climate adaptation investments—for example, when programs include activities to shock-proof public infrastructure like roads, schools, or clinics, or to plant trees. They can also be used to restore, recover, and rebuild public infrastructure after a shock. However, recent social protection assessments in several Caribbean countries found that these programs do not systematically engage participants in activities related to climate adaptation or postdisaster recovery (Beazley and Williams 2021).

Few Caribbean social protection systems have complementary measures to support beneficiary households (Beazley and Williams 2021). The most common foundational programs are family accompaniment and social worker case management,[18] which rely on social workers or other staff having the capacity

to deliver them and being able to refer cases and coordinate arrangements with agencies that provide complementary services. But most programs focus on delivering their core benefits and services, without any complementary support to enhance resilience. Two exceptions are Jamaica and Belize, whose flagship cash transfer programs include complementary measures to increase resilience (*box 8.7*) (Beazley and Williams 2021).

BOX 8.7 >>

Resilience-enhancing complementary measures in Jamaica and Belize

In Jamaica, the **Steps-to-Work** program voluntarily engages working age members of the flagship cash transfer program PATH in a set of initiatives—including job readiness, skills training, competency building, job matching, and business development—to build human capital and strengthen resilience. It has four components: second chance education programs for persons aged 17–25 and skills development training and certification for persons aged 18–64, which are both implemented in partnership with the National Training Agency (Human Employment and Resource Training); job readiness training for persons aged 17–25, delivered in partnership with the job-matching facility, Electronic Labour Exchange; and business development and entrepreneurship training for persons aged 18–64, which provides business training and grants.

In 2018, 78 percent of PATH households that had received business development grants were still in business after six months, 28 percent of persons in PATH households who had completed a Steps-to-Work program were employed within 12 months, and 452 working-age members of PATH households had completed skills training.

In Belize, the **Job Readiness** component aims to improve participants' skills and capacities to increase both their employability and income-generating capacity. The program does not offer any specific in-house training. Rather, it provides advice, mentoring, and referrals to relevant training programs, links beneficiaries with job-matching agencies to become aware of employment opportunities, and offers financial support.

Each beneficiary is assigned a social worker and placement officer to develop a job readiness plan that outlines their career aspirations and goals. After an initial assessment, beneficiaries are directed to one of three "economic empowerment routes" that matches their interests and capacity: life skills (reading, writing, numeracy), job preparedness (resume writing, interview skills, work ethics), or vocational skills.

In 2018, 180–200 beneficiaries got support from the program, 140–150 beneficiaries of whom were part of the BOOST cash transfer program.

Sources: World Bank 2018, 2019a, and 2019b

Building skills for resilience

Investing in human capital is integral to advancing disaster risk reduction, resilience, and adaptation to climate change, thereby sustaining economic growth. External shocks disrupt economic and social well-being and redefine jobs and commensurate skills requirements, as countries have to generate short-term employment and rethink the future of work and the structure of their economies. Past disruptions have magnified the vulnerabilities of relying on single-sector economies and understaffed schools and hospitals, and underqualified education and health personnel, and vulnerable groups continue to be most affected. For

example, while COVID-19 triggered an overall loss in household income across the board, the percentage of Caribbean households with incomes lower than the minimum wage increased from 19.9 percent in January 2020 to about 45.5 percent in April 2020 (Arteaga Garavito, Beuermann and Giles Alvarez 2020).

Building resilient societies requires equipping them with the right skillset to cope with shocks, manage continuity, and improve and accelerate, seizing opportunities to make education more inclusive, effective, and resilient than it was before the shock. This section presents considerations for—and measures countries' progress towards—strengthening education systems and developing the necessary skills for resilience.

Foundational challenges and institution building

To effectively integrate resilience subjects into curriculums, the first step is addressing the foundational challenges faced by Caribbean education systems, as identified in *chapter 7*. Low learning levels, high dropout rates, and low-quality teaching make it difficult to effectively integrate disaster risk reduction and climate change into teaching and learning. As Caribbean countries face high out-of-school rates—partly as a result of shocks—reaching this group will require novel skills training interventions, such as developing dropout EWSs and specialized second chance programs to reintegrate this group (Bellony and Powers 2021).

At regional level, institutional and governance structures for skills development are in place (Bellony and Powers 2021). Institutions like CDEMA, the Caribbean Community Climate Change Center, the Caribbean Center for Renewable Energy and Energy Efficiency, and the CROSQ provide guidance on disaster risk reduction, climate change, energy, and standards and quality. University systems, national training authorities, and the Caribbean Examinations Council lead the overarching structures for training, skills development, and certifications. Sector-specific organs in agriculture, tourism, education, and health provide policy direction guidance to inform the creation of skills for resilience in their respective areas. However, building and sustaining skills for resilience will require greater collaboration between these entities for developing and supporting multidisciplinary training programs. CARICOM's *Human Resource Development 2030 Strategy*, which outlines the policy framework for collaborating on regional skills development (CARICOM 2020), provides an avenue for coordinating efforts and guiding the development and implementation of a skills for resilience agenda.

School curriculums

Incorporating skills for resilience into the school curriculum implies developing a proper understanding of the science and mechanisms of natural disasters, learning and practicing safety measures and procedures, understanding risk drivers and how hazards can become disasters, and building both community risk reduction capacity and an institutional and community-wide culture of safety and resilience (Kagawa and Selby 2014). Several examples suggest that disaster risk reduction is being integrated into curriculums in the Caribbean, including initiatives aimed at integrating DRR into mainstream education platforms. In some cases, hazards and risks—especially hurricanes—are included in education from kindergarten to university. In Cuba, Jamaica, Martinique, and Trinidad and Tobago, the national meteorological services, NDMOs, and educational institutions have joined forces to develop specific school programs on meteorological phenomena and the risks they pose. In terms of informal education, an abundance of content and tools is available for the Caribbean, including through international web sites like the International Federation of Red Cross and Red Crescent Societies, the National Hurricane Center/NOAA, the Asian Disaster Preparedness Center, the World Bank Open Learning Campus, and ReliefWeb; regional portals such as CDEMA, UWI, Swiss Red Cross, and the Caribbean Disaster Risk Management Reference Centre; publications; learning packages; audio and video materials; conferences and training workshops; and social media sites like YouTube, WhatsApp, and Facebook.

Outcomes of the *Caribbean Safe Schools Roadmap*[19] indicate that progress is being made in DRR and resilience education, including incorporating these topics into school curriculums and training education staff, families, and the wider community on the key components of DRM. However, only Dominica and St. Vincent and the Grenadines have reviewed and updated the DRM components of their education curriculums, weaving climate change and DRR into the traditional curriculum, and integrating the concepts within all subject areas at all educational levels. Both countries receive an "established" score for developing and implementing climate change and DRR curriculums in schools (***table 8.4***).

Progress on DRM training of staff, family, and community is more extensive and there are examples where: institutional structures have been created to improve disaster risk reduction and resilience within education (the Dominican Republic); school interventions on hazards, vulnerability, and capacity assessment have been expanded after a disaster (Dominica, Hurricane Maria); and engaging school communities in developing school safety plans has fueled positive action at family level, with the creation of home safety plans (St. Lucia).

The core workforce: public and private actors engaged in resilience building

To ensure business continuity during and after shocks, the core workforce engaged in these activities needs the right skillset to cope, recover, and build back better. The core workforce consists of public and private sector staff with key roles in preparedness and response (first responders) and support sectors such as specialized engineering, procurement management, digital technology, and risk financing (Alexander 1997). These groups require different skillsets and trainings across three areas: disaster preparedness, planning, response and recovery; risk management and financing, information management and communication; and targeted capacity building to benefit different segments of the economy (Bellony and Powers 2021).

Major damage and destruction of housing and public buildings after natural disasters point to a construction and maintenance problem (Bellony and Powers 2021) and suggest that the skillset of people involved in this sector can be improved. Housing construction in certain social strata is often informal and lacks regulation, exposing the most vulnerable households to increased risks during disasters and pandemics (Bellony and Powers 2021). Often touted as one of the key actions for achieving sustainable and resilient development, urban planning is considered a key element for reducing disaster risks in urban areas. The capacity to undertake planning activities and integrate disaster risks into planning considerations is a vital element of the planning system. While planning education is present in the region—for example, Jamaica, Haiti, Guyana, and Trinidad and Tobago have recognized regional planning schools that usually include training on disaster risk reduction—the number of planners in the region is far below the benchmark, set at one per 30,000 people (CAP 2018). Only Belize has an active National Association of Planners, and although Caribbean planners have the technical capacity to implement disaster risk, there are problems related to the scale and quality of available disaster risk information and the lack of communication between planning actors (***table 8.4***; Johnson, Caroca Fernandez and Restrepo Cadavid 2021).

Building the necessary skills for resilience is not limited to professional planning and engineering. Rather, it extends to other technical fields—such as heavy equipment management and maintenance—to support postdisaster debris removal, waterway clearance, hurricane-proof roof installation methods, and other risk reduction activities. Analysis of the National and Caribbean Vocational Qualifications (NVQs and CVQs) for key technical education and training skills highlights gaps in skills that are relevant to climate change mitigation and adaptation (***box 8.8***).

BOX 8.8 >>

National and Caribbean vocational qualifications

NVQs and CVQs provide competency-based certifications assessed against occupational standards. These qualification systems are established in the Caribbean, especially Jamaica, Barbados, and Trinidad and Tobago. The certification structure covers five levels of competence: Level 1 for entry-level occupations; Level 2 for skilled occupations; Level 3 for technical, skilled, and supervisory occupations; Level 4 for technical, specialist, and middle management occupations; and Level 5 for chartered, professional, and senior management occupations. There are numerous course offerings for Levels 1 to 3, and a few vocational courses at Level 4. Vocational qualifications up to Level 2 are available for students at schools that have the necessary infrastructure, and schools collaborate closely with national training agencies when offering these programs.

The Caribbean Examinations Council awards the CVQ certificate to students in secondary schools. Outside schools, national training agencies oversee course content delivery and approve training institutions to offer CVQ training. They also develop standards, accredit programs, prepare and administer assessments, and award certificates to trainees meeting defined competences. Practitioners can also be awarded a CVQ for prior learning through assessments and recognition. The course contents and occupational standards are developed by industry experts and this insider knowledge informs the design and supply of the right mix of courses in line with industries' evolving needs. Courses that can build skills for disaster resilience include those in construction and building trades, agriculture, tourism, and hospitality. However, national policy directives on skills training that are directly related to DRM at technical vocational and training level are embryonic and many of the top CVQ courses at secondary level are in fields that are not directly related to DRR, such as general cosmetology and furniture making.

Source: Bellony and Powers 2021

Transforming and diversifying economic activity

Diversifying within and away from vulnerable industries will promote resilience in Caribbean economies and require the development of complementary skills. The rapid move to distance education and remote learning—accelerated by COVID-19—alongside the growth in technology at work and in leisure, business, and health, the push for improved internet connectivity, and a large talented youth population provide an enabling environment for developing innovative skills in the projected diversification sectors. However, skills development and training in digital technologies related to disaster management and health shocks in the Caribbean remain at a nascent stage, and countries should address this gap (Bellony and Powers 2021).

Human capital development around resilience to climate change, DRR, digital technologies, and pandemics varies across countries. The limited progress on integrating DRR into school curriculums reduces the impetus for teacher training programs in corresponding subject areas. At a regional level, there is an awareness on the importance of developing DRR and resilience skills. The regional CDM Strategy (2014–2024) has defined outcomes to increase and sustain knowledge and learning for disaster management.[20]

Through the CDM Harmonized Implementation Program, development partners have consistently provided short training courses, toolkits, and learning resources for diverse audiences. Education planners, infrastructure planners, and curriculum developers have benefitted from programs on comprehensive school safety policy and methods for integrating DRR concepts into the curriculum. Through its "Building the resilience of CARIFORUM States to disaster risks and climate change impacts program", the European

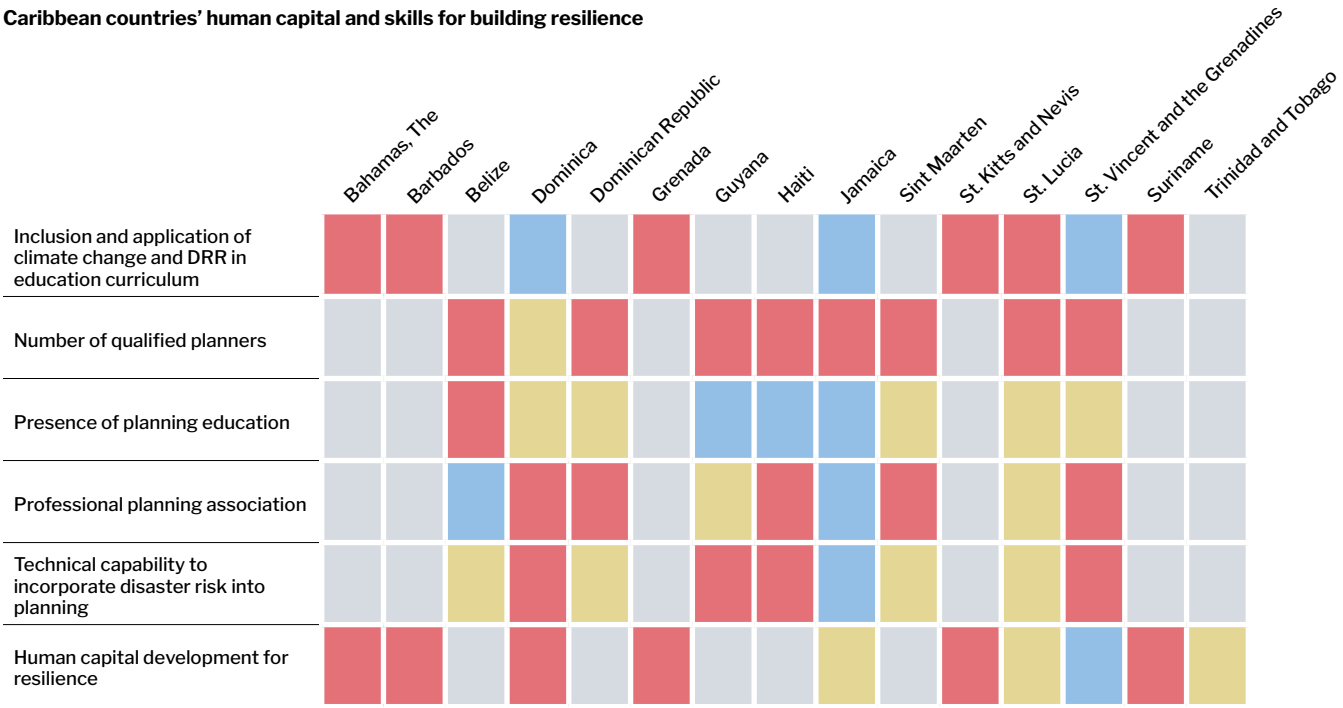
Union has made grant financing available to support comprehensive disaster management. However, progress has been slow, as developing DRR skills largely remains an externally financed project output, and courses are short, lack certification, and are not tailored to build technical competencies that are specific to country needs.

Only St. Vincent and the Grenadines has a human capital development plan that addresses DRR, climate change, and other resilience topics, thus receiving an "established" score for developing human capital for resilience (*table 8.4*). Jamaica, St. Lucia, and Trinidad and Tobago, who are in the process of developing and implementing their plans, receive an "emerging" score. Building resilience by mainstreaming disaster risk reduction into vocational training requires special emphasis on developing the skills of low wage earners and vulnerable workers, who suffer most from shocks. The core components of a training program for vulnerable workers should include courses on digital skills, using technology, and financial literacy.

In the short term, combining income support from social protection programs with active labor market policies sets the foundation for sustainable future employment of vulnerable workers. In the longer term, policy makers need to assess vulnerable workers' job prospects and tenure security and devise skills development opportunities to increase their accumulation of human capital and improve their employment prospects.

TABLE 8.4 >>

Caribbean countries' human capital and skills for building resilience



Sources: Based on data from Bellony and Powers 2021; Johnson, Caroca Fernandez and Restrepo Cadavid 2021.

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and are beyond the initiation point but have not reached the final point; and countries in blue (established) meet the standard entirely. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Leveraging opportunities for the future of work

Although the future of work presents opportunities, there are significant challenges that require revolutionary and visionary thinking and planning before countries can realize the benefits. Automation and the expanding use of artificial intelligence, robotics, big data, 3D printing, and other technological innovations progressively displace workers and expand technological unemployment, especially in manufacturing and customer service fields (Acemoglu and Restrepo 2019). At the same time, COVID-19, with its requirements for physical distancing and fear of eroded profits, is intensifying the appeal for automation, potentially accelerating job destruction for low wage earners (Susskind 2020).

Education and skill development have important roles in allowing vulnerable workers with lower educational attainment to upskill, retrain, adapt, and engage in lifelong learning. In the Caribbean, the shift in mindset on the importance of science, technology, engineering, and mathematics (STEM)—key fields for advancing resilience—has started, with expanded course offerings and project-based learning. However, data from regional examinations identify the need for major improvements in STEM teaching and learning. Further investment in incorporating STEM in education curriculums and in creative ways to expand access to lifelong learning outside of formal education systems with corresponding certifications will contribute to building skills for resilience (Bellony and Powers 2021).

The skills of the Caribbean diaspora are another underused resource for disaster risk reduction and building resilience in the region. Harnessing the human capital of tertiary educated Caribbean emigrants provides technical resources during and after disasters, pandemics, and ongoing climate change discussions. Developing a model for deploying the specialized skills of the diaspora at CARICOM level would help harness this potential.

Finally, while Caribbean countries have subscribed to the SDGs, the Paris Agreement, and other international accords, initiatives under these agreements are nationally focused and do not consider for value added through regional coordination and collaboration. New economic growth drivers in energy and the blue and green economies, and structural changes in tourism and agriculture, will require new skills and more regional coordination to consider lessons learned, best practice, and innovations across the region. Building and sustaining resilience in skills for the future will require dialogue, consensus building, and pooling of expertise through regional institutions and Caribbean heads of government summits.

Endnotes

1. https://unece.org/sendai-framework.
2. For example, http://www.antiguamet.com/Climate/CLIMATE_DATA/ServiceCatalogue.pdf; http://www.antiguamet.com/; http://nods.gov.ag/hazzards/earthquake/; http://nadma.gd/past-disasters/; http://3d-barbados.chordsrt.com:3000/; https://www.caribank.org/work-with-us/procurement/procurement-notices/road-management-and-rural-road-improvement-programme.
3. For example, Geodata Point (2018); IFRC (2016).
4. For example, Canevari et al. (2015); Alleyne (2019).
5. For example, Nurse (2018); Commonwealth of The Bahamas (2018); Douglas (2010); Government of the Commonwealth of Dominica (2020).
6. https://sendaimonitor.undrr.org/analytics/global-targets/16.
7. https://public.emdat.be/.
8. Bathymetry is the measurement of depth of water in water bodies, including oceans, rivers, streams, and lakes. https://oceanservice.noaa.gov/facts/bathymetry.html.
9. https://www.caribbeanclimate.bz/blog/2018/11/30/ccccc-adds-lidar-to-boost-caribbeans-climate-change-fight/.
10. https://projects.worldbank.org/en/projects-operations/procurement-detail/OP00054567.
11. https://www.gfdrr.org/en/caribbean-risk-information-programme-support-integration-disaster-risk-management-strategies.
12. https://www.cdema.org/virtuallibrary/index.php/charim-hbook/methodology/2-analysing-hazards/2-1-introduction-to-hazards.
13. https://www.cdema.org/ews/component/edocman/introduction-to-vulnerability-and-capacity-assessment?Itemid=0.
14. https://www.worldbank.org/en/programs/statistical-performance-indicators.

15. MiFi devices are compact, wireless devices, usually smaller than a smartphone, that create a localized WiFi signal and can be used on the go. With MiFi, multiple users can share one broadband connection, in a similar way as done with a wireless router by home broadband providers.
16. The Bahamas has also passed legislation for establishing a credit bureau, with its registry expected to become operational in 2021.
17. https://projects.worldbank.org/en/projects-operations/project-detail/P127226.
18. Family Accompaniment is a type of counselling aimed at setting goals and modifying behavior to improve people's safety and well-being, and is based on established ties between the social worker and family or individual/client. Case management involves the joint assessment of client needs and the amount and types of benefit or service required to achieve the goals set during a client's participation in a social protection program or service, and monitoring and evaluating that participation (World Bank 2020c).
19. These were presented during the second Caribbean ministerial Safe School Forum in April 2020. https://www.preventionweb.net/files/63939_2ndcaribbeansafeschoolministerialfo.pdf.
20. For example, its Performance Monitoring Framework Priority Area 2 states: #11. Number of accredited Centers of Excellence operating, 2024 Target 6. #12. Percentage of managers and technical professional from state institutions certified by a Center of Excellence, 2024 Target 75.

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9

CHAPTER 9 >>

Design resilient infrastructure systems, urban and coastal plans

Beyond direct support to households and businesses, governments have a transformative role to play in ensuring their country, economy, and citizens can cope with shocks by increasing the resilience of power, road, water and sanitation, telecommunications, and other infrastructure systems.

And because urban, land use, and coastal management plans influence private investments in housing and productive assets, it is important to adapt these to evolving long-term climate risks to avoid locking people into high-risk areas.

Lifeline infrastructure: a governmentwide strategy

To increase the resilience of lifeline infrastructure services—water, transport, energy, and telecommunications services—the World Bank's Lifelines report recommends measures in five areas (Hallegatte, Rentschler and Rozenberg 2019):

1. The basics of general infrastructure design and maintenance
2. An integrated institutional approach to infrastructure resilience
3. Regulations and incentives to integrate resilience into infrastructure investments and planning
4. Data, information, and analytical tools for risk-informed decision making
5. Finance and funding

This diagnostic on the resilience of lifeline infrastructure in the Caribbean defines three maturity levels (*table 9.1*) and presents indicators to measure progress towards resilience covering the first three areas mentioned above (*table 9.2*). Points 4 and 5 are further elaborated on in *chapters 8 and 12*, respectively. The remainder of this section draws on the sectoral background papers prepared for the report, namely Erman et al. 2021, Johnson et al. 2021, Miyamoto International 2021, and Valero et al. 2021.

TABLE 9.1 >>

Defining terms: nascent, emerging, and established resilient infrastructure systems

Nascent	Emerging	Established
» The infrastructure system is **unreliable under normal conditions** and cannot withstand shocks » **Infrastructure design** neither follows relevant codes and standards, nor considers prevailing hazards » Infrastructure **operation and maintenance** are severely lacking » **Public and private decision makers** do not have the data, tools, skills, capacities and incentives they need to prevent disruptions, so infrastructure continues to be built in risky areas » Poor **governance and management** and severe **financing constraints** impede the creation of a resilient infrastructure ecosystem	» The infrastructure system is **usually reliable under normal conditions** but may not withstand shocks » **Infrastructure design** follows some international building code and standards; in some cases, it considers prevailing hazards » There is room for improvement in infrastructure **operation and maintenance** » Although **public and private decision makers** have some data, tools, skills, capacities and incentives they need for avoiding disruptions, these do not always consider changing threats, nor are they consistent with risk-informed land use plans » There is room for improvement in **governance and management**, and **financing constraints** impede the creation of a resilient infrastructure ecosystem	» The infrastructure system is **reliable** and can withstand most shocks » **Infrastructure design** follows local building codes and standards that consider prevailing (and changing) hazards » Infrastructure is **properly operated and maintained**, reliable under normal conditions, and can deliver its core functions when disaster strikes » **Public and private decision makers** have the tools, data, skills, capacities and incentives they need to avoid disruptions and these are adjusted regularly for climate change and consistent with risk-informed land use plans, which guide development towards safe areas » Good **governance and management** and **appropriate funding** create a resilient infrastructure ecosystem

The basics: reliable infrastructure systems under "normal" conditions

The first step in building more resilient infrastructure systems is to make them reliable under normal conditions by ensuring appropriate design, operation, and maintenance. Erman et al. (2021) estimate water and power infrastructure reliability, using results from a representative survey in the Caribbean tourism sector. Most countries can provide these services on a relatively reliable basis; but in some, like Antigua and Barbuda and the Dominican Republic, firms experience, on average, disruptions to their water supply every four days and to their power supply every five days (Erman et al. 2021).

To improve reliability, infrastructure should be built to appropriate design standards and consider prevailing hazards. For example, floods present the most critical hazard for (paved) roads in the Caribbean; so earthquakes and wind hazards are usually only considered if a road is located on liquefiable soil or close to a fault experiencing permanent ground deformation (Miyamoto International 2021).

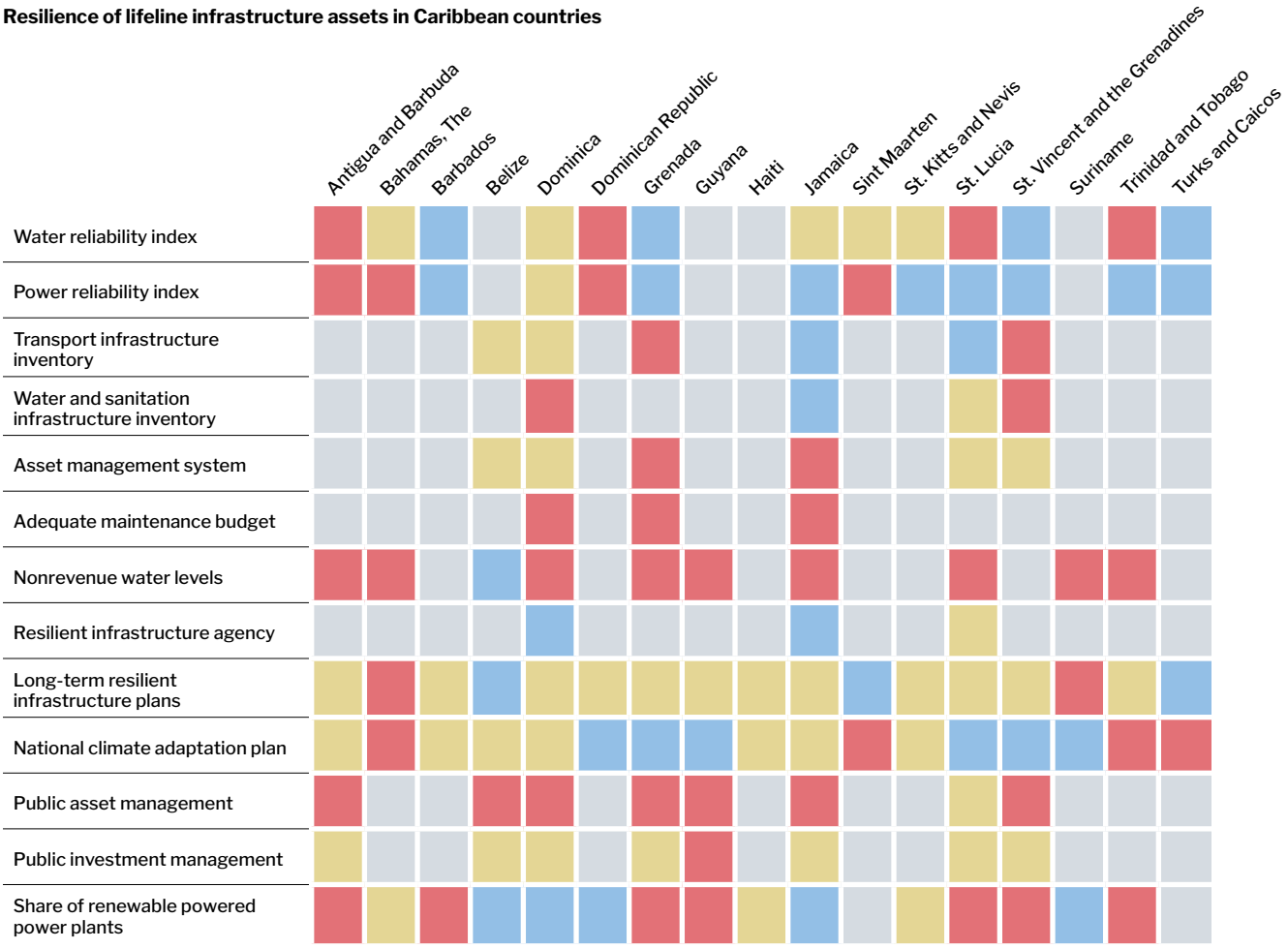
But specialized design codes are generally lacking, and where they exist, they are rarely followed or enforced. Although the design and construction of water and wastewater treatment plant buildings and equipment—such as pipelines and nonstructural components—follow international or Caribbean building codes, there are no specialized design codes for this type of facility in the region. Trinidad and Tobago is the only country that has a water and wastewater treatment plants design guideline. But it is specifically for water treatment plants in name only, as it merely refers to the country's general building code. Design practice for the power sector, on the other hand, provides criteria for structures, including provisions to design assets to withstand hazards like extreme wind speeds, earthquakes, floods, and combinations of these hazards (Miyamoto International 2021). However, the act of having design standards does not ensure they will be followed. For example, the Wadadli power plant—one of two in Antigua and Barbuda—never operated at full capacity. Poor design, improper sizing of auxiliary equipment, and the use of construction materials that were unsuitable for the marine environment rendered it inoperable within several years of opening in 2011 (K&M Advisors 2020a).

Operations and maintenance are critical to ensure the performance of infrastructure systems and reduce investment costs. For example, culverts cannot protect roads if they are blocked by solid waste; and without proper vegetation management, transmission lines are at risk of toppling trees and falling branches. Estimates indicate poor maintenance can increase infrastructure investment needs by 50 percent in the transport sector and by more than 60 percent in the water sector (Rozenberg and Fay 2019). So, how can utility operators ensure proper maintenance? An infrastructure asset management system can help them move away from a reactive approach towards evidence-based, preventive maintenance for better operations management. In its simplest version, such a system lists each asset independently of the system in which it functions, with information on how much it costs, who is responsible for its maintenance, its condition and functionality, and when it requires rehabilitation. A more complex system also includes the strategic, financial, and technical aspects of managing the assets across their life cycle and documents the functional context in which they deliver services.

Although most Caribbean countries have some type of asset registry in place, few have expanded this to a comprehensive inventory or management system (***table 9.2***). As a result, they tend to make reactive decisions based on experience, rather than driven by data. St. Lucia's Department of Infrastructure is in the process of implementing a road and bridge management system in a project that aims to give the country the tools to switch from reactive to preventive maintenance. The system will cover over 1,000 kilometers of roads and 100 major bridges in the country (Sirvio and Philogene-Mckie 2019).[1] The project aims to achieve a 15 percent saving in maintenance, 10 percent lower road use costs, and general enhancement in safety. As part of the Prioritizing Climate Resilient Transport project, Belize developed its first primary road network and geospatial database, which includes 747 road survey points with detailed information about road surface, condition, and natural hazards (Pedroso 2019). The intention was to enable risk-informed road planning and maintenance and increase the efficiency of decisions, but the database is neither being updated nor used. In Trinidad and Tobago, a multi-year project assessing 96 bridges completed in the early 2010s resulted in 40 bridges being rebuilt incorporating seismic measures (Miyamoto 2021).

TABLE 9.2 >>

Resilience of lifeline infrastructure assets in Caribbean countries



Sources: Based on data from April and Zrinski 2021; Erman et al. 2021; Medina et al. 2021; Schweikert et al. 2012; Valero et al. 2021

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; and countries in blue (established) meet the standard entirely. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Many countries have significantly expanded their water networks, providing good coverage in terms of water and sanitation service accessibility (*chapter 7*), but these generally require upgrades, maintenance, and rehabilitation. Caribbean countries face significant water loss, driven by inattention to infrastructure, theft, and metering inaccuracies (Medina, Kullman and Felter 2021). These losses, also known as *nonrevenue water*, are significant: 24–63 percent of potable water never reaches the customer after leaving the point of production (Burdescu et al. 2020). *Figure 9.1* shows the level of nonrevenue water for different state-owned water agencies in the Caribbean. Although optimal nonrevenue water depends on the cost of water production—for example, it is more expensive to produce water from desalination than from surface sources—in general, a water utility with more than 30 percent nonrevenue water should take steps to reduce this value. This implies that almost all the utilities shown would benefit from efforts to reduce their nonrevenue water. Performance-based contracts, which link contractor payments to asset performance, are one way to decrease nonrevenue water and improve maintenance of water and other infrastructure (*box 9.1*).

BOX 9.1 >>

Using performance-based contracts to increase water sector resilience in The Bahamas

The Bahamas' water sources are overstressed, and New Providence is one of the most overstressed cities in the Caribbean (IDB 2018). The Water and Sewerage Corporation (WSC) began operations here in 1976 in good financial condition. However, problems with poor water quality, low pressure, nonrevenue water, and occasional rationing eroded its financial condition as customers departed. Deficient service has made the government reluctant to authorize tariff increases, exacerbating the company's financial problems. Since the 1990s, this vicious cycle has led to large government subsidies.

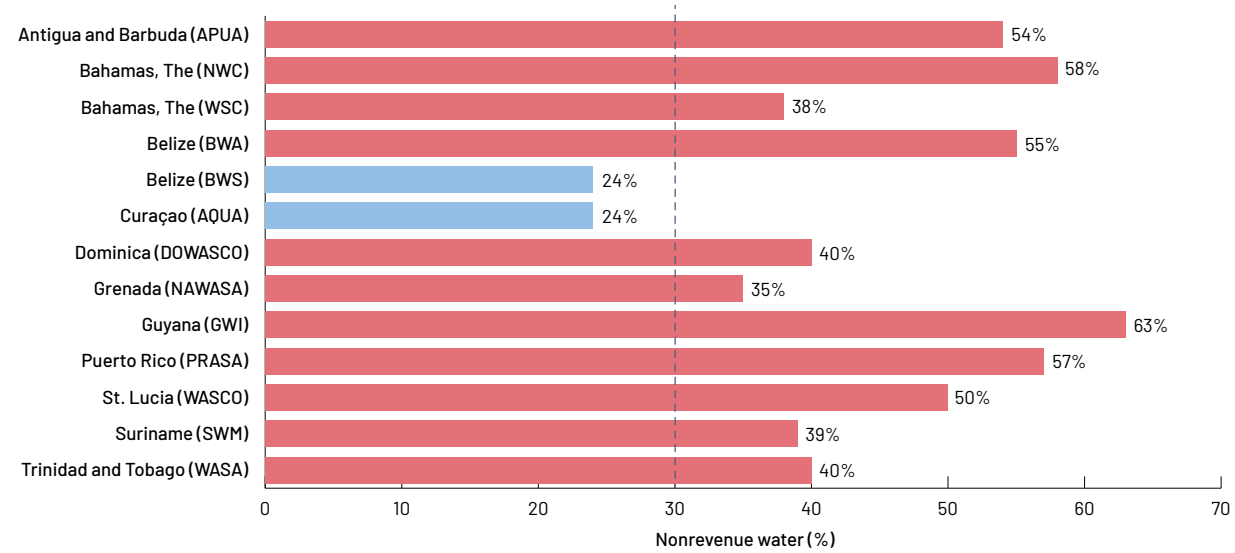
Nonrevenue water—one of the problems faced by WSC—creates a well-known vicious cycle that erodes financial resilience. Low tariffs and tariff collection rates discourage responsible water use, which in turn, increases costs. At the same time, inadequate funding leads to poor maintenance and postponed investments, further deteriorating the service, increasing the number of customers who are unwilling to pay for it. As with WCS, a service provider in this situation will appeal for government subsidies. But these are not always awarded, due to political pressure. Without subsidies, the situation worsens, until the utility cannot pay salaries and other operating costs. The service then deteriorates further and infrastructure becomes inoperative. The utility becomes bankrupt and customers are forced to seek alternative, more expensive, sources of water (Baietti, Kingdom and van Ginneken 2006).

Reducing nonrevenue water is therefore vital. But it is also a complex financial, institutional, and political undertaking. With its initial ad hoc approach, WSC did not achieve any major improvements in leak detection and repair. Realizing it needed a larger nonrevenue water control program, the company developed a comprehensive performance-based contract plan for 2008–09, which included several technical interventions to reduce leakage. This significantly reduced nonrevenue water, cutting losses by more than 50 percent and achieving significant financial and operational benefits. Although the technical skills required to execute nonrevenue water programs are straightforward, the expertise, good collaboration between WSC and the operator (Miya), and a willingness to solve the problem were essential elements for a proper diagnosis and effective program design and execution (IDB 2018).

Source: Medina, Kullmann and Felter 2021

FIGURE 9.1 >>

Share of nonrevenue water for state-owned enterprises in Caribbean countries



Source: Burdescu et al. 2020

Notes: The water providers in each country are in parentheses. The dotted line indicates the maximum nonrevenue level (30%) that water utilities should strive for. The blue shading shows water losses at acceptable levels; those in red indicate that losses exceed the maximum recommended level.

An integrated institutional approach

Governments play a key role in ensuring the resilience of critical infrastructure and should adopt a whole-of-government approach (Hallegatte, Rentschler, and Rozenberg 2019; Renn 2008). This means involving sectoral ministries, local authorities, agencies overseeing infrastructure service delivery and regulation in multiple critical sectors, and agencies that are responsible for resilience to hazards and threats. Proper coordination and good governance can increase infrastructure resilience and be cost-efficient, with data showing a clear correlation between governance and infrastructure quality (WEF 2018).

The most common solution for improving risk management coordination across risks and systems is placing a new or existing multiministry body in charge of information exchange, coordinating, and even implementing infrastructure risk management measures. Most countries have bodies and coordination mechanisms with some resilience function, and have assigned national, regional, and international targets and priorities to a responsible body that enforces and monitors them. Only St. Vincent and the Grenadines, Suriname, and Sint Maarten have no interministerial committee or governmental body responsible for climate change/resilience (Valero, Miranda and Murisic 2021). But, while most countries have bodies and agencies that have some resilience role, few of these are dedicated to the resilience of infrastructure. Only Dominica is known to have an established resilient infrastructure agency (***table 9.2***).

But with so many public institutions or agencies having some specific mandate in resilience, there are major challenges around institutional coordination, enforcement and monitoring as well as technical and human capacity constraints. Confusion about roles and mandates among the different involved stakeholders only complicate the process (Valero, Miranda and Murisic 2021).

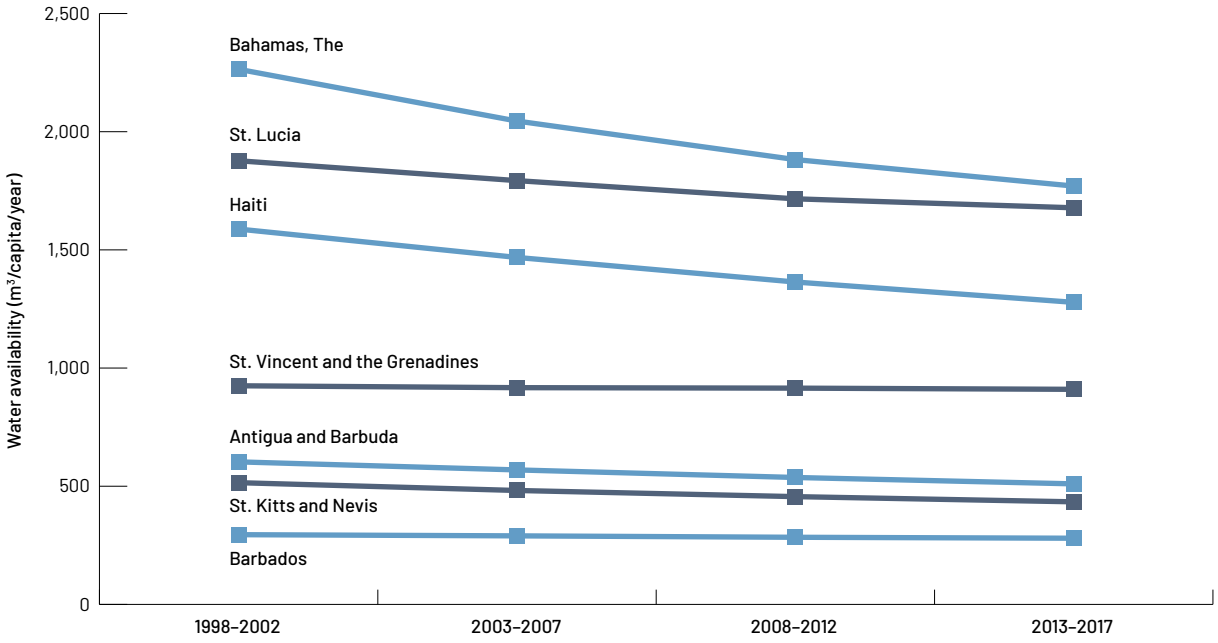
The water sector is a case in point. With annual available water per capita decreasing since 1998 (***figure 9.2***), about half of all Caribbean countries are near water-stressed or already water-scarce.[2] Several countries are also extracting large amounts of water and using their scarce resources unsustainably—for example, St. Kitts and Nevis, which faces scarce annual water availability levels of less than 500 cubic

meters per capita, continues to extract more than 50 percent of its freshwater resources (Medina, Miranda and Murisic 2021).

But despite the urgent need for the region to adopt strong water policies to balance water demands and gain resilience to climate change under dwindling freshwater resource conditions, there are several obstacles to water resource management in the region. First, governments lack formal cross-sector collaboration mechanisms to coordinate drinking water, irrigation, drainage, sewerage, emergency management, and urban development and address water scarcity and resilience. Second, water utilities tend to be state-owned enterprises, so managing water resources can take a back seat to their utility functions. As a result of lax management, streams and rivers are allowed to deteriorate, thus exhibiting higher peak flows during storms, and as land use changes from natural cover to built-up urban areas and land cultivated for food production, water quality suffers (GWP 2014). However, there are steps countries can take to reduce water losses and increase resilience (***box 9.2***).

FIGURE 9.2 >>

Water availability in water-stressed and water-scarce Caribbean countries



Source: Based on data from FAO's AQUASTAT database[3]

Notes: The FAO defines water scarcity as less than 1,000 cubic meters of total renewable water resources per capita per year, and water stress as less than 1,700 cubic meters of total renewable water resources per capita per year.

BOX 9.2 >>

Three steps to increasing resilience in the water sector in St. Lucia

Fresh water in St. Lucia is largely supplied by surface water withdrawals from rivers and watersheds. During the rainy season, the island's mountainous topography and low-permeability rock basement mean flows are reliable, and unlike many other Caribbean SIDS, St. Lucia does not rely on desalination for municipal water production. Instead, 13 water treatment plants, with various levels of filtration, are located around the island, operated by the Water and Sewerage Company. The Theobalds plant provides more than half of all municipal water and serves most of the northern population. It treats water from the John Compton Dam and reservoir, which has had its storage capacity halved by heavy siltation due to upstream erosion from heavy rainfall and landslides. The southern part of the island faces water security issues during the dry season between December and May. The tourist sector accounts for approximately 16 percent of annual demand, and meeting this is a challenge during the dry season, which coincides with the arrival of cruise ships. As a result, several tourist resorts have commissioned desalination plants.

Nonrevenue water levels are a major problem in St. Lucia, where around 56 percent of total water supply is lost through leaks, theft, or metering inaccuracies. Without urgent efforts, water shortages will continue to increase. A national infrastructure assessment by the government of St. Lucia with the United Nations Office for Project Services and the University of Oxford-led Infrastructure Transitions Research Consortium (Adshead et al. 2020) identifies priority areas to meet this demand and eliminate the gap between reliable water supply and peak demand in the long term (***figure B9.2.1***). Its strategy focuses on:

1. **Reducing water loss:** Systematically replacing pipes in the north of the island can improve transmission efficiencies by 80–90 percent. Establishing metering and pressure zones along faulty networks will increase flow and pressure monitoring, help identify leaks, and eventually, reduce system losses.

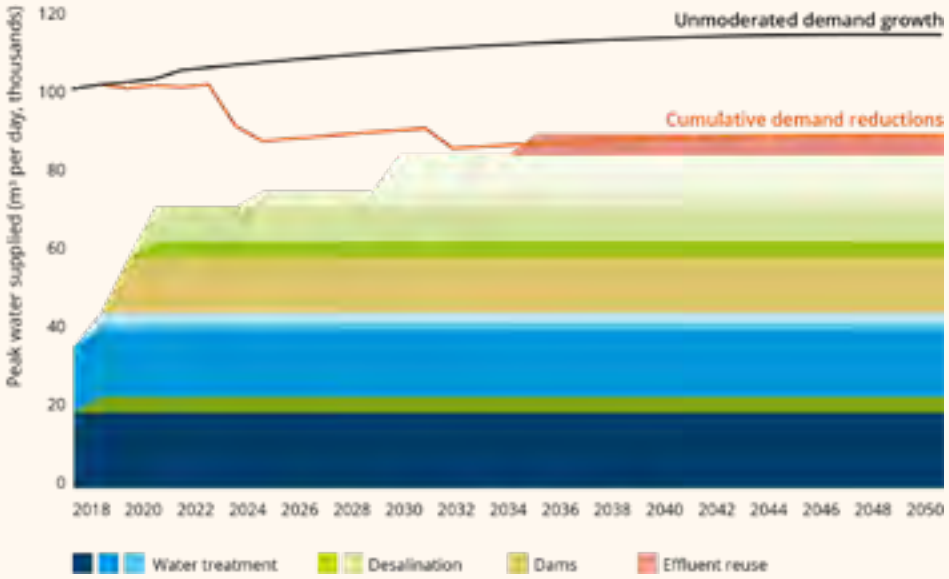
2. **Increasing water storage capacity:** To meet demand in the dry season, adding storage capacity is key. Integrating rainwater harvesting into new building construction is one option.

3. **Dam desilting and rehabilitation:** Work began in 2018 to remove 1.5 million cubic meters of sediment from the John Compton reservoir restoring it to its original capacity. To ensure the dam and its main outlet pipe do not become obstructed by hurricanes or other events, vegetation or other forms of reservoir basin protection should be considered.

FIGURE B9.2.1 >>

Long-term water demand planning in St. Lucia

Source: Adshead et al. 2020



Regulations and incentives

There are few incentives for public and private decision makers to avoid disruption. Investment decisions often only consider lower repair costs, rather than the full social cost of infrastructure, making building resilience seem unprofitable. For example, an assessment of the cost-benefit ratio of building resilience into power infrastructure in Antigua and Barbuda, St. Kitts and Nevis, and St. Vincent and the Grenadines shows that considering benefits to the power sector only gives ratios of 0.34–0.7. As these are lower than 1, investments would be considered economically unviable. However, when also considering the benefits to other sectors, all assessments yield ratios larger than 1, advocating for building resilience (K&M Advisors 2020a, 2020b).

To incentivize all actors to build resilient infrastructure, governments should: include resilience objectives in master plans, standards, and regulations, adjusting them regularly for climate change; create financial incentives for services to promote resilient infrastructure services; and ensure regulations are consistent with risk-informed land use plans guiding development towards safe areas (Hallegatte, Rentschler and Rozenberg 2019). Having a long-term resilient infrastructure plan that dictates some of these objectives is a good start.

In the region, however, only Belize, Sint Maarten, and Turks and Caicos Islands have a long-term resilient infrastructure plan or similar document in place. The Bahamas and Suriname have no such plan, and the other countries are in the process of developing plans and policies (*table 9.2*). Formulating and implementing national adaptation plans (NAPs) helps countries integrate climate change adaptation into national decision making and infrastructure planning. And while many have started mainstreaming adaptation into their national development plans and climate change policies, there is still progress to be made. Only the Dominican Republic, Grenada, Guyana, St. Lucia, St. Vincent and the Grenadines, and Suriname have a NAP that considers relevant economic sectors. For example, St. Lucia's NAP focuses on building the capacity of infrastructure sectors to integrate adaptation into their operations and plan both the retrofit of public infrastructure that is most at risk of climate impacts and the phased relocation of vital infrastructure (Government of St. Lucia 2018). The Bahamas, Sint Maarten, Trinidad and Tobago, and Turks and Caicos have no such plan, while the other countries are in the process of developing a NAP or similar type of document (*table 9.2*).

Public investment and asset management represent opportunities for governments to build resilience into their physical assets, public infrastructure, and services. The project design, physical placement, and construction of public assets should use projections of the frequency and intensity of extreme weather events over its intended lifetime to consider the asset's vulnerability to natural hazards. Given their long operating lifetimes, it is important to also consider the impact of climate change on the intensity and frequency of extreme weather events, and gradual shifts in ecological zones. Project appraisal practices should therefore verify that designs adequately consider and address vulnerability to natural hazards and changing environmental conditions (April and Zrinski 2021).

However, Caribbean countries do not generally integrate disaster resilience into public asset and investment management systems. Despite their vulnerability to natural hazards, none of the countries has a systematic approach to identifying, appraising, and selecting disaster and climate-risk informed investment projects, and most of the countries for which data are available receive an "emerging" score for public investment management (*table 9.2*). They all score "nascent" on public asset management, as they do not systematically track financially protect public assets. This makes it difficult to quickly undertake accurate postdisaster needs assessments or replace destroyed assets (April and Zrinski 2021).

BOX 9.3 >>

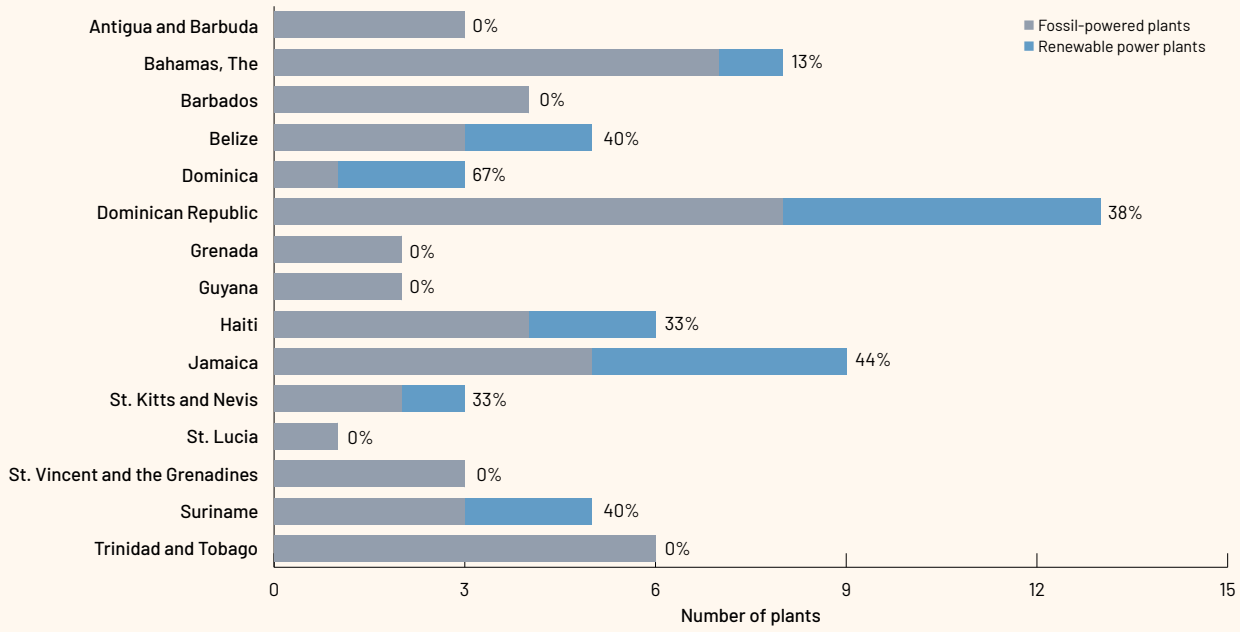
Tapping into renewables

Switching to renewable energy is one way of reducing costs linked to infrastructure systems and decreasing vulnerability to global commodity prices. Apart from Guyana and Trinidad and Tobago, which have abundant oil and natural gas resources, Caribbean countries are highly dependent on fossil fuel imports. For example, approximately 99 percent of St. Lucia's installed capacity depends on fuel imports, costing the government around 10 percent of annual GDP. As a result, electricity tariffs in the region are high, averaging $0.33/kWh—more than triple the U.S. average.

Considering electricity needs are likely to increase in the long term under population and tourism growth (with tourism accounting for a large share of electricity), countries should develop a resilient power infrastructure strategy that capitalizes on the favorable conditions for solar, wind, and geothermal energy in many Caribbean countries, and develop integrated energy use and demand interventions (Adshead et al. 2020). But although efforts are under way to leverage the potential of renewables, most of the region's power plants are still powered by imported fossil fuels (figure B9.3.1). Although its does not consider total plant capacity, the ratio of renewable to fossil fueled plants provides an indication of a countries' progress towards tapping into this potential.

FIGURE B9.3.1 >>

Ratio of renewable to fossil powered power plants



Source: Based on Schweikert et al. 2020

Notes: The number at the end of each bar shows the percentage of the country's power plants that are powered by renewable energy.

Finance and funding

The quality of infrastructure services depends on many factors—from good planning to good maintenance—and each of these has a cost (Hallegatte, Rentschler and Rozenberg 2019; *figure 9.3*). If there are not enough resources to meet the needs for any of these factors, the quality of services is likely to suffer. To meet objectives in terms of infrastructure services and resilience, countries need to provide enough resources and distribute these appropriately. But maintenance budgets in the Caribbean tend to be inadequate (*table 9.2*). Estimates of what Latin America and the Caribbean should spend on infrastructure until 2030–40 vary significantly, from 3–8 percent (Bhattacharya, Romani and Stern 2012; CAF 2011; Fay and Morrison 2007; Kohli and Basil 2011; Perotti and Sanchez 2011; Ruiz-Nuñez and Wei 2015).[4] But current spending is well below this. Between 2008 and 2019, Belize, Guyana, Haiti, the Dominican Republic, and Trinidad and Tobago—the five countries with available spending data[5]—spent 1.95 percent of GDP on average on infrastructure, which is below the Latin America and Caribbean average of 2.2 percent. Belize had the highest spending (4.2 percent) and Haiti the lowest (0.39 percent).

FIGURE 9.3 >>

The full cost of infrastructure

Source: Hallegatte, Rentschler and Rozenberg 2019

It is not, however, only about spending more; spending better can also make a significant difference. Exploring the relationship between spending more and spending better, Kornejew, Rentschler and Hallegatte (2019) show that, if governance quality is held constant, the impact of spending is largely muted. However, when improving the quality of governance, there are substantial potential savings on infrastructure spending for governments. The study shows that an ambitious but feasible governance reform could allow governments to cut their transport expenditure by 30–90 percent. Of the 160 countries examined, Haiti would be one of the biggest beneficiaries of improved spending effectiveness, with the potential to cut road expenditure by 90 percent in the long term without reducing performance. The Dominican Republic and St. Lucia could save about 56 percent.

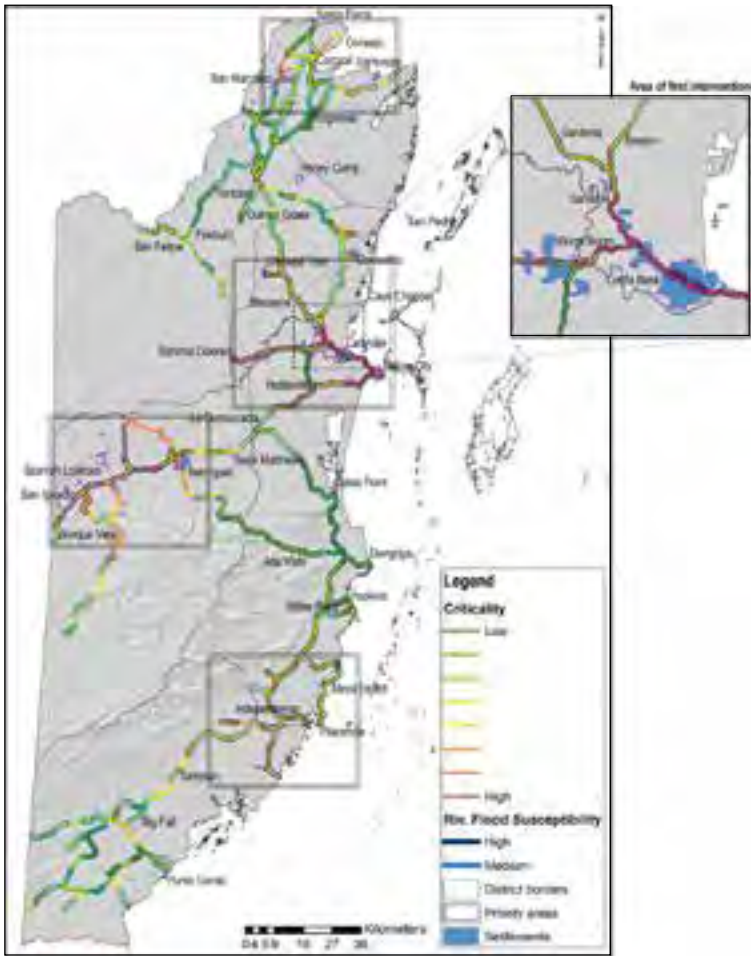
Assessing criticality to prioritize assets

When funding for infrastructure is limited, building resilience in infrastructure systems at an acceptable cost starts by identifying the systems, assets, facilities, and networks that provide essential services for the functioning of the economy and the well-being of the population (OECD 2019). Criticality analyses (*chapter 2*) can help identify the most important parts of networked systems, allowing the prioritization of interventions that will give the largest benefits. After identifying the critical infrastructure assets and systems, governments need to redefine acceptable and intolerable levels of risk, which individual sectors can use to design their own regulations and measures, ensuring consistency across systems. As part of the Prioritizing Climate Resilient Transport project, Belize conducted a criticality analysis of its primary

road network, identifying four priority areas for flood vulnerability reduction investments (*figure 9.4*). The identified areas—greater Belize City, west of Belmopan, to the north of Corozal, and to the south of Independence—are extremely susceptible to floods and have high socioeconomic criticality. As part of the project, a practitioners' guide was also developed to guide future criticality analyses in environments where data are scarce (GFDRR 2019).

FIGURE 9.4 >>

Priority areas for flood vulnerability reduction investments in Belize

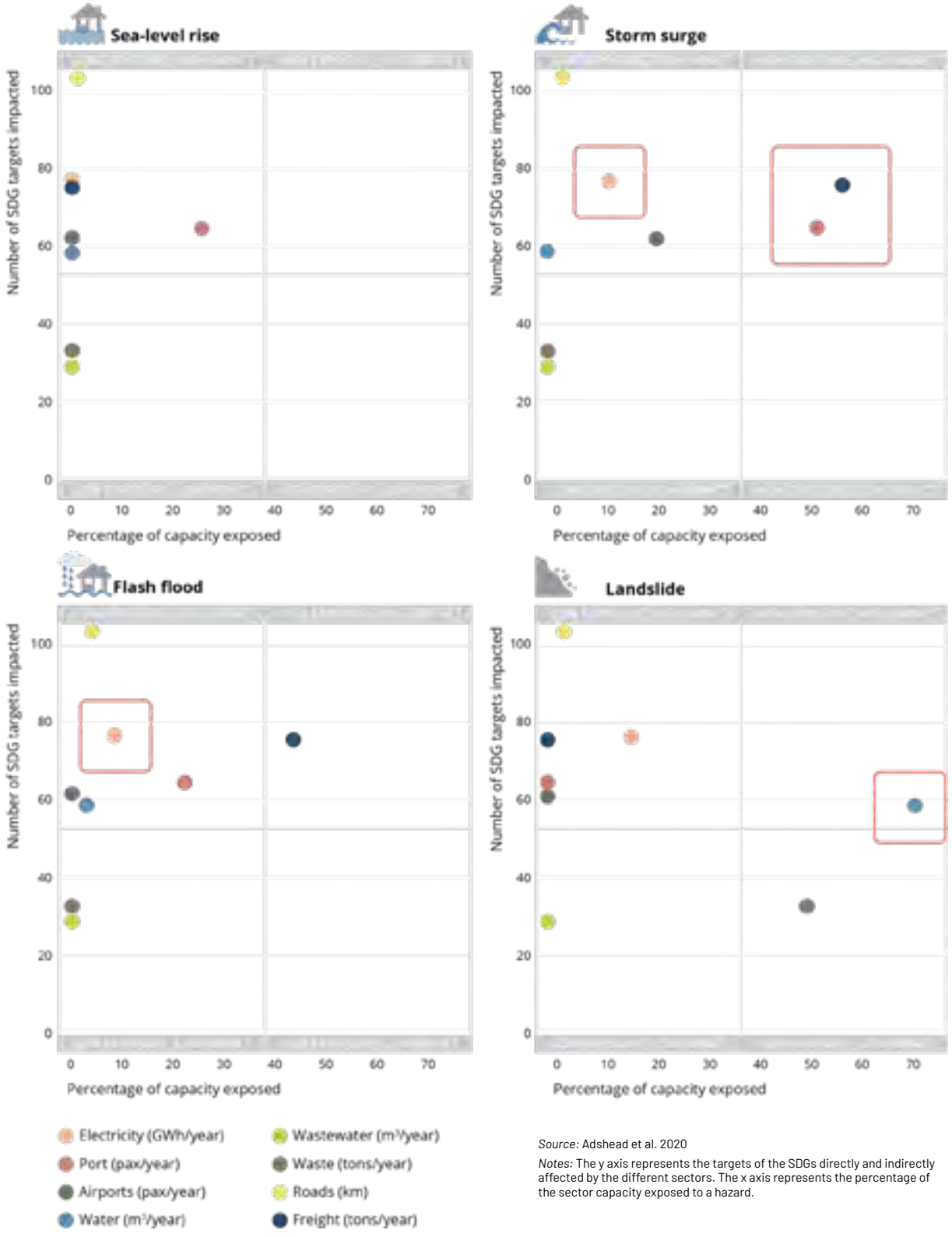


Source: GFDRR 2019

It is also possible to assess criticality at a higher level—for example, across infrastructure sectors. Overlaying hazard information with economic infrastructures provides valuable insights on sectoral budget planning and risk reduction prioritization. *Figure 9.5* shows an infrastructure sector prioritization for St. Lucia, based on the SDGs. The results suggest that preparing the transport sector for storm surges and flash floods is most beneficial in terms of reducing exposed capacity, given that these hazards expose 43–57 percent of national freight capacity, potentially affecting more than 75 targets established in the SDGs. The electricity sector might focus adaptation on storm surges, flash floods and landslides, and given the large landslide exposure, the water sector should prepare for potential sediment impacts that could reduce water supply (Adshead et al. 2020). The same type of analysis can be performed at asset, economic sector, or natural environment sector levels (for a detailed analysis of this in St. Lucia, see Adshead et al. 2020).

FIGURE 9.5 >>

Infrastructure sector prioritization in St. Lucia



Source: Adshead et al. 2020

Notes: The y axis represents the targets of the SDGs directly and indirectly affected by the different sectors. The x axis represents the percentage of the sector capacity exposed to a hazard.

BOX 9.4 >>

Telecommunications infrastructure

Natural shocks are likely to damage exposed telecommunications assets, such as towers and antennas, and underground assets, such as ducts and cables. Last mile telecommunication infrastructure—poles and antennas—make up the primary structure used to extend mobile coverage and are most exposed to natural hazards but can be recovered quickly when taking appropriate measures (Hallegatte, Rentschler and Rozenberg 2019).

Tower structure strength in the Caribbean has improved significantly: with strong foundations giving them more stability in strong winds, these structures can generally withstand winds up to Category 4 or 5. As their ability to withstand a disaster is key for the resilience of telecommunications infrastructure, mobile network operators should conduct structural stability studies for all cell sites, consider geographical risks when selecting tower locations, and adhere to building standards when renting rooftop sites for towers.

Given the unreliability of the power network, especially in times of disaster, and the fact that many towers depend on fuel generators, telecommunications facilities must have a backup generator and secure enough fuel to bridge a prolonged power outage. Their heavy reliance on power grids that got destroyed in some areas during the 2017 hurricane season highlighted that mobile network operators did not have enough backup capacity—in terms of batteries and fuel for power generators—to bridge outages. At the same time, transport infrastructure disruptions and other operational problems hampered fuel provision. For example, although the Puerto Rican authorities had given special provision to mobile network operators to obtain fuel for their sites after Hurricane Maria in 2017, fuel delivery vehicles in Puerto Rico were refused special access and had to wait in long queues to fill up, use of delaying the networks' backup generators.

Building redundancy in the network is key for preparing for disasters. Prepositioning temporary backup equipment and ensuring that antennas are tightened, grounding cables are removed, and temporarily taking down sites that are unlikely to withstand strong winds, are proven preparation actions that are already employed. Some Caribbean operators also send out advance messages to customers to alert them of the planned network loss. While removing equipment minimizes damage and reinstating it after the danger has passed is faster than repairing it, it is important to weigh these benefits against customers losing connectivity in the immediate run-up to a storm. To continue offering connection, network operators can lease satellite connections for backup connectivity.

During disasters, when telecommunication disruptions are hard to avoid but essential for relief activities (***chapter 11***), it is possible to use mobile cell sites or transportable telecommunications infrastructure to quickly reinstall connections and provide access in restricted spaces. Digicel Group—a mobile network operator in the Caribbean—positions their "Cell on Wheels" in strategic locations to ensure most markets have access to at least one mast. In an emergency, they deploy them to wherever they are needed. Digicel has also made arrangements with transportation companies to prebook planes or helicopters for personnel and equipment.

Source: GSMA 2020a, 2020b

Risk-informed land use and urban planning

Land markets are powerful tools for driving new construction in a way that efficiently meets population needs. However, they are also imperfect, and often fail to fully internalize climate change and natural hazards (Bin and Polasky 2004; Holway and Burby 1990). As a result, developments spring up in risky areas, especially when developers do not carry the cost of future climate change impacts. Agglomeration externalities and long building and urban infrastructure lifetimes mean that new developments are also largely irreversible. When a neighborhood is urbanized, it is likely to remain so forever, even if it requires massive protection or adaptation investment. Land use regulations can help ensure that new development takes place in areas that are safe or can be easily and cheaply protected. Regulations can also keep urban development in check, ensuring there is enough porous green space to avoid increasing runoff and flood risk (Lall and Deichmann 2012).

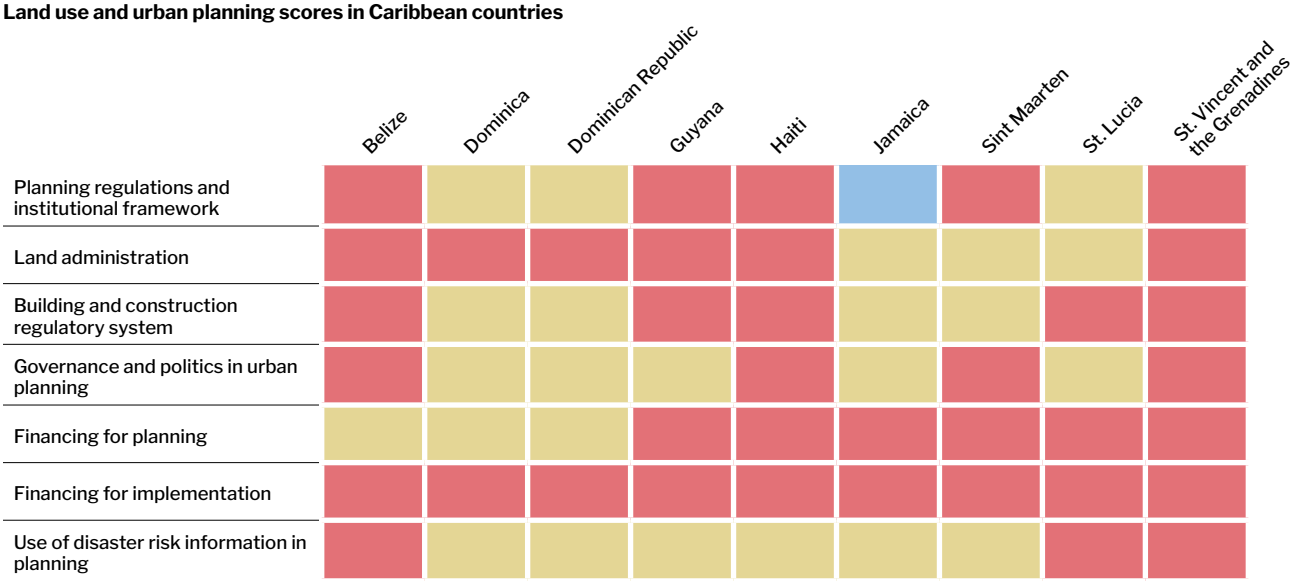
With limited land available for development in most SIDS, developing on coastal land is a necessity, which increases exposure to storms through coastal zone ecosystem loss. Flooding is also a major issue, with many cities left flood-prone by unsustainable, unregulated urban development, poor solid waste management, and inadequate drainage infrastructure. Urbanization has affected drainage patterns of natural catchment areas by increasing volume and rate or surface run-off. Inadequate sewage treatment means that water pollution is common, while traffic congestion leads to air pollution. Across the Caribbean, the increase in urban land cover is destroying green infrastructure, such as mangrove forests, which helps urban areas adapt to climate change impacts.

The high (3–4 percent per year) urbanization rates in the 1960s–1980s have been slowly but steadily decreasing for the past 30 years and the current average urban growth rate for Caribbean small states is 0.9 percent per year. But cities are still growing, and higher urbanization levels are projected for some countries, stemming from rural-urban migration and population growth. The highest annual urban population growth rates in the region are in Haiti (2.9 percent), Belize, and the Dominican Republic, (both with 2.2 percent).[6] On average, 51 percent of the Caribbean population is urban, but shares vary across countries. The least urbanized are St. Lucia (19 percent) and Guyana (27 percent); the most urbanized is Sint Maarten (100 percent), followed by the Dominican Republic (82 percent) and Dominica (71 percent).[7]

This analysis of land use and urban planning for risk management is based on the eight foundational building blocks identified in Johnson, Caroca Fernandez, and Restrepo Cadavid (2021) for Belize, Dominica, Dominican Republic Guyana, Haiti, Jamaica, Sint Maarten, St. Lucia, and St. Vincent and the Grenadines (*tables 9.3* and *9.4*). It does not cover human capital/skills, which are discussed in *chapter 8*. *Table 9.3* shows that, in general terms, all countries included in the study are emerging or nascent for all indicators. There are serious weaknesses across all the categories and countries, and comprehensive and coordinated work is required on all the building blocks. But, despite the low figures, it is possible to find some nuances between countries and building blocks.

TABLE 9.3 >>

Land use and urban planning scores in Caribbean countries



Source: Based on data from Johnson, Caroca Fernandez and Restrepo Cadavid 2021

Note: Only the subset of countries shown in this figure was considered for this analysis due to data limitations. Countries in red (nascent) do not meet the standard (table 9.4) and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point. No countries in this analysis meet the standard yet, so there are no scores in blue (established).

TABLE 9.4 >>

Defining terms: nascent, emerging, and established land use and urban planning

Nascent	Emerging	Established
» **Planning regulations and the institutional framework** are weak or nonexistent	» **Planning regulations and the institutional framework** are in place but lacking or not put into practice in some areas	» **Planning regulations and the institutional framework** clearly indicate who is responsible for making, updating, and implementing plans, and give a clear mandate for including disaster risk information and considerations into planning
» The **cadastral system** is nonexistent or weak, the **land registration process** is weak but might be usable for larger projects, and there is no **land tenure security**	» There is a functioning **cadastral system**, but it lacks information or is out of date, **some land is registered** but the process is long and costly, and there are weaknesses in **land tenure security**	» A digitized **cadastral system** provides all the necessary information, **all land is registered** through an easy, affordable land administration system, **land tenure security** is sufficient to strong, and most people perceive their rights to land as secure
» **The building and construction regulatory system** is weak or nonexistent; **local building codes** are nonexistent, weak, or under development; the **building approval system** is nonexistent, weak, or seldom used because it is too long, complicated, or expensive and possible to bypass	» There is a functioning **building and construction regulatory system** with **locally relevant building codes**, but many builders cannot afford this standard, so only large projects apply for **building permits**	» There is a fully functioning **building and construction regulatory system**, with affordable, **locally relevant building codes and standards** so most buildings are built to standard, and an efficient and affordable **building permit system** ensuring most or all projects undergo the process
» **Governance and politics** are weak: there is little to no **decentralization**, **urban planning** is not or barely part of the political agenda, and **DRR** is a low priority	» **Governance and politics** are developing: **decentralization** is in progress and local government exists but is not fully functional, **urban planning** is part of the political agenda, and **DRR** is usually a medium priority, rising to high after a disaster	» **Governance and politics** are well developed, with a countrywide accountable and functional **local government** system, **urban planning** is mentioned as a priority in key political documents, and **DRR** is always a high priority
» **Financing for planning** is weak or nonexistent, so plans are often out of date and do not feature disaster risk considerations; both implementation plans and participation are weak or nonexistent	» **Financing for planning** is available, and some plans are up to date, with others pending approval; plans consider disaster risk but are not always implemented, and stakeholders are consulted but not well engaged at all stages of planning	» There is enough **financing for planning** to ensure plans are up to date, aligned to national objectives, consider disaster risk, and include clear implementation plans that involve the relevant stakeholders
» **Financing for implementation** is weak or nonexistent, so very little development is guided by plans, budget is insufficient or almost nonexistent, and there is little to no DRR budget	» **Financing for implementation** is available but not sufficient, so while some urban development and infrastructure is guided by plans, low budgets often cause delays and DRR is not considered part of planning	» There is enough **financing for implementation** to ensure urban development and infrastructure is guided by plans; there is enough budget for implementation and DRR activities, and most activities are achieved within the set timeframe
» There is very little to no high-quality **disaster risk information** available	» **Disaster risk information** exists, but lacks elements or is not available to actors for use in planning	» High-quality **disaster risk information** is available for use in planning

Planning regulations and institutional framework

All countries have a legal framework for planning. However, in many countries—including Belize, Guyana, and Jamaica—the laws are outdated, based on colonial planning regulations from 1930 to 1950. Although they have been revised, this is still regarded as a weakness and new, locally relevant laws need to be drafted. Other countries have too many laws regulating planning, land use, and building, creating confusion. In Haiti, for example, there are seven laws or decrees regulating land use and urban development, four for land expropriation, and two for local planning, resulting in multiple overlaps and gaps in responsibilities, procedures, and tasks.

Dominica, St. Lucia, and St. Vincent and the Grenadines are part of the OECS. As such, their planning laws were created in the early 2000s using the same model, instructing the development and enforcement of national land use and physical development plans, which in turn provide a base for community-level land use plans. However, none of these countries have produced—or even drafted—their national plans. National land use policies, on the other hand, tend to be more robust, comprehensive, and recent in Caribbean countries. However, unlike laws, these policies are not binding, making it difficult to enforce them or to secure the required implementation budget.

Few countries' revised planning legislation mentions that disaster risk should be considered in plans. Nor does disaster risk legislation mention planning, as it usually focuses on emergency response. Other national policies, on the other hand, has a more robust approach to disaster risk. For example, Jamaica's Natural Hazard-Risk Reduction Policy explicitly aims to direct development through land use planning, zoning, and subdivision regulations, and one of the guiding principles of St. Lucia's Hazard Mitigation Policy is that "hazard risk management (must be) integrated in development planning"; it also acknowledges the need to integrate climate-based and natural hazards into physical planning. National development plans, most of which are recently updated, also make much more explicit connections between planning and disaster risk, highlighting the positive aspects of developing crosscutting strategies.

Planning laws rarely mention participation, beyond mandating the authorities to inform the affected population and hold a short consultation period before approving new planning schemes. National development policies, on the other hand, are likely to show a deeper and more democratic notion of participation. Despite this, decisions are often said to be taken behind closed doors, with participation branded as tokenistic or paying lip service.

It is difficult to draw conclusions about the extent to which communities and stakeholders are involved in planning, as perceptions and experiences vary significantly between countries and country experts. Although most plans mention public involvement, this could merely be presenting the new planning proposal to communities or allocating some time for consultation. There are some notable exceptions, however, such as the plan for Belmopan in Belize, St. Lucia's Castries Vision 2030, and Sint Maarten's Dutch Quarter Plan, which were developed through workshops and wider stakeholder involvement, including academia and other professional associations.

Land administration

More than 60 percent of the Caribbean's urban population lives in substandard, informally built houses that are highly vulnerable to the effects of earthquakes and hurricanes (Hausler et al. 2020). There are, of course, differences between countries, with rates ranging from 11–12 percent in Belize and St. Lucia to 60 percent in Jamaica and 75 percent in Haiti.

The quality of the land cadaster also varies considerably, but no country has a fully coordinated, comprehensive, georeferenced system. Many cadasters have not been digitized, making them vulnerable

to disaster or loss, while in other cases, information is scattered across several government agencies. Nevertheless, national governments—including Guyana, Haiti, and St. Lucia—are working to improve land cadasters.

Land registration is usually unclear, expensive, and/or slow. There are many competing claims for land ownership, mostly due to informal occupation and unclear or duplicated land registries. Several countries, such as Belize, Haiti, Jamaica, and St. Vincent and the Grenadines, do not formally register land, using alternative family, or customary titling systems instead. Informal land trade—which is sometimes more common than formal trade—adds an extra layer of complexity.

Land tenure security largely depends on the different land ownership systems and the extent to which national governments officially support them. Customary, informal, or family land ownership tend to pose greater insecurity—for example, in Haiti, such uncertainty has become "a constraint on the development of safe, affordable housing" (Lozano-Gracia and Garcia Lozano 2017). But in Jamaica, squatting has become an institutionalized form of tenure over time, with squatters acquiring ownership rights to private land after 12 years, and rights to state land after 60 years.

Building and construction regulatory system

Due to their high exposure to climate events and historic disaster losses, many countries have building codes in place. Indeed, the Caribbean region is quite advanced in developing and promoting resilient building codes and standards.[7] However, risk-informed land use is not effectively applied, and building regulations and codes are not adequately implemented or enforced, which all contributes towards the growth in informal buildings, especially among poorer populations. Contributing factors include under-resourced regulators, a lack of regulatory cooperation between relevant agencies, a lack of public awareness on the significance of complying with building regulations, inadequate quality of infrastructure services such as testing and product certification, and insufficient political support (Benavidez 2021).

In countries that do not have official urban plans, building codes usually guide development. But in many countries, there is confusion around which code to use. While some, like Dominica, St. Lucia, and St. Vincent and the Grenadines, have regional and national codes that provide some guidance, others do not. Belize has no official code, relying instead on government agents' discretion or multiple nonbinding guidelines. The Dominican Republic has an extremely strict code that is unsuitable for the national context, while multiple international building codes have been introduced in Haiti, increasing the general sense of confusion as foreign developers tend to use their own home country standards. In Sint Maarten, building codes dictate what it is possible to develop or build while local plans are still at the draft stage. This has led to many developments with adverse spatial effects that are difficult to reverse, such as new buildings in risk-prone or protected areas (Johnson, Caroca Fernandez and Restrepo Cadavid 2021).

Building codes are often poorly enforced and there is a general lack of quality control throughout the region, due to understaffing at local or national levels, a lack of political will, or corruption. The exceptions are St. Lucia, where building approvals have been positively evaluated by both country experts and the World Bank's Doing Business index;[8] and Belize, where the recently created municipal building units have decentralized the administration of building permits, improving timelines and efficiency.

At the same time, they do not always include specific requirements around natural hazards, such as tropical storms, hurricanes, floods, or earthquakes (Johnson, Caroca Fernandez and Restrepo Cadavid 2021), or they rely on outdated hazard maps and data, are disparately developed according to different project needs, or are not widely available, let alone systematically incorporated into building practice (Benavidez 2021). As a result, builders and developers rely on local knowledge of risk-prone areas, which

may not capture the full spectrum of potential risks, changes in risks, or suitability factors of a given site. For example, in The Bahamas in 2019, Hurricane Dorian's high winds and storm surge compounded existing risks from poor construction practices and communities and infrastructure located in vulnerable areas, resulting in 93 percent of the total damage to the housing sector (Benavidez 2021).

When building approvals are too expensive, too slow, or lack a clear procedure, people often decide to build without them. For example, although Haiti has developed several building regulations since the 2010 earthquake to improve housing standards, translating building codes into common practice is hindered by fundamental challenges—from financial constraints to the difficulty of attracting and retaining qualified personnel (Johnson, Caroca Fernandez and Restrepo Cadavid 2021). While it is unclear how many buildings go up without permission, country experts and national reports acknowledge that this is a common practice in the region. This increases risk, as informal constructions tend to be in hazardous or unprotected areas.

Governance and politics

Urban planning and disaster risk are usually included in yearly budgets and presidential speeches. But when it comes to disaster risk reduction, political discourses and national budgets usually focus on recovery, housing reconstruction, and preparedness, and do not link such actions with long-term planning strategies. Country experts argue that, despite official documents mentioning disaster risk as a priority, politicians rarely follow this up unless a new disaster occurs or access to new funding is negotiated. Political intentions are likely to change from one day to another.

Despite this historical trend, Jamaica, Belize, the Dominican Republic, Guyana, Haiti, and St. Vincent and the Grenadines are increasingly incorporating disaster risk reduction as part of their long-term planning objectives. This is reflected in their recent national development plans highlighting the role of disaster risk reduction in achieving socioeconomic development and creating national risk management agencies.

Financing for planning and implementation

Urban development plans are mostly absent in the region. In many countries, planning legislation mandates the local authorities to develop city plans, but this is not accompanied by adequate technical capacity training or funding. Many larger cities have an updated city plan, but most are unlikely to be implemented. These are often made possible through technical and/or financial support from international agencies—the Belize City master plan, for example, was produced with technical support from the Inter-American Development Bank. Small cities, villages, rural, or wilderness areas are highly unlikely to have a plan, let alone the resources to implement one. And in the absence of wider plans, one-off funded projects or private sector investments tend to shape development. Planning and infrastructure development is often inefficient, either managed by different agencies or ministries (as in Guyana) or with gaps and duplication between authorities (as in Haiti) (Johnson, Caroca Fernandez and Restrepo Cadavid 2021).

Local plans are still at draft stage in Sint Maarten, so building codes tend to dictate what can or cannot be developed or built. The national authorities acknowledge that, partially due to this, the last decades have seen many developments with adverse spatial effects that are difficult to reverse, including inadequately planned developments on hillsides, incompatible developments competing for space, and inadequate road infrastructure.

In general terms, city plans tend not to include implementation plans or are very general strategies that do not specify tasks, actors, or timeframes. Many are just an outline of a proposed development or based on large-scale projects without a long-term strategy. At the same time, most countries have not secured enough budget to implement urban or regional plans. Even where there is a detailed implementation and

financing plan—as in Belmopan and Corozal in Belize (*figure 9.4*)—the lack of allocated budget makes it difficult for the plan to take off.

Many revised urban plans have no clear information on their current stage of development or potential implementation. A critical case is Port-au-Prince in Haiti, which has seen almost a dozen attempts to produce an effective master plan over the last few years. While these plans help fill an important information gap, implementation remains unresolved, because many planning instruments exist in law but are not implemented in practice, and there is a gap between expectations set by the plans and the financial and technical capacity to put their recommendations in practice (Lozano-Gracia and Garcia Lozano 2017).

Disaster risk information

Of the few recent urban plans in the region, most consider disaster risk to a degree. As a minimum, they contain some type of risk map and a broad disaster risk reduction strategy. Among the better examples are the plans for Santo Domingo (2019) and Santiago (2018) in the Dominican Republic. But disaster risk considerations in urban plans are usually not well integrated with other dimensions, or they focus on certain threats without including multihazard risk assessments. Exceptionally, Jamaica's Kingston Development Order mandates the use of multihazard vulnerability information in new development designs and layouts. In countries like St. Vincent and the Grenadines, where risk assessment in planning is rare, large-scale developments produce their own assessments (Johnson, Caroca Fernandez and Restrepo Cadavid 2021).

A lack of budget also hinders the consideration of disaster risk when implementing plans. Most countries have not secured enough budget to implement their disaster risk reduction strategies, so little is available for planning or development-related activities. Many countries' approach to disaster risk reduction is often project-based and funded by international agencies such as UNDP, the IMF, the World Bank, and the Inter-American Development Bank. And while most of these project focus on important DRR aspects such as reconstruction, adequate housing, and infrastructure provision, as one-off projects, they lack a strategic risk reduction vision (Johnson, Caroca Fernandez and Restrepo Cadavid 2021).

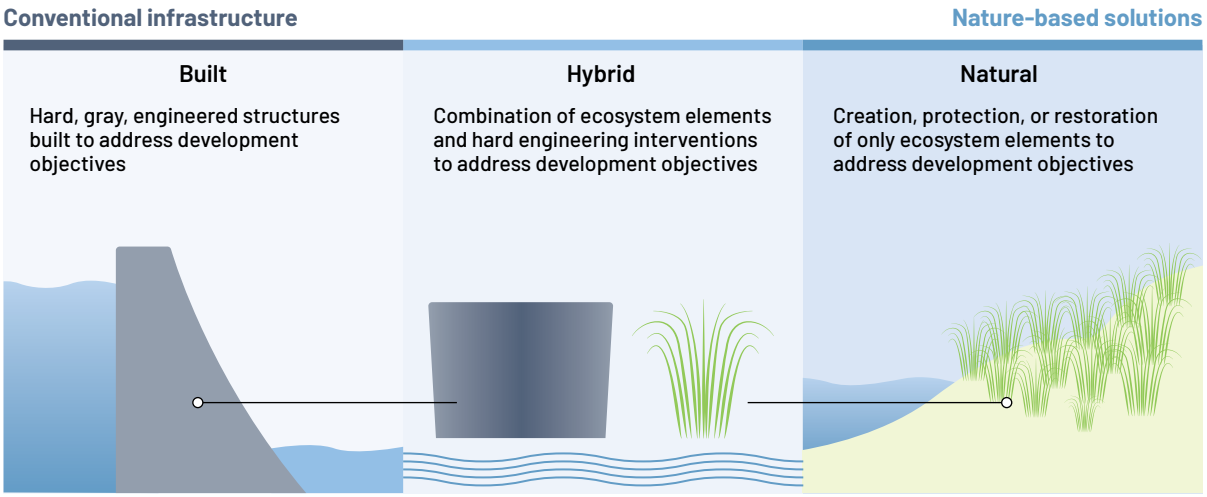
Coastal management plans and nature-based solutions

As shown in *chapters 1 and 3*, climate change and sea level rise bring unprecedented challenges to Caribbean countries and the tourism industry there. To adapt to sea level rise and beach erosion, countries will need to rely heavily on natural barriers. But unplanned urbanization close to coastlines is often associated with the deterioration of mangroves, sea grass, and corals. And these are not only indispensable for marine and coastal ecosystems, they also provide significant protection from storm surge and winds.

NBS are intended to address infrastructure needs, protect from climate impacts, and act as hazard mitigation tools. They differ from conventional engineered infrastructure solutions (*figure 9.6*) and can effectively and adaptively protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges—such as coastal flooding and erosion—while simultaneously providing human well-being and biodiversity benefits, particularly in the Caribbean (World Bank 2017).

FIGURE 9.6 >>

Comparing conventional and nature-based infrastructure



Source: Adapted from World Bank 2017

NBS offer an opportunity to solve challenges at local and national levels in an integrated way while bringing high economic benefits. For example, restoring and replanting mangroves along the coast of a low-lying country provides coastal protection from storm surge, sea level rise, and extreme weather events, a sanctuary for marine flora and fauna, a carbon sink to mitigate climate change emissions, a habitat for terrestrial species, and a livelihood for coastal communities. By their nature, Caribbean SIDS have significant coastal areas that act as natural defense systems, protecting population and infrastructure from coastal changes such as erosion, flooding, and storm surge. The sustainable and integrated management of these coastal zones is vital for adaptation. Recent evidence from Caribbean countries suggests that the presence of mangrove helps to mitigate hurricane damages, avoiding 6–40 percent of total economic damage (Miranda et al. 2021). Similar evidence has been corroborated in other contexts, such as Central America, where the impact of hurricanes is fully mitigated in areas protected by belts of one or more kilometers of mangrove (del Valle et al. 2020).

Studies suggest that coastal NBS are more resilient and can mitigate flood and storm damage more effectively than gray infrastructure alone. For these reasons, coastal states are investing in natural infrastructure solutions, restoring wetlands, mangroves, marshes, and oyster reefs, and installing living shorelines (with plants and natural elements designed to stabilize and protect coastlines) to help reduce wave impacts during storms. According to the NOAA and The Nature Conservancy, 15 feet of marsh can absorb up to 50 percent of incoming wave energy, and 330 feet of mangrove trees can reduce wave height by 66 percent,[9] while gray infrastructure redirects, rather than dissipates, wave energy.[10] And, as waves can overtop jetties, bulkheads, levees, and seawalls, gray infrastructure only protects to a certain peak wave height (Gibbens 2019).

Natural infrastructure solutions are generally cost-effective, depending on the site. For many locations along the Gulf of Mexico, wetland and reef restoration have been found that every $1 spent saves $7 in flood reduction benefits, and it is estimated that NBS could help avert more than 45 percent of the climate risk over a 20-year period, saving the region more than $50 billion in flood damages (Reguero et al. 2018). Another study demonstrates that every $1 invested in protecting Barbados' Folkestone Marine National Park can avoid $20 million in annual damages from hurricanes (Mueller and Bresch 2014).

This evaluation of the state of coastal management and NBS implementation in the region considers four main pillars. First, governments need plans, strategies, and guidelines that inform and guide environmental management (including NBS), and those documents—including a coastal zone management plan and updated environmental and climate change laws and policies—should form part of an integrated resilience strategy. Second, governments need tools to assess coastal management strategy performance that combine economic and coastal flood modeling under several sea level rise scenarios. Third, governments need to set up the necessary bodies, coordination mechanisms, targets, and priorities, and assign them to a responsible body that enforces and monitors them. And fourth, they must put in place the necessary financing instruments to catalyze the uptake of environmental solutions. Countries can be at one of three different maturity levels across the four pillars shown in *table 9.5*, offering a generic guide to assess the state of coastal management plans and integration of NBS in the region.

TABLE 9.5 >>

Defining terms: nascent, emerging, and established coastal management plans and NBS

Nascent	Emerging	Established
» There are no **national plans/strategies** or similar documents to inform resilience, adaptation, environmental management (including NBS) and disaster risk planning and management	» **National plans/strategies** or similar documents are in progress to inform resilience, adaptation, environmental management (including NBS) and disaster risk planning and management	» There are up-to-date **national plans/strategies** or similar documents to inform resilience, adaptation, environmental management (including NBS) and disaster risk planning and management
» There are no **decision support tools** for use in resilience building and disaster risk planning that could increase the uptake of NBS	» There are limited **resilience building and disaster risk planning tools** that could increase the uptake of NBS, and their uptake is scarce	» There are enough **decision support tools** for use in resilience building and disaster risk planning to increase the uptake of NBS and these are regularly updated and applied
» The necessary **institutions and coordination mechanisms** are lacking, so national, regional, and international targets and priorities are not properly assigned to responsible bodies that will enforce and monitor them	» The necessary **institutions and coordination mechanisms** exist or are being established, so national, regional, and international targets and priorities are assigned or in the process of being assigned to responsible bodies that enforce and monitor them	» The necessary **institutions and coordination mechanisms** exist and national, regional, and international targets and priorities are properly assigned to responsible bodies that enforce and monitor them
» **Financial instruments** for resilience and/or disaster management do not exist	» **Financial instruments** for resilience and/or disaster management are in progress	» **Financial instruments** for resilience and/or disaster management exist

Planning framework

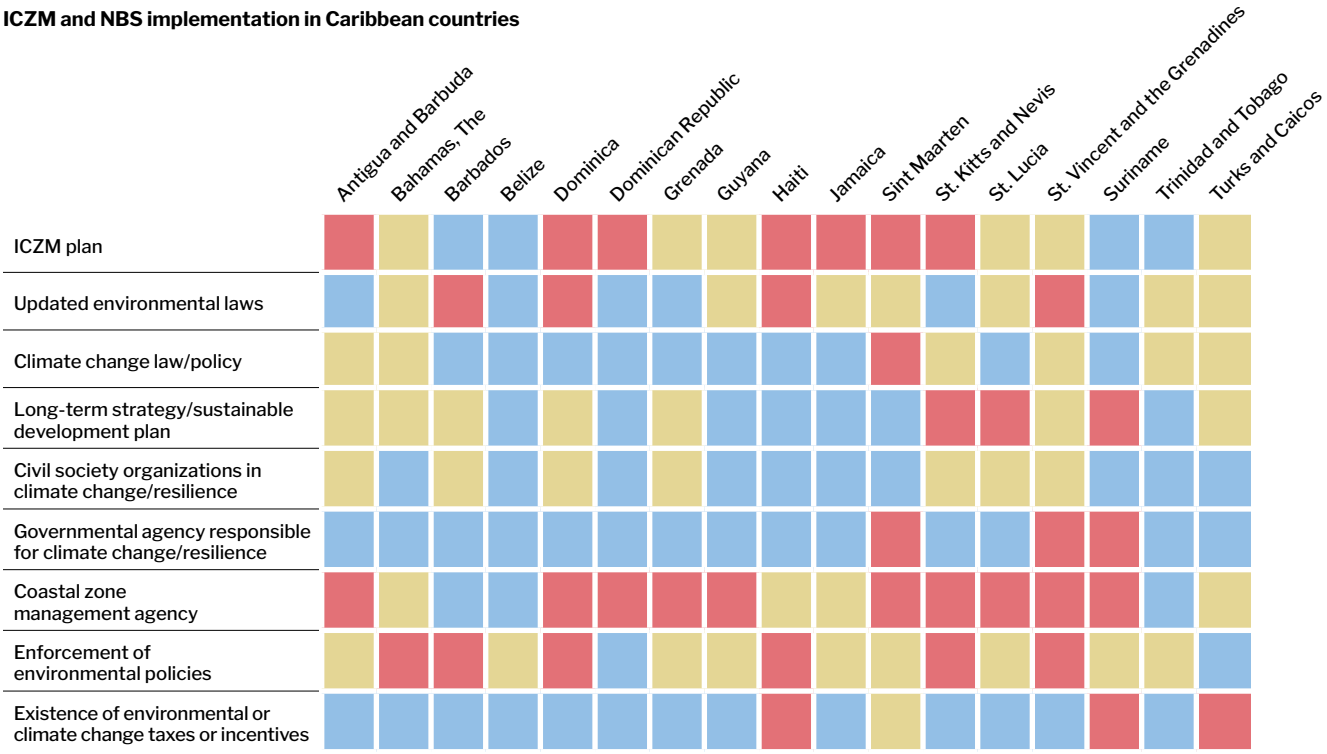
Only Barbados, Belize, Suriname, and Trinidad and Tobago have an established ICZM plan. Other countries are either in the process of developing one or do not have one at all (*table 9.6*). This implies that, despite depending on their coastal zone in many ways, just a few have a plan to manage this extensive space in an integrated manner. This is a significant gap that can affect the way countries manage and protect their coastal ecosystems and could determine the feasibility of incorporating NBS into resilience planning (Valero, Miranda and Murisic 2021).

While not directly targeting coastal zone development, long-term development plans and climate change policy provide an entry point to set ICZM on the policy agenda and introduce NBS and ecosystem-based adaptation alternatives to resilience building. Long-term development plans—also known as national horizons or visions—are relatively common in the region. While the scope of these comprehensive documents is much broader than the coastal zone, they establish a set of long-term development goals, targets, and indicators, providing a framework for action and investments. This includes investments related to resilience building, which can include NBS. St. Kitts and Nevis, St. Lucia, and Suriname are the only Caribbean countries without a long-term strategy or development plan. Most have an up-to-date climate change policy or plan, and a few are in the process of developing or updating such a plan to incorporate post-Paris Agreement developments, issues related to the 2030 Agenda for Sustainable

Development,[11] and the latest developments in terms of climate change impacts and their vulnerabilities (Valero, Miranda and Murisic 2021).

TABLE 9.6 >>

ICZM and NBS implementation in Caribbean countries



Source: Valero, Miranda and Murisic 2021

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; and countries in blue (established) meet the standard entirely. The standards for each indicator can be found in Appendix B.

Decision support tools

The quality and availability of risk information is presented in *chapter 8*. While countries have made good progress in producing the datasets needed for risk modeling (including coastal floods and erosion), there are gaps that prevent these datasets from being shared publicly and widely used.

To translate risk information into decision support tools, the Dominican Republic, Grenada, and Jamaica participate in the Resilient Islands Initiative,[12] a program funded by the German International Climate Initiative (IKI) and implemented by The Nature Conservancy and the International Federation of the Red Cross and Red Crescent Societies. This four-year initiative is designed to help Caribbean islands cope with the impacts of climate change by promoting ecosystem-based solutions that protect and restore coastal habitats proven to reduce risks. The project provides communities and governments with tools and training to integrate nature-based interventions into existing and future policies and community planning, and access funding to reduce vulnerability and build resilience against the escalating threats of climate change. The Resilient Islands Initiative works with communities and governments to design decision support tools, train local leaders, integrate ecosystem-based adaptation strategies into national policies, and implement ecosystem restoration projects in vulnerable coastal areas.

Institutional framework and coordination

Ensuring that the necessary coordination mechanisms, bodies, and protocols are in place is vital for ensuring efficient and effective NBS mainstreaming in overall resilience and DRM efforts. Apart from Sint Maarten, St. Vincent and the Grenadines, and Suriname, all the countries assessed for this study have an interministerial committee or governmental body responsible for climate change and resilience building. Going forward, it will be important to ensure that these committees are properly staffed, tasked with a specific mandate, and given the necessary financial resources to ensure their long-term sustainability. While most countries have a more general, overarching body in place, only Barbados, Belize, and Trinidad and Tobago have an agency dedicated to managing coastal areas and the ocean space and resources. In some countries, certain departments within ministries are involved in coastal management, but their mandate and relevance are not always clear, and their role often expands beyond the coast and ocean.

While plans and laws are available and often established and up to date, enforcement is a common challenge. Only the Dominican Republic and Turks and Caicos receive an "established" score for enforcing environmental policies; most countries are trying to improve their enforcement capacity and frameworks, while others have very low performance and evidence to show in this regard (*table 9.6*).

Community-based and nongovernmental organizations are quite active in all the countries and often undertake activities that would normally fall under the responsibility of government. Their strong role in resilience and adaptation building as well as environmental management is key for the successful management of those agendas.

Finance and funding

All countries except Haiti, Suriname, and Turks and Caicos collect a form of environmental tax or levy (*table 9.6*), but they do not generally explore or use related budged allocations as an instrument for scaling up NBS for resilience objectives. Some countries do, however, have innovative solutions in this area. For example, St. Vincent and the Grenadines recently introduced a Climate Resilience Levy for hotels to charge stayover visitors, and St. Lucia has begun to examine the potential of climate change-related instruments, similar to debt-for-nature swaps,[13] to finance marine conservation (Valero, Miranda and Murisic 2021). This type of innovative financing has been successful in the Seychelles and shows promise for other small states. Other options Caribbean countries could consider include implementing biodiversity-friendly incentives and subsidies and reforming or removing biodiversity-harmful incentives and subsidies to increase funding for biodiversity.

Endnotes

1. Also, Ministry of Infrastructure. 2018. "Road Asset Management System Project Officially Launched." Government of St. Lucia, May 8. http://www.govt.lc/news/road-asset-management-system-project-officially-launched.
2. The FAO defines *water scarcity* as less than 1,000m^3 of total renewable water resources per capita per year, and water stress as below 1,700m3 of total renewable water resources per capita per year. https://www.un.org/waterforlifedecade/scarcity.shtml.
3. http://www.fao.org/aquastat/en.
4. All estimates except those from Bhattacharya, Romani and Stern (2012) include 1–2.5 percent of GDP on maintenance.
5. Countries for which spending data were available on Infralatam, http://es.infralatam.info/.
6. https://data.worldbank.org/.
7. In the 1980s, the Caribbean Uniform Building Code was developed to provide appropriate building standards for the region. While not widely adopted, they have provided a technical basis for building codes in the Eastern Caribbean region (Ötker and Srinivasan 2018). All OECS member countries have adopted the 7th edition (published in 2016) tailoring it to their specific administrative and enforcement requirements. Other building codes adopted in the region include the International Code Council's International Building Code and International Residential Code. The CDEMA and CROSQ also developed a regional code or practice to inform resilient house construction in 2005 and they continue to promote resilient building regulation across the region. In 2019, the CROSQ released a set of new standards for energy-efficient buildings for CARICOM member states, building on the 2018 CARICOM Regional Energy Efficiency Building Code, which covers commercial and residential construction.
8. https://www.doingbusiness.org/en/doingbusiness.
9. NOAA. (n.d.). *Fast Facts: Natural Infrastructure*. Office for Coastal Management, National Oceanic and Atmospheric Administration. Retrieved June 1, 2021, from https://coast.noaa.gov/states/fast-facts/natural-infrastructure.html.
10. The Nature Conservancy. https://www.nature.org/en-us/what-we-do/our-insights/perspectives/natural-climate-solutions/.
11. https://sdgs.un.org/2030agenda.
12. https://coastalresilience.org/project/resilient-islands/.
13. Debt for nature swaps involve the exchange of a debtor country's external obligation for that country's agreement to use local currency instruments to support a specific environmental project—for example, developing conservation management plans, training park personnel, or environmental education activities. http://documents.worldbank.org/curated/en/300181468739253960/Debt-for-nature-swaps.

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10

CHAPTER 10 >>

Build resilient health and education systems

Like critical infrastructure, public health care and education must be thoroughly climate risk assessed and managed, as people's well-being depends on them both during and after a shock. Even relatively short disruptions in health care or education can have long-term adverse consequences, especially for vulnerable groups, such as children.

This chapter elaborates on what countries are already doing to increase resilience of these critical services and highlights the areas that are falling short. It draws on sectoral background papers prepared for this report, namely Bellony and Powers (2021) and Harnam and Khan (2021).

Resilient health systems: a government-wide strategy

Natural disasters, disease outbreaks, and other shocks pose direct threats to people, in the form of injuries and infections. They also pose direct and indirect threats to health care provision, by damaging facilities or forcing them to close, disrupting critical infrastructure that hospitals depend on, and increasing demand for health care. Over the years, storms have had devastating effects on health care provision in the region and the health system has battled multiple disease outbreaks (*chapter 5*). For a health system to respond to such threats in a resilient way, health actors, institutions, and people must have the capacity to prepare for and effectively respond to crises; maintain core functions when a crisis hits; and, informed by lessons learned during the crisis, reorganize if necessary (Kruk et al. 2015).

A framework for analyzing the health system's resilience to shocks

Far from operating in isolation, health systems are embedded in a wider network of emergency response systems (*figure 10.1*; Rentschler et al. 2021). As such, their resilience is underpinned by: the resilience of their facilities and workers; the resilience of the wider system and medical supply chain network; collaboration with emergency response agencies; and the quality of lifeline infrastructure on which health care facilities rely. Drawing on lessons from disaster risk and emergency practice, the World Bank's *Frontline* report (Rentschler et al. 2021) outlines five crucial principles for evaluating and strengthening the resilience of health care systems:

1. **Strong foundations** (*chapter 7*)—including adequate equipment and medical technologies, skilled staff, financing, and efficient management and operating protocols—will help build capacity to effectively meet routine demand.

2. **Ex ante contingency planning**—preparing crisis protocols, maintaining emergency stocks of medical supplies, upgrading facility structures, and so on—helps prepare to meet surge demand for health care in emergency times.

3. **Strategies to increase surge demand capacity and system-level coordination** can help meet surge demand through system-level response. When resources are limited, it is impossible to immediately equip every facility to the highest standard, so organized planning and flexible solutions are vital.

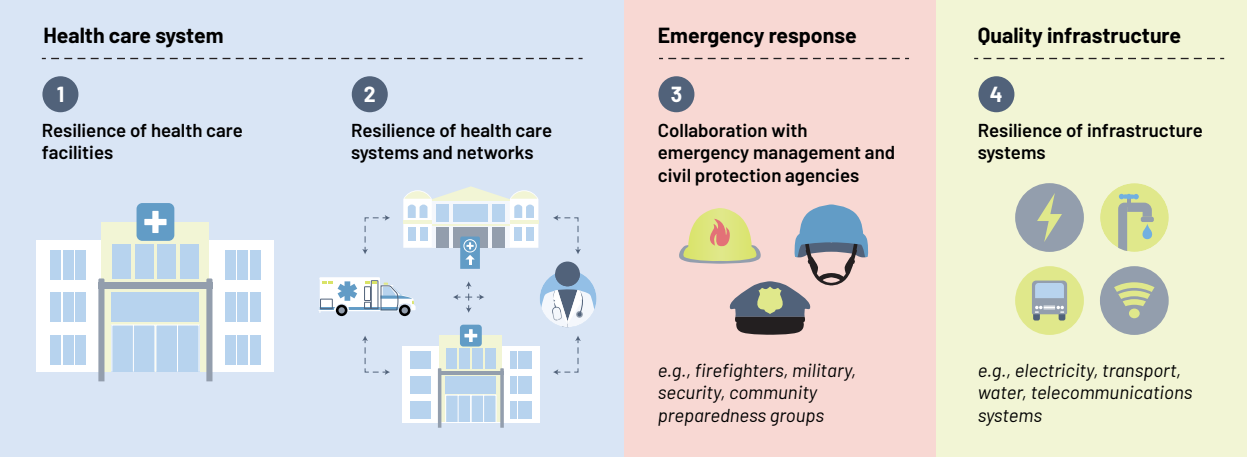
4. **Closely coordinating emergency preparedness** with the country's overall emergency management and disaster response systems (*chapter 11*) will help rapidly mobilize critical supplies and critical resources during emergencies.

5. **Resilient lifeline infrastructure**—water, energy, transport, communication, and digital systems (*chapter 9*)—will ensure the proper functioning of health systems and improve the delivery of care during emergencies.

Taking a systems perspective to health care resilience (*figure 10.1*), this section builds on the six elements for effective health care systems proposed by the WHO (*figure 10.2*) to show countries how to anticipate, absorb, and adapt to shocks so they can deliver the same level of care with fewer resources and use lessons learned to transform and improve. Defining three maturity levels for health systems (*table 10.1*) and showcasing examples from Jamaica and St. Lucia, it provides key indicators for evaluating their resilience, identifying gaps, and measuring progress towards resilient systems.

FIGURE 10.1 >>

Taking a systems perspective to health care resilience



Source: Adapted from Rentschler et al. 2021

FIGURE 10.2 >>

The building blocks of a resilient health care system

Source: Adapted from Harnam and Khan 2021; Rentschler et al. 2021

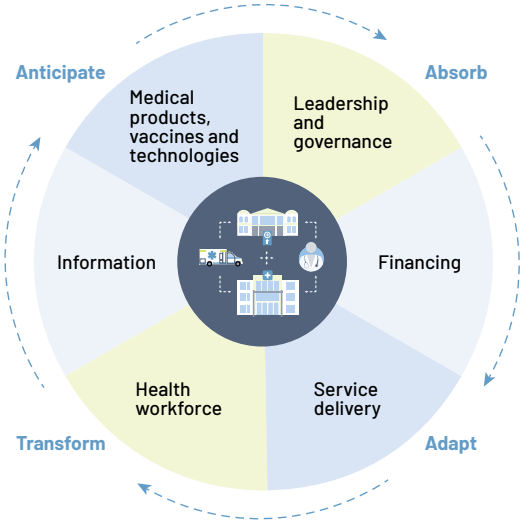


TABLE 10.1 >>

Defining terms: nascent, emerging, and established health systems

Nascent	Emerging	Established
» The **health system** is unable to effectively prepare for, respond to, or recover from a shock	» The **health system** is likely able to effectively prepare for, respond to, and recover from mild shocks	» The **health system** is likely to effectively prepare for, respond to, and recover from a shock
» The system is **likely to cease functioning effectively** in the event of any shock	» In the event of a moderate to severe shock, the system is likely to cease functioning effectively and **may take a long time to recover**	» Health service coverage is either **uninterrupted** by the shock, or only interrupted for a brief period
» **Short and long-term health outcomes are likely to decline** after the shock, especially in vulnerable groups	» **Population health indicators are likely to decline** after the shock, especially in vulnerable groups	» **Indirect health outcomes are likely to remain the same** as before the shock
» Governments need to **take urgent and extensive action** to prioritize, plan, and build health system resilience capacities	» Governments must **take targeted actions** to prioritize, plan, and build health system resilience capacities, where needed	» Governments must **ensure continuous improvement** of health system resilience capacities, based on the results of frequent evaluations (especially after a shock) and maintaining existing capacities

Managing demand and capacity and preparing for shocks

Because health care facilities play a central role as point of care, resilient facilities should be able to withstand or quickly recover from shocks, while maintaining capacity to continue providing essential care during emergencies (Harnam and Khan 2021; Rentschler et al. 2021).

To provide effective care during shocks, facilities must first be able to withstand them structurally. However, like all critical public infrastructure systems, health care facilities in the Caribbean are exposed to a wide range of external shocks. Landslides, earthquakes, and hurricanes form the largest risk to health facilities, exposing half to two-thirds of the facilities in the region (*chapter 2*). In many countries, all health care facilities are exposed to some hazard. But it is possible to reduce disruptions of critical facilities through stronger building standards, systematic risk assessments, and upgrades.

The Health Safety Index (HSI) provides a snapshot of the probability that a hospital or health facility will continue to function in emergency situations, based on structural, nonstructural, and functional factors (PAHO and WHO 2019). By placing health facilities into three safety categories, this exercise helps authorities determine which need most urgent intervention and establish maintenance and monitoring routines where improvement is less urgent. Of the 148 health care facilities assessed under the PAHO's Smart Hospitals Initiative[1] in Jamaica, 65 percent fell within category B and 35 percent in category C. There were none in category A.[2] Plans are underway to strengthen several health care facilities under the Smart Hospitals project, but updated health facility rankings are not available. In St. Lucia, 15 health care facilities were strengthened under the project to reduce risks from natural hazards. With these upgrades, HSI rankings improved significantly. One facility has now received the highest rating (category A), but about one-third still need urgent upgrades (category C) and about two thirds need relatively urgent upgrading (category B). Both countries therefore receive an "emerging" score for hospital facility safety (*table 10.2*).

TABLE 10.2 >>

Indicators for improving individual health facilities and results for Jamaica and St. Lucia

Building block	Indicator	Jamaica	St. Lucia
Service delivery	Hospital facility safety		
Health workforce	Emergency education and trainings		
	Adequate number of doctors, nurses, and midwives		
	Adequate number of CR-FELTP trained workers		
Information	Health information system		
Leadership and governance	Plan for emergency preparedness activities		

Source: Based on data from Harnam and Khan 2021

Notes: CR-FELTP = Caribbean Regional Field Epidemiology and Laboratory Training Programme. In Harnam and Khan (2021), the indicator *hospital facility safety* is named *HSI scores*. Scores in red (nascent) show that the standard is not met and the country includes areas that are only starting to or do not address the standard at all; scores in yellow (emerging) show the standard is partly met and the country has progressed beyond the initiation point but has not reached the final point. There are no blue (established) scores, showing that neither country has met the standard. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

To ensure continuity of care in a postdisaster situation, there must be enough trained health care professionals available. Estimating potential demand for health care services for both routine needs and surge demand during emergencies and identifying underserved regions and neighbourhoods can help prioritize capacity investments to ensure enough personnel are available at the facility when required. Although Caribbean countries have not estimated their surge capacity needs and underserved areas, a quick scan using health capacity norms set by the WHO[3] shows that many health care systems already operate at low capacity for routine services. Only Antigua and Barbuda, Dominica, Grenada, and St. Vincent

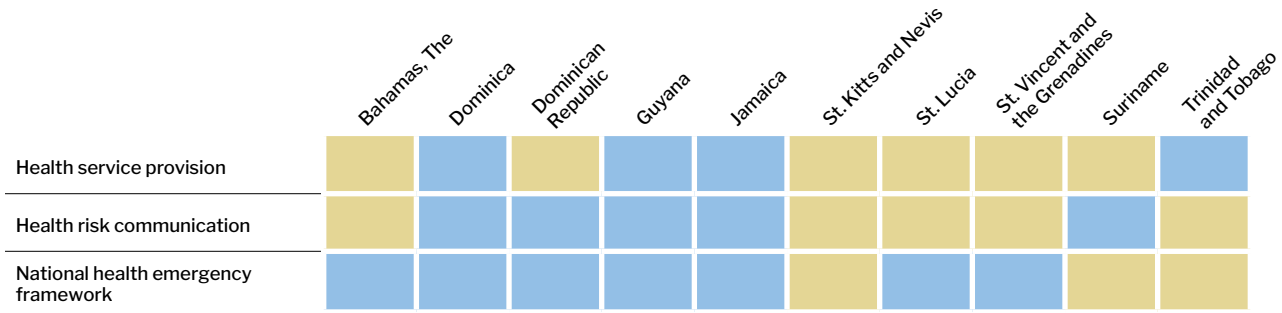
and the Grenadines meet the WHO norm (*chapter 7*), indicating that most countries do not have enough capacity to respond to demand surges in emergency situations. Jamaica and St. Lucia, for example, obtain a "nascent" score for "adequate number of doctors, nurses, and midwives" (*table 10.2*). Countries also need enough adequately trained field epidemiologists to detect and monitor disease outbreaks. The number of graduates from the Caribbean Regional Field Epidemiology and Laboratory Training Programme (CR-FELTP)[4] provides an indication for a country's epidemiological capacity, and to date, only Grenada, St. Lucia, St. Vincent and the Grenadines, and Suriname have at least some capacity.

However, it is not only a matter of adding more capacity. Better assignment of staff, more efficient use of space, and more efficient management of limited resources can increase a hospital's capacity up to 500 percent to serve pandemic patients (Rentschler et al. 2021). Repurposing space and beds, redeploying personnel across hospital units, implementing crisis standards of care, referring patients to alternative health facilities, and managing demand can help scale up capacity quickly in times of emergency (Miller-Hooks and Tariverdi, forthcoming).

Finally, hospitals and health centers should formulate concrete emergency standards that increase their self-sufficiency during emergency situations and help facility managers take the necessary precautionary actions (Rentschler et al. 2021). This could include maintaining critical inventories of medical supplies—including basic medicines and equipment—and ensuring these are also accessible off-site; investing in generators and water tanks, and determining a backup capacity standard that will bridge outages; developing and training specific disaster response plans; and ensuring vital day-to-day functions like plumbing, air quality, and sewage disposal are disaster proof (Brands et al. 2013). Jamaica and St. Lucia both receive a "nascent" score on availability of a plan for emergency preparedness activities (*table 10.2*).

TABLE 10.3 >>

International Health Regulations indicators for Caribbean countries



Source: Based on data from WHO 2018

Notes: Health service provision concerns the ability to provide routine care in times of emergency while adhering to optimum infection prevention and control practices; *health risk communication* concerns whether risk can be communicated effectively during a public health emergency; and *national health emergency framework* concerns preparedness to respond to any public health event, including emergencies. These global scores are based on self-reported data ranging from 0–100 and allow for high-level cross-country comparison rather than providing an in-depth overview of the situation in a country. Countries in yellow (emerging) scored 21–60; those in blue (established) scored above 60. None of the countries are shaded red (nascent), which would indicate a score of 20 or below.

The WHO's International Health Regulations (IHR) are a legally binding instrument that aims for international collaboration "to prevent, protect against, control, and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks and that avoid unnecessary interference with international traffic and trade" (WHO 2008, p1). Using self-reported data, the IHR offers a score for health service provision, based on whether facilities have the capacity to provide routine care demand services and care in times of emergency and adhere to optimum infection prevention and control practices to minimize the risk of onwards transmission of

diseases. This includes having appropriate sanitation and hygiene measures, safe waste management and decontamination of chemical, radiation, and other hazardous substances, and a functioning referral system. Of the countries included in this scoring exercise, Dominica, Guyana, Jamaica, and Trinidad and Tobago are in the "established" category, while The Bahamas, the Dominican Republic, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Suriname fall into the "emerging" category (*table 10.3*).

Strategies to increase system-level coordination

Health systems are interconnected networks of facilities providing a variety of services. When shocks hit and facilities lose functionality or surge demand exceeds the capacity of single health facilities, system-level collaboration can ease the burden on single facilities and ensure uninterrupted delivery of care (Rentschler et al. 2021). Modeling efforts examining the distribution of demand between hospitals in case of a shock shows that this increases the quality of service delivery (Shahverdi, Tariverdi and Miller-Hooks 2020). However, to share resources and capacity during shocks, hospitals must prepare. Steps hospitals can take to increase system-level operationality and ensure health systems can help absorb shocks include signing memorandums of understandings (MOUs) for sharing information and human and medical resources, ensuring digital health information systems are compatible, establishing regional warehouses, prepositioning critical supplies, evaluating resource and capacity constraints, and drawing up contingency plans (Rentschler et al. 2021).

Ensuring a local or regional stockpile of medicines, medical, and laboratory supplies and establishing mechanisms for their efficient mobilization are vital. There is no information on the existence of local medical supply stockpiles or protocols or established mechanisms to guide their efficient mobilization, but Caribbean Public Health Agency (CARPHA) and PAHO member countries can access regional stockpiles. As such, Jamaica and St. Lucia receive an "emerging" score for this (*table 10.4*). Other regional attempts to circumvent national supply chain issues include the OECS Pharmaceutical Procurement Service, which procures medicines and health equipment on behalf of OECS member states. But these regional mechanisms can be overwhelmed if a shock affects multiple countries.

TABLE 10.4 >>

Indicators for improving system-level coordination and results for Jamaica and St. Lucia

Building block	Indicator	Jamaica	St. Lucia
Medical products, vaccines, and technologies	Stockpile of medicines, and medical and laboratory supplies		
	Mobilization protocols		
Information	Health sector surveillance system		
	Information sharing mechanisms		
	Research capacity		
Financing	Costed and funded health system strengthening plans		

Source: Based on data from Harnam and Khan 2021

Notes: Scores in red (nascent) show that the standard is not met and the country includes areas that are only starting to or do not address the standard at all; scores in yellow (emerging) show the standard is partly met and the country has progressed beyond the initiation point but has not reached the final point; and scores in blue (established) show that the standard is met. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

When a hospital's capacity is overwhelmed, or certain regions are inaccessible, mobile health clinics can supplement health systems, treating isolated and vulnerable groups as well as newly displaced populations. The WHO, PAHO, and their partners have extensive experience of deploying mobile clinics to offer disaster relief through regional coordination mechanisms in the Caribbean and elsewhere—for example, setting up mobile clinics in response to COVID-19 outbreaks. They also deploy self-sufficient

emergency medical teams to provide direct care to populations in need and support local health systems. These teams, which have enough personnel, equipment, supplies, and logistical resources to provide timely care, can be deployed to alternative facilities or set up mobile clinics.[5]

For effective risk communication during emergencies, countries should have an integrated risk monitoring and routine surveillance system in place, and the mechanisms to share this information. Although Jamaica and St. Lucia both have a surveillance system, historic underreporting of cases in disease outbreaks reflect shortfalls in these systems. To give a high-level overview of countries' ability to communicate risk, the IHR's core capacity score for risk communication indicates whether they can communicate risk effectively during a public health emergency. Caribbean countries score relatively well on this aspect, with Dominica, the Dominican Republic, Guyana, Jamaica, and Suriname receiving an "established" score, and The Bahamas, St. Lucia, Trinidad and Tobago, St. Kitts and Nevis, and St. Vincent and the Grenadines scoring "emerging" (*table 10.3*).

Coordinating with the wider emergency preparedness network

After a shock, it is important for countries to coordinate health system preparedness closely with their overall emergency preparedness and response systems. Multisectoral issues must be addressed simultaneously, including meeting basic needs such as food and shelter, and providing essential public services such as security, social safety nets, rescue, and health care. An up-to-date emergency response plan forms the blueprint for a coordinated response in this situation. While most countries in the region have national emergency management plans, none has a tailored plan for the health sector (Rentschler et al. 2021), and both Jamaica and St. Lucia receive a "nascent" score for this indicator (*table 10.5*). Caribbean countries could learn from Japan's use of its health sector emergency plan to coordinate disaster response (*box 10.1*).

TABLE 10.5 >>

Indicators for increasing multisectoral coordination and results for Jamaica and St. Lucia

Building block	Indicator	Jamaica	St. Lucia
Leadership and governance	Health sector emergency response plan		
	Emergency operations center or unit for health sector		
	Legislation guiding national health emergency response		
	Decentralized decision making		
	Signatory to agreements		
	Emergency funding arrangements with external bodies		

Source: Based on data from Harnam and Khan 2021

Notes: Scores in red (nascent) show that the standard is not met and the country includes areas that are only starting to or do not address the standard at all; scores in yellow (emerging) show the standard is partly met and the country has progressed beyond the initiation point but has not reached the final point; and scores in blue (established) show that the standard is met. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Effective local-level coordination is important as this is the interface of usually detached systems and agencies. For example, the way in which first responders, such as the military, coordinate their dispatch and field operations with the capacity of health care facilities is crucial to enable an effective emergency response. So, a resilient health care system needs to be embedded in an effective DRM framework at both local and national levels (*chapter 11*).

To give a high-level overview of countries' health emergency preparedness, the IHR also scores countries based on their ability to prepare to respond to any public health event, including emergencies. This

includes ensuring there are risk-based plans for emergency preparedness and response, robust emergency management structures, and resource mobilization protocols. The countries included in this exercise score relatively well, with seven receiving an "established" score and three "emerging" (*table 10.3*).

At the regional level, membership of coordination organizations that play critical roles in supporting health sector shock preparation and response can increase health systems resilience (Harnam and Khan 2021). Recognizing their unique vulnerabilities, Caribbean countries have a long history of regional cooperation, and several coordination organizations exist (*table 10.6*).[6] All Caribbean countries are members of the PAHO/WHO and the World Bank Group, which can provide technical and financial support in a health emergency. All except the Dominican Republic are also members of CARPHA, CARICOM, and CDEMA, which provide leadership, coordination, and support for Caribbean health system to prepare and respond to shocks. CARPHA also provides key testing capacity and health guidelines at the beginning of any outbreak. These organizations facilitate access to a larger pool of regional resources, which is crucial as shocks can quickly overwhelm a small island's local resources.

Although the high membership rates generally reflect some anticipatory, absorptive, and adaptive resilience capacities in Caribbean countries, shocks that affect multiple countries simultaneously—such as a global pandemic or a hurricane affecting several islands—can strain regional or international capacities to provide local support. This is demonstrated by PAHO's public appeal for $95 million to support its COVID-19 response in Latin America and the Caribbean.[7]

TABLE 10.6 >>

Membership of intergovernmental organizations

	CARPHA	CARICOM	CDEMA	CCRIF SPC	PAHO/ WHO	World Bank Group	IDB	State party to IHR
Antigua and Barbuda	✓	✓	✓	✓	✓	✓		✓
Belize	✓	✓	✓	✓	✓	✓	✓	✓
Dominica	✓	✓	✓	✓	✓	✓		✓
Dominican Republic					✓	✓	✓	✓
Grenada	✓	✓	✓	✓	✓	✓		✓
Guyana	✓	✓	✓		✓	✓	✓	✓
Haiti	✓	✓	✓	✓	✓	✓	✓	✓
Jamaica	✓	✓	✓	✓	✓	✓	✓	✓
St. Kitts and Nevis	✓	✓	✓	✓	✓	✓		✓
St. Lucia	✓	✓	✓	✓	✓	✓		✓
St. Vincent and the Grenadines	✓	✓	✓	✓	✓	✓		✓
Suriname	✓	✓	✓		✓	✓	✓	✓
Trinidad and Tobago	✓	✓	✓	✓	✓	✓	✓	✓

Source: Harnam and Khan 2021

Notes: CCRIF SPC = Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company; IDB = Inter-American Development Bank.

BOX 10.1 >>

Lessons from Japan: coordinating disaster response and cooperating to supply equipment, staff, and training

Japan's Disaster Prevention Basic Plan—the highest-level plan in the disaster prevention field prepared by the Central Disaster Prevention Council based on the Disaster Prevention Basic Law—forms the basis of disaster prevention measures in the country. Through this plan, the Ministry of Health Labor and Welfare (MHLW) and prefecture governments established a mutual support system for medical activities between neighboring parishes. It also offers support for improving or developing systems to coordinate emergency medical activities, provide pediatric perinatal liaison, and dispatch the disaster medical assistance team. This is further complemented by operational guidelines for helicopter disaster medical response teams.

Under the plan, the MHLW, Ministry of Education, Culture, Sports, Science and Technology, Japanese Red Cross Society, National Hospital Organization (an independent administrative agency), Japan Community Health Care Organization, local governments, and airport managers stockpile emergency medicine, medical equipment, and other requirements for situations when many people are injured or transportation is interrupted. The plan also considers how to improve emergency medical systems in the event of a disaster—for example, by designating base hospitals for disaster response as the main medical facility in the event of a disaster. At these base hospitals, efforts are made to improve heliports and stockpile food, drinking water, medicines, fuel for emergency power, and so on.

Through these efforts, the MHLW, local governments, and medical institutions strive to develop a wide area emergency medical information system and provide regular training on operations to enable a quick grasp of information—such as health care facilities' medical care status—in the event of a disaster. Local governments impacted by a disaster can request additional support from private medical institutions to complement medical activities conducted within public facilities. Medical institutions in disaster-affected areas carry out procedures to restore damage to hospital buildings and medical equipment, and request emergency restoration from lifeline operators, as necessary. Further actions and dispatch support from the MHLW, local public organizations, and medical institutions are guided by facilities' medical care status through emergency medical information systems.

Source: Rentschler et al. 2021

Lessons learned from the COVID-19 pandemic

On March 1, 2020, the Caribbean's first case of COVID-19 was confirmed in the Dominican Republic. On the same day, CARICOM held an emergency meeting to plan a regional response to potential local outbreaks, as several member states had inadequate laboratory testing capabilities and insufficient health care facilities to address a surge of cases (Hambleton, Jeyaseelan and Murphy 2020). Establishing this regional emergency mechanism indicated a degree of anticipatory capacity for member states.

On March 11, the WHO declared a global pandemic, resulting in widespread travel restrictions. But up to 27 days before the first confirmed case, many Caribbean governments had already started restricting movement into and within their countries, reflecting anticipatory capacities and showing strong national leadership. Most countries in the region had closed their national borders, established quarantine and social distancing protocols, and supported the coordination of regional policies.[8]

Regional and international bodies have also played integral roles in supporting the Caribbean's response to the pandemic. CARICOM coordinated the procurement of some necessary equipment, CDEMA and CARPHA supported outbreak response logistics and regional testing capacity strengthening, and the OECS scaled up activities under its Pharmaceutical Procurement Service model to swiftly purchase and distribute critical medical supplies across the region. PAHO provided equipment, reagents, and training to increase testing capacity and surveillance within the region; the EU committed funds to supply health and medical equipment, restoring livelihoods and providing budget support to governments; the UN Office for Project Services procured and distributed PPE and medical equipment for treating COVID-19 in Haiti; and UNICEF helped develop an online portal to deliver virtual mental health and psychosocial services to frontline workers and caregivers in the Eastern Caribbean. There was also private sector support, as demonstrated by Digicel, a telecommunications provider in Trinidad and Tobago that gave their customers free calls to local health centers and free access to health information websites. Such coordination between the health sector and a private company during the pandemic demonstrates adaptive leadership capacity.

International and regional banks provided financial support. For example, the Caribbean Development Bank (CDB) made emergency loans available to Antigua and Barbuda, Belize, Dominica, Grenada, St. Lucia, St. Vincent and the Grenadines, and Suriname; the World Bank provided fast-tracked financial and knowledge assistance for procuring essential supplies, strengthening health systems, and expanding social protection; and the IMF provided millions of dollars in emergency financing through its Rapid Credit Facility and Rapid Financing Instrument.

In general, the region's early response to the COVID-19 pandemic has garnered global praise, with some noting that most Caribbean islands experienced less steep outbreak growth in the earlier months compared to their Central and South American counterparts. Some countries, such as Dominica, Grenada, St. Lucia, and St. Vincent and the Grenadines, have developed in-country testing capacity, reflecting adaptive capacity. However, in the Dominican Republic, there have been reports of inadequate PPE in hospital settings, including designated COVID-19 response sites, due to market shortages and increased costs. The country has also struggled with health communication, as media misinformation led to national shortages of groceries and drugs such as hydroxychloroquine, preventing some patients from accessing necessary treatments.

Resilient education systems: a governmentwide strategy

School closures can have significant and long-lasting impacts on education (*chapter 5*), and natural disasters are one of the main causes of school closure. A stocktake of the education buildings damaged or destroyed historically in the Caribbean shows that natural disasters take a heavy toll on education assets, damaging buildings, disrupting access to facilities, and interrupting basic services in schools, such as water and electricity. The use of schools as shelters during emergency situations further prolongs education losses. When schools close, the immediate impacts go beyond education. For students relying on school feeding programs, it can disrupt their daily nutrition intake. School disruptions can also affect family well-being, when children—particularly girls—forced to stay home become subject to domestic violence, which can increase in the aftermath of a disaster (Gennari et al. 2015; Horton 2012; Weitzman and Behrman 2016). Some students never return to school after a disaster, threatening efforts to achieve equity in education. The evidence on learning loss due to time away from school and the impacts beyond education reinforce the importance of building resilience in education infrastructure. This section provides an overview of what the region has been doing to minimize education disruption and proposes a framework with indicators to measure progress toward achieving resilient education systems with scores for The Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Guyana, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

Regional progress

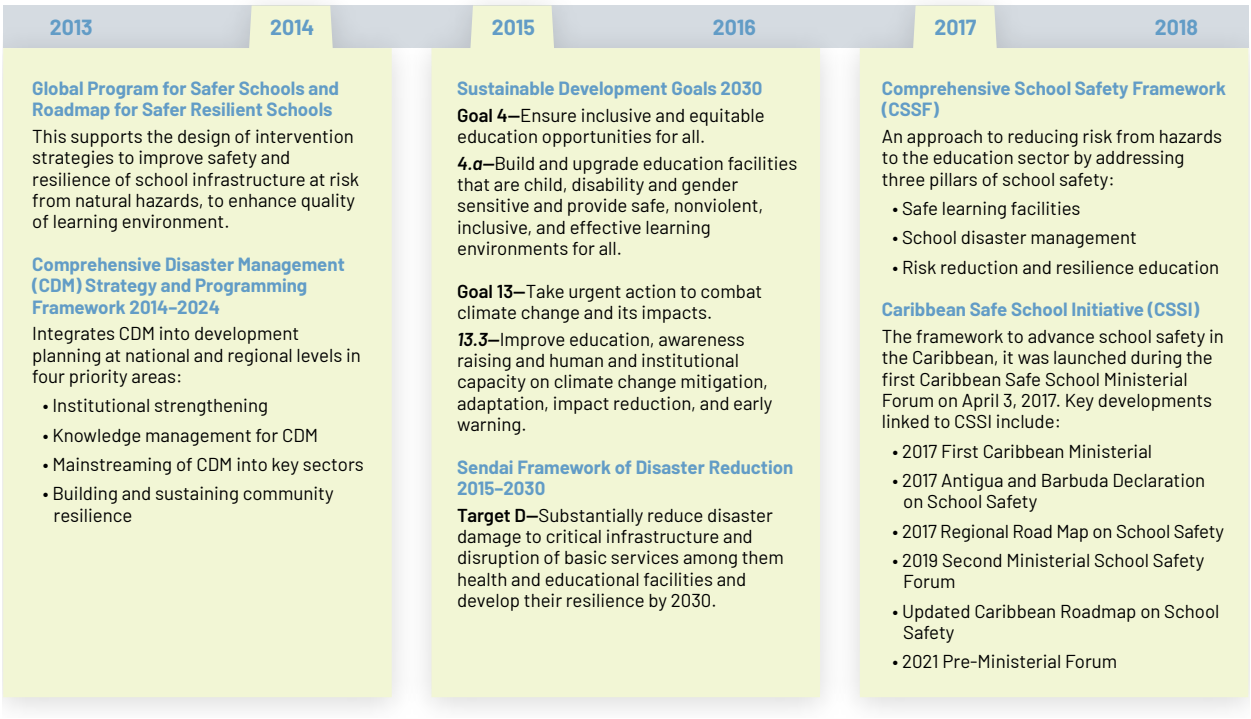
The Caribbean Roadmap on School Safety (EIRD 2017, 2019) and the Antigua and Barbuda Declaration on School Safety (Ministry of Education Antigua and Barbuda et al. 2017) act as guiding documents for the Caribbean Safe School Initiative, the region's contribution to the Worldwide Initiative on Safe Schools.[9] Building on the Comprehensive Safe School Framework (GADRRRES and UNISDR 2017), the Caribbean initiative aims to address risks from all hazards to the education sector using four core pillars of school safety: an enabling environment; safe learning facilities; school disaster management; and DRR and resilience education.

These pillars, elaborated in the Caribbean Roadmap for School Safety, were launched during the 2017 inaugural Caribbean Ministerial Forum on School Safety,[10] as part of the broader Caribbean Safe School Initiative. Twelve countries—Anguilla, Antigua and Barbuda, British Virgin Islands, Dominica, the Dominican Republic, Cuba, Guyana, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Turks and Caicos—signed the Antigua and Barbuda Declaration on School Safety after the initial forum in 2017; Curaçao, Grenada, Haiti, Jamaica, Sint Maarten, and Suriname signed at the second forum two years later.

Figure 10.3 lists the main regional and international guiding documents on education infrastructure and school safety in the Caribbean. The agreements that Caribbean countries have endorsed—including the 2030 Agenda for Sustainable Development and the Sendai Framework for Disaster Risk Reduction—collectively highlight the region's commitment to building resilience in the education sector. In April 2020, more than half of all country respondents had achieved or made significant progress on all four school safety pillars, with the most significant regional accomplishments in stakeholder coordination (school disaster management) and deployment of human and financial resources (enabling environment). However, some areas still require attention. At regional level, there must be greater emphasis on: improving the development of multihazard school safety plans, guiding documents, and safe school standards; DRM training of school staff, family, and community; and including DRM in the curriculum.

FIGURE 10.3 >>

Regional and international guiding documents on education infrastructure and school safety



Source: Bellony and Powers 2021

A framework for analyzing education systems' resilience to shocks

In a resilient education system, schools are safe and inclusive learning environments that can provide equitable access to quality teaching and learning during and after crises and equip children and families with the right skillset to better prepare for, manage, and recover from crises. Building a resilient education system requires actions in four areas:

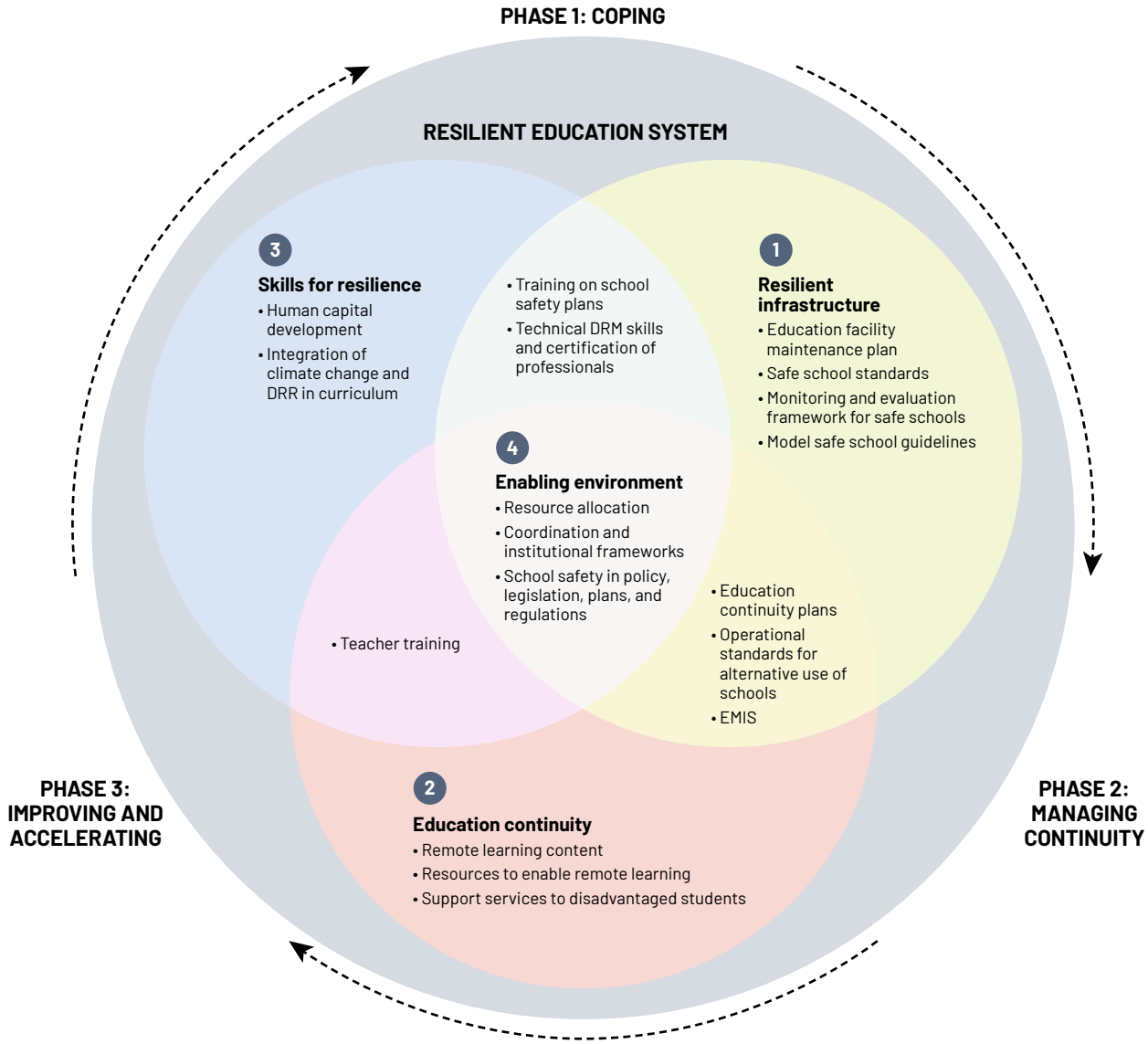
1. Ensuring education infrastructure is safe and inclusive
2. Safeguarding education continuity when shocks occur, by minimizing learning loss
3. Ensuring the learning program equips societies with the right skills for resilience
4. Adopting an enabling environment that provides appropriate policies and legislation and the necessary financing to successfully implement measures in the other three areas

This section defines three maturity levels for resilient education systems (*table 10.7*) and introduces a framework covering the four areas outlined above (*figure 10.4*), proposing indicators to monitor and measure progress towards resilience in education. The overlapping sections contain indicators that benefit more than one area. For example, appropriate teacher training equips teachers with the means to transfer the appropriate skills to their pupils while also teaching them how to continue doing so, when the education system is temporarily disrupted. The figure also shows the three response phases to shocks. In Phase 1, policy interventions are geared to support education systems to cope with school closures; in Phase 2, responses are focused on managing continuity of education, with controlled reopening of schools, recouping learning losses, expanding skills training, and reducing school infrastructure challenges. In Phase 3, effective policy responses are scaled up exploiting opportunities for improving and accelerating education and skills development (World Bank 2020).

Focusing on infrastructure, continuity of education, and an enabling environment (skills for resilience are evaluated in *chapter 8*), this section explores Caribbean countries' efforts to improve resilience in their education systems, and what they still need to do. Using key indicators and the TLS, it evaluates the resilience of The Bahamas, Barbados, Dominica, Dominican Republic, Grenada, Guyana, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago to help them identify gaps and measure progress towards achieving a resilient education system.

FIGURE 10.4 >>

A framework for assessing the resilience of education systems



Source: Adapted from GADRRRES and UNISDR 2017
Note: EMIS = Education Management Information System

TABLE 10.7 >>

Defining terms: nascent, emerging, and established education systems

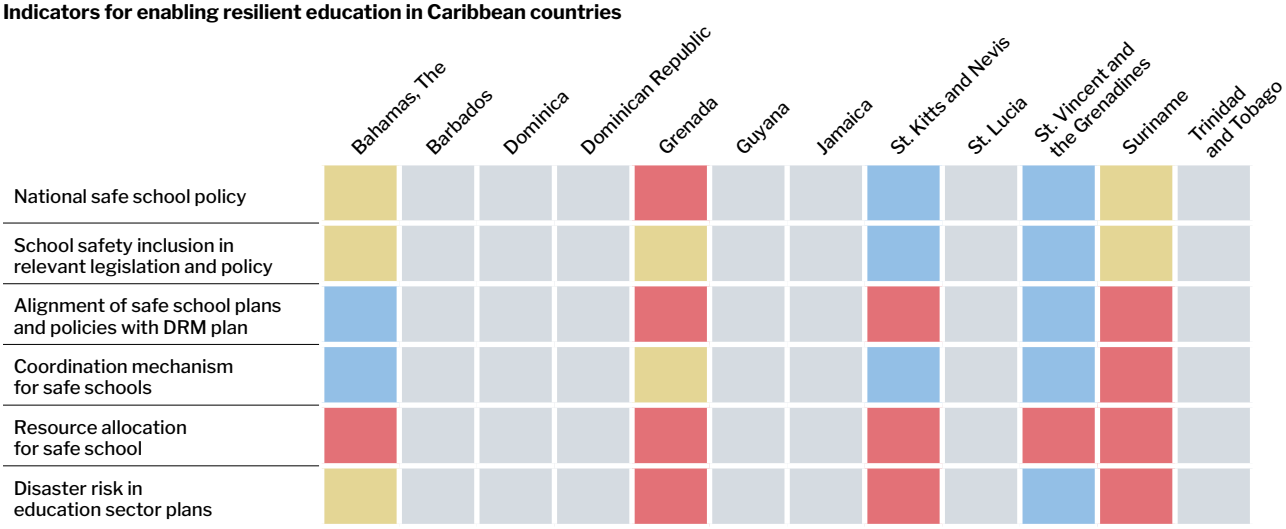
Nascent	Emerging	Established
» The education system **lacks the necessary provisions to ensure continuity** of education in times of emergency	» There is **some provision for managing education continuity**, but gaps remain	» There are **solid and effective provisions to ensure continuity** of learning during emergencies, and education disruptions are kept to a minimum
» Education **infrastructure needs upgrading**, and the regulatory system for safe schools is weak	» Education **infrastructure has been upgraded** to comply with safe school standards, but there is room for improvement	» Education **infrastructure is designed to provide a safe learning environment**
» Schools are used as emergency shelters, but there are **no operational standards** for this use	» Schools' **operational standards include some guidance** on their use as emergency shelters	» Schools are used as emergency shelters, and **clear operational standards** guide their use
» **Resilience is inadequately addressed** in the curriculum, and teacher training programs are weak, failing to equip all actors with the right skillset to cope with shocks	» **Resilience is being incorporated** into the curriculum and teachers are trained in resilience, but rollout is uneven, and progress is required to equip all actors with the right resilience skillset	» The system **equips societies with the right skillset** to cope with shocks and manage continuity, seizing opportunities and making education more inclusive, effective, and resilient than before the shock

An enabling environment for resilient education

Countries are progressing on providing an enabling environment for resilient school systems (*figure 10.4*), and this progress is mostly driven by regional cooperation and agreements. But they need to focus more on developing, implementing, and monitoring enabling national school safety policies and coordination mechanisms for safe schools, and including DRR in education sector plans. Each school should also have a safe school plan aligned with broader DRM requirements and providing guidance on drill timing, wardens, and protocols and procedures to follow in case of disaster.

TABLE 10.8 >>

Indicators for enabling resilient education in Caribbean countries



Source: Based on data from Bellony and Powers 2021

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; countries in blue (established) meet the standard entirely. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

It is important for governments to also provide adequate funding and build their own capacity to implement policies. For example, Jamaica's National Education Trust, created in 2010, secured financial investments to build, retrofit, rehabilitate, and maintain education infrastructure, while in Suriname, Barbados, Trinidad and Tobago, and Jamaica, technical divisions for oversight and management of

school infrastructure are established organizational structures within Ministries of Education. Overall, St. Vincent and the Grenadines has an enabling environment for school safety with the necessary policies and coordination mechanisms in place, scoring "established" for all aspects except funding, which is "nascent" (*table 10.8*). All the other countries for which data are available are lagging on more than one indicator, highlighting that there is room for improvement.

Resilient infrastructure

Guided by regional agreements, countries are progressing towards building more resilient school infrastructure, applying the model safe school guidelines, and developing safe school standards. CDEMA's model safe school guidelines form a checklist to collect information on safety management, school safety compliance, building conditions, and green standards, and provide guidance on things like water and sanitation standards, and how to ensure schools are accessible for persons with disabilities, gender friendly, and so on.

Based on this information, countries can develop their own tailored safe school standards. Usually developed and monitored in consultation and collaboration with Ministries of Education, Health, Planning, Public Works, Infrastructure, Environment, Disaster Management Agencies and fire and police departments, these are a cross-sectoral effort, although participating actors differ by country. Using the school safety assessment results, countries can establish a prioritization program that dictates which schools to rebuild or retrofit and in which order. *Table 10.9* provides an overview of country status for applying and developing these documents and programs. It shows that, although data are lacking for many countries, The Bahamas, St. Kitts and Nevis, and St. Lucia have documents and plans in place or in development but have yet to prioritize school rebuilding or retrofitting. More information is available on monitoring and evaluation systems to effectively track progress on safe schools; these are nascent or emerging in all countries except St. Lucia, which scores "established" on this aspect.

The Caribbean Uniform Building Code serves as a guideline to provide appropriate building standards across the region, including for schools (Miyamoto 2021), providing structural design requirements for gravity, wind, and seismic load. But the degree of enforcement and compliance with this building code varies by country; some adopt it as an integral part of the design process and others treat it as a supplemental document (Miyamoto 2021). Developing prioritization plans to retrofit school stock and planning for maintenance are areas for improvement (*table 10.9*), mostly due to financing challenges rather than a lack of technical capacity.

Sometimes disasters are an opportunity to radically transform a sector. In Haiti, for example, after more than 4,000 schools were damaged or destroyed in the 2010 earthquake, the Ministry of Education worked with development partners to draft guidelines for education infrastructure. Published in 2014, these documents provide building standards, model plans, specifications, supervision tools, and maintenance manuals to support the rebuilding of public education infrastructure, with specifications that meet standards for seismic and hurricane events. Technical professionals have been trained in applying the standards to encourage compliance, regulation, and harmonization of education infrastructure in Haiti (Government of Haiti 2020). However, they only apply to public schools, which form around 20 percent of Haiti's school stock (Bellony and Powers 2021).

Schools in the Caribbean are often multifunctional spaces used as emergency shelters during disasters. For example, in Barbados, 60 percent of all public primary and secondary schools are assigned as emergency shelters, while in Antigua and Barbuda and Belize, half the school stock is used this way (Bellony and Powers 2021). Using schools as emergency shelters during disasters requires operational standards to ensure they are equipped with the necessary provisions. But only The Bahamas and St. Kitts and Nevis

have established operational standards for alternative use of schools (*table 10.9*). Barbados, Grenada, Jamaica, and St. Lucia score "emerging" on this aspect, implying that schools' operational standards include some guidance on their use as emergency shelters. Dominica, Suriname, and St. Vincent and the Grenadines score "nascent", implying that, although schools have a dual use, their operational standards lack policy on their use as emergency shelters.

TABLE 10.9 >>

Indicators for resilient education infrastructure in Caribbean countries

Source: Based on data from Bellony and Powers 2021

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; countries in blue (established) meet the standard entirely. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Continiuity of education

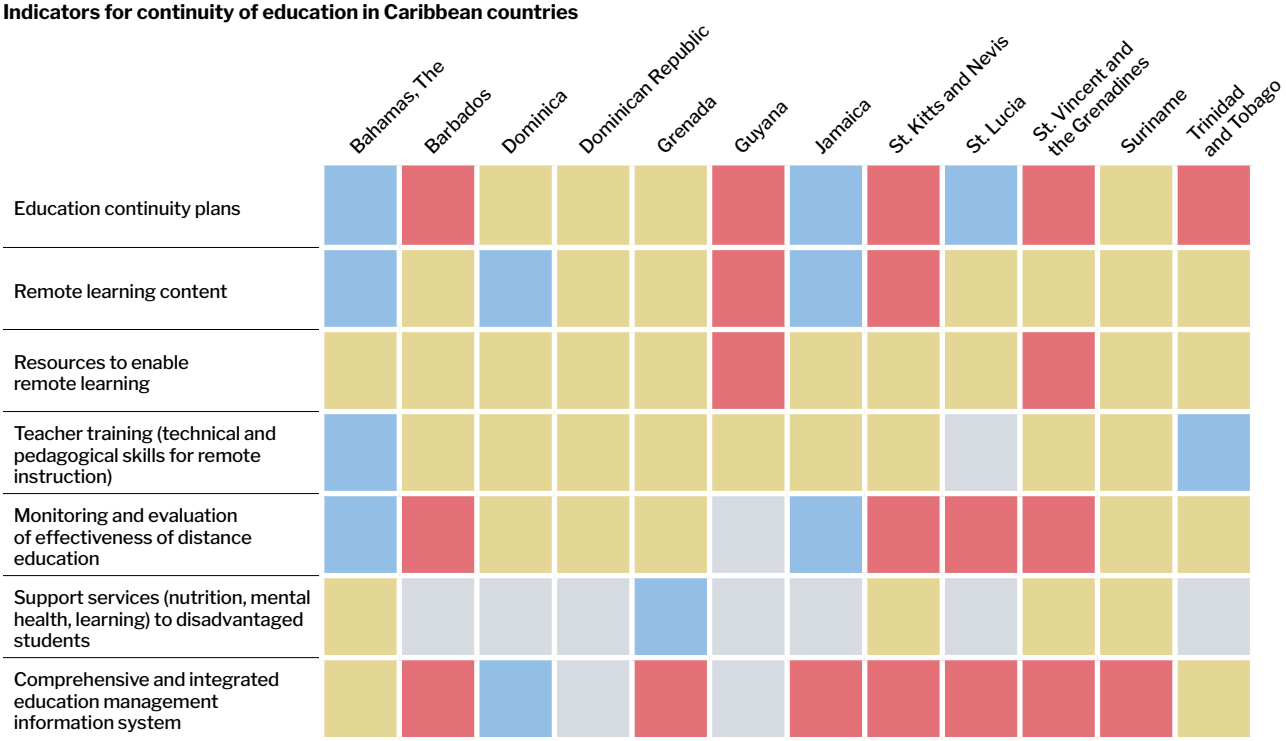
Disasters cannot always be avoided, so a resilient education system must be prepared to manage the continuity of learning in times of disruption (*chapter 11*). For different disasters, this will entail different strategies, so a layered response is important. During the COVID-19 pandemic, distance education has been the short-term alternative to in-person instruction, whereas for naural disasters, the focus is on making infrastructure more reliable for use despite shocks and stresses to the system and defining clear operational standards for alternative use of schools.

Minimizing the time children spend out of school after a shock or disaster requires comprehensive education continuity plans at both national and school levels. Tied to this are access to remote learning content and resources that enable distance learning, such as access to internet, computers, mobile devices, radio, or television. Teachers should be trained to ensure they have the skills to lead online instruction, and both school and national authorities need mechanisms to actively monitor and evaluate the effectiveness of distance education, as this will allow them to plan responses to support both students and teachers, especially the most vulnerable. Disadvantaged students should be offered support services when they are out of school, since many rely on school feeding programs and for those who face domestic violence at home, school is a safe place.

In terms of teacher training skills for remote instruction, Trinidad and Tobago and The Bahamas score "established" as they have introduced strategies to cope with and manage distance education during the COVID-19 pandemic; most countries score "emerging" for this indicator (*table 10.10*). In Dominica, the Dominican Republic, Jamaica, St. Kitts and Nevis, St. Vincent and the Grenadines and Suriname at least 50 percent of teachers have the necessary digital, technical, and pedagogical skills to effectively deliver distance education, which they acquired through short courses, filling an immediate gap.

TABLE 10.10 >>

Indicators for continuity of education in Caribbean countries



Source: Based on data from Bellony and Powers 2021

Notes: Countries in red (nascent) did not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; countries in blue (established) meet the standard entirely. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Table 10.10 also shows that, in The Bahamas, Jamaica, and St. Lucia, education continuity plans are available and an established feature of the system. These plans, combined with a functional and integrated education management information system (EMIS), provide data to monitor the effectiveness of disaster education and a platform to disseminate remote content and facilitate teacher training. Unfortunately, only Dominica scores "established" for availability of and access to data—on demographics, learning outcomes, assessment, certification, social safety net programs, and so on—through its EMIS. The Bahamas and Trinidad and Tobago score "emerging", while Barbados, Jamaica, St. Kitts and Nevis, St. Vincent and the Grenadines, and Suriname all score "nascent", implying an interoperable EMIS is either in the early stages of development or nonexistent. Across the Caribbean, governments must prioritize education continuity planning and monitoring and evaluation of distance education. Formalizing programs for pre- and in-service teacher training is paramount for improving and accelerating progress in teaching, learning, and attaining resilience in education.

Lessons learned from the COVID-19 pandemic

School closures due to COVID-19 left an unprecedented number of students out of school. Of the 1 billion affected students worldwide, more than 1 million were in the Caribbean. To analyze continuity of education during the COVID-19 health shock, Bellony and Powers (2021) sent a questionnaire to Ministries of Education in CARICOM countries, the Dominican Republic, and Sint Maarten and used data from recent rounds of household surveys in Antigua and Barbuda, Grenada, Jamaica, and St. Lucia to understand access to and support for remote learning. The results reveal considerable diversity in self-reported preparation levels across countries and types of service (***figure 10.5***).

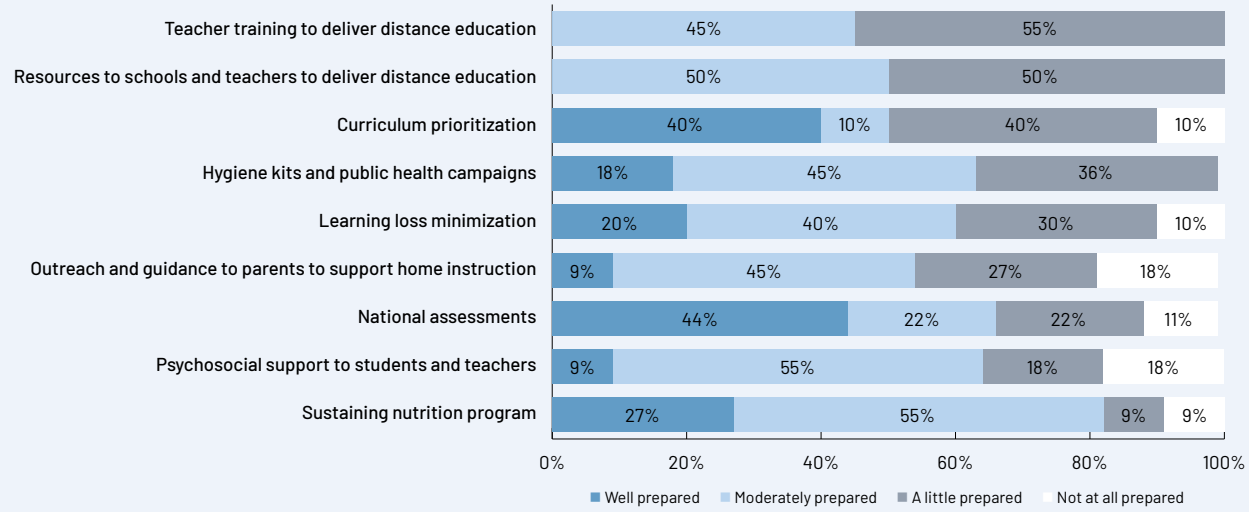
Although countries' disaster contingency plans provided some baseline for distance learning delivery, resources and plans were overwhelmed by the sheer scale of the disruption from COVID-19. In Haiti, Jamaica, the Dominican Republic, and other countries, functioning national school nutrition programs existed before COVID-19, while the system for distributing hygiene kits after a disaster is well established in the Caribbean through CDEMA, NDMOs and NGOs. This may explain the higher level of preparation in school nutrition, hygiene kits, and public campaigns.

Despite governments' best efforts, distance learning in its varied forms did not reach all learners. Inequalities in access to distance delivery methods, especially internet services, reinforced the need to use multiple mediums to deliver distance education and raise serious equity concerns about the primacy of online instruction. There are also significant inequalities in access to a supportive home environment for distance education, which is crucial for continuity of learning. The household survey shows that Caribbean households in the lower income quintiles have less favorable conditions for learning at home.

Policy makers have identified a lack of internet connection and devices as potential contributing factors to student's unintentional exit from the education system during COVID-19. As well as using different distance learning modalities, countries tried to give students—especially those from disadvantaged households—the tools they needed to access online learning. However, the unanticipated nature of school closures during the pandemic and the vast demand for online tools have restricted governments' ability to finance, procure, and supply all students simultaneously. Formal EWSs, based on EMIS, to identify students at risk of dropout are in embryonic stages across the Caribbean,

FIGURE 10.5 >>

Perceptions of Ministry of Education preparedness to deliver services



Source: Bellony and Powers 2021

Note: Shows responses from The Bahamas, Dominica, the Dominican Republic, Grenada, Guyana, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

posing a challenge to identifying and reaching these children. Most Caribbean countries do not have an EMIS. Where they do exist, they are not always up to date; and where they are current, they are often not linked up with other government administrative databases.

While governments have implemented distance education solutions (*box 10.2*), data to better monitor and evaluate student access to, participation in, and learning through these mediums are limited. There is also a need for more focus on incorporating assistive technologies, tutoring, and other measures into distance learning to ensure the inclusion of children with disabilities and special educational needs.

Private schools account for 58 percent of education supply in OESC member states;[11] and even more in other countries, such as Haiti (80 percent). And, with the economic shock that has accompanied the pandemic limiting households' ability to invest in education, constraining their ability to function, most are unlikely to survive COVID-19. As such, governments should consider supporting both private and public schools and their students during and after the pandemic to ensure the supply of quality education spaces, minimize student dropout, and reduce the number of out-of-school children.

The experiences from the COVID-19 pandemic have brought to light opportunities and challenges of distance learning, providing lessons for policy makers to finetune response policies for coping, managing recovery, and improving and accelerating education both during and after shocks.

BOX 10.2 >>

Continuity of education responses triggered by COVID-19 in selected countries

The Bahamas: Online learning had already been developed before the COVID-19 pandemic, from September 2019 as a solution for teacher shortages on the remote islands. As a result, the government was able to expand remote education within one week of school closure from COVID-19 on March 25, 2020. To further strengthen its capability for education in emergencies, the government is developing its policy on continuity of education in emergencies, continuing negotiations to establish a national e-learning platform, and undertaking preliminary discussions to develop an EMIS to help track students at risk for dropout.

Dominican Republic: Policy makers were moderately well prepared to transition to distance education. The education sector support plan provided guidance on all aspects of continuity of learning and used data on remote learning and device access to inform decisions and find solutions to reach learners. Using a range of online tools, radio, television, and mobile phones—alongside the Ministry of Education's (MOE) website as main online education delivery mode—the ministry delivered about 1 million learning packages to early childhood and primary students. Yet, 3 out of 10 students still lacked access to distance education in any form. The school nutrition program was sustained, delivering 9 million food packages over a three-month period from March 23, 2020.

Jamaica: Policy makers implemented education in emergency policy guidelines to manage all aspects of distance education. This included psychosocial support, a nutrition program for students on the conditional PATH cash transfer, examinations, transportation, specific interventions for educational levels, and online homeschooling.

Trinidad and Tobago: The national school learning management system (SLMS) for distance education provides an interface for teachers and students that has allowed educators to document, track, grade, report, upload resources, teach, and give feedback via remote learning during the pandemic. The MOE also has a functioning EMIS, accessible to administrators, educators, and parents, that provides data on learning analytics and tailored information for users.

The MOE was moderately prepared to provide teacher training and remote learning resources to school populations. Teachers could participate in various massive open online courses, blended learning, webinars, and other forms of remote training. The ministry also developed mechanisms to inform the administration and the monitoring of teaching and learning during the pandemic, including guidelines for online teaching and navigating the SLMS, and national policies for uploading and creating student materials, teaching, and learning online, and intellectual property and copyright.

The use of online tools for distance education (mainly the SLMS) highlighted the problems teachers and students face in accessing devices and the internet. This prompted the MOE to engage with the Telecommunications Authority, Ministry of Public Administration, and internet service providers to improve equity and inclusion and offer free access to the SLMS, live classrooms, and MOE websites. It also explored a program to loan devices to teachers and students as the lack of immediate public funding hindered the procurement of additional devices.

Source: Bellony and Powers 2021

Endnotes

1. https://www.paho.org/en/health-emergencies/smart-hospitals.
2. Category A health care facilities are deemed able to protect the life of their occupants and likely to continue functioning in disaster situations; category B facilities can resist a disaster but their equipment and critical services are deemed at risk; in category C facilities, the lives and safety of occupants are deemed at risk during disasters.
3. The WHO recommends 4.45 doctors, nurses and midwives per 1,000 population for operational routine services, plus a 30 percent surge capacity, at least one trained (field) epidemiologist (or equivalent) per 200,000 population for surveillance, and at least one trained epidemiologist per rapid response team (WHO 2019). Although these standard population ratios for health workers are not well-suited for countries with small populations—typically resulting in a higher-than expected ratio of health workers—they do provide a point of reference.
4. The CR-FELTP aims to develop professionals who can address public health issues in the Caribbean through surveillance, outbreak investigation, and operational research and analysis using classroom learning and field training. The CR-FELTP's curriculum has three tiers and has been coordinated by CARPHA. Only CR-FELTP intermediate or advanced training levels are considered comparable to formal epidemiological training. https://carpha.org/What-We-Do/FELTP/Introduction.
5. https://www.paho.org/en/health-emergencies/emergency-medical-teams#:~:text=EMTs%20are%20teams%20of%20health,and%20support%20local%20health%20systems.
6. Harnam and Khan (2021) showcase an extensive list of the different organizations and documents involved in leading, coordinating, supporting, collaborating on, guiding, and/or financing different aspects of health system resilience in the region.
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10. The Ministerial Forum is comprised of Ministers of Education and their representatives, who meet biennially to discuss progress, lessons learned, and bottlenecks in implementing the Caribbean Roadmap on School Safety.
11. OECS members states include Anguilla, Antigua and Barbuda, the British Virgin Islands, Dominica, Grenada, Guadeloupe, Martinique, Montserrat, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines.

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11

CHAPTER 11 >>

Help firms and people manage residual risks and natural disasters

No matter how much private actors and governments try to reduce exposure to shocks or increase their assets' and networks' resistance to natural hazards and climate change, risk cannot be reduced to zero, particularly in a region as prone to extreme events as the Caribbean.

Shocks will continue to inflict damage, so as well as reducing risk, improving people's ability to cope with and minimize the impact of unavoidable shocks is vital. This section draws on sectoral background papers prepared for this report—namely Beazley and Williams (2021), Campbell, Gonzalez-Escalada Mena and McAllister (2021), and Erman et al. (2021)—and covers five key areas:

1. Preparedness and response focused on anticipating events, saving lives, and managing the emergency
2. Insurance and financial instruments, to cover financial losses
3. Adaptive social protection, to help the poorest and most vulnerable recover from shocks
4. Business continuity plans, to help firms maintain business functions or quickly resume them after a major event
5. Building back better, to reduce levels of pre-shock exposure and vulnerability

Emergency preparedness and early warning systems

Emergency preparedness and response (EP&R) systems allow people to anticipate and prepare for extreme events, ensuring quick action, timely evacuation and saving thousands of lives. EWSs—which focus on observing and monitoring approaching events, communicating warnings and actions to persons at risk—are an important part of EP&R.

Emergency preparedness and response

To be effective, EP&R systems need to work with EWSs, both horizontally across government ministries and departments, and vertically through national, regional, and local levels of government. Inclusive in these systems is the role played by nongovernmental response partners in delivering assistance and aid regardless of the scale and impact intensity of an event. An effective preparedness system enables communities to prepare for disasters while also creating supportive and aligned coordinating capacity and specialized resources at national and subnational levels for larger-scale events.

The World Bank's Ready2Respond framework provides a comprehensive approach to assess the effectiveness and plan the development of EP&R systems. Aimed at protecting public safety, building institutional capacity, increasing climate change resilience, and safeguarding socioeconomic development, it has five buildings blocks: legal and institutional framework, information, facilities, equipment, and personnel (*figure 11.1*).[1]

FIGURE 11.1 >>

Components of resilient EP&R systems

Source: Based on GFDRR and GSURR 2017

This section examines the EP&R capabilities of the five Disaster Preparedness & Response Capacity Assessment (DPRCA) project[2] countries—Dominica, Grenada, St. Lucia, St. Kitts and Nevis, and St. Vincent and the Grenadines. The diagnosis identifies key indicators to measure progress towards achieving resilient EP&R systems and critical gaps or obstacles that prevent countries from developing and implementing emergency preparedness architectures and response systems. Progress on selected EP&R indicators is shown in *table 11.1* and the three maturity level definitions three maturity levels are presented in *table 11.2*.

TABLE 11.1 >>

Emergency preparedness and response in Caribbean countries

EP&R component	Indicator	Dominica	Grenada	St. Kitts and Nevis	St. Lucia	St. Vincent and the Grenadines
Legal and institutional framework	EP&R legislation					
Information	Disaster management information system (DMIS) for EP&R					
Facilities	Emergency operation centers					
Equipment	Urban firefighting equipment and capabilities					
Personnel	Formal EP&R training					

Sources: Based on data from Campbell, Gonzalez-Escalada Mena and McAllister 2021; Miles et al. 2020

Notes: Countries in red (nascent) do not meet the standard (shown in table 11.2) and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; countries in blue (established) meet the standard entirely. Indicators align with World Bank's Ready2Respond diagnostic for EP&R systems (GFDRR 2017) and the outcomes from the recent World Bank DPRCA project.[2] The DPRCA classifications have been transposed in the three-level scoring approach as follows: the DPRCA's "critical and urgent need for investment" were combined into "nascent"; "high and medium need for investment" into "emerging". There were no DPRCA scores that could be considered "established".

TABLE 11.2 >>

Defining terms: nascent, emerging, and established EP&R indicators

Nascent: *0–2 of the statements for the component are true*	**Emerging:** *3–4 of the statements for the component are true*	**Established:** *All statements for the component are true*

Legal and institutional framework: EP&R legislation

1. Accountabilities are clear for all phases of emergency management, including central coordination, and for short- and long-term risk reduction activities, such as emergency response roles and risk-sensitive land-use planning
2. Resilience requirements for time-critical public and private sector services are clearly stated and universally applied
3. Agencies with emergency response roles are required to have detailed plans and report annually on improvements to their state of preparedness
4. Emergency management accountabilities are clear across all levels of government, reducing or eliminating jurisdictional ambiguity
5. The legislation and policy framework requires a collaborative, risk-informed, progressive approach from accountable agencies

Information: DMIS for EP&R

1. The DMIS has an uptime of 99% or higher with established redundancy and a recovery plan
2. A common DMIS is used by all emergency operations centers (EOC), even if only codified in policy as common email, work processing, and spreadsheet tools
3. The DMIS is interoperable with common DMIS platforms used by regional and/or international disaster support agencies
4. The DMIS uses commonly available commercial-off-the-shelf software or networked/cloud-based applications
5. EOC personnel and other DMIS users receive ongoing training on DMIS use

Facilities: Emergency operation centers

1. EOCs have resilient systems to ensure continuous operation despite critical service disruptions
2. Primary EOCs have an established backup site in case they require evacuation or are unavailable
3. EOCs are staffed, or have staff on call, 24 hours a day, 365 days a year, who can serve as duty/watch officers
4. The government has established an operational program budget, including capital funding for facility, personnel, training improvements, and annual testing
5. EOCs are fully equipped with the tools and technology necessary to coordinate response activities within their jurisdiction

Equipment: Urban firefighting equipment and capabilities

1. Jurisdictional programs for fire prevention exist and are delivered by the fire service
2. A network of jurisdictional fire services exists, and professional and volunteer firefighters are equipped with modern PPE and enough functional equipment to safely suppress exterior and interior fires
3. Industrial firefighting capability exists in either the public or private sector, including marine fire suppression where appropriate
4. Fire services can extinguish fires in high buildings (six stories or greater), including residential and commercial structures
5. Jurisdictional budgets exist, are reviewed regularly to support urban firefighting readiness, and consider training, equipment needs, employee costs, deployment costs, prevention/mitigation efforts, and management/administration costs

Personnel: Formal EP&R training

1. A training program exists for those with legislated emergency response job requirements
2. A training program exists for all primary emergency response agency—fire, police, paramedic/ambulance—personnel
3. A training program exists for nontraditional emergency response roles, such as logistics specialists, disaster relief coordinators, hospital staff, emergency social services
4. Training programs are tiered and establish skillsets and experience required for attaining each level
5. A comprehensive training evaluation/review process exists to ensure continuous improvement of the training program

Legal and institutional framework

Internal and external clarity about the role of public and private agencies is critical during the disaster and response phase to avoid inefficiencies and jurisdictional overlap and reduce potential and actual losses. Ideally, these accountabilities should be clearly enshrined in legislation with directive regulations. Where possible, deconflicted policy instruments should identify the operational expectations on agencies that are assigned a preparedness and response mandate.

Through engagement with various countries, including the five countries assessed in this section, CDEMA has developed model DRM legislation for use by any CARICOM country. While intended to be adapted to country context, the availability of a common starting point for such legislation represents a strong step forward. However, because legislation can be challenging to develop and pass in government (Campbell, Gonzalez-Escalada Mena and McAllister 2021), disaster management legislation and plans are often out of date, nonexistent, or have been reviewed but not transposed and implemented. For example, all five countries have disaster management plans dating back to 2005 or earlier, some with reviews and updates, but none have been implemented (Miles et al. 2020). As a result, DRR responsibilities are neglected, ignored, or delegated downwards to National Emergency Management Organizations (NEMOs) along with unrealistic expectations around required manpower, skillsets, and responsibilities, without additional resources. In general, ministries with disaster management portfolios do not routinely budget for disaster response or risk reduction activities, and rely instead on (uncertain) external assistance (Miles et al. 2020).

Information

Collecting, analyzing, and swiftly disseminating information enables better decision making before emergencies, during response, and through recovery. Community engagement is also vital, to understand needs and impacts and reach a well-developed state of preparedness. Coordinating emergency information from responding agencies and social media ensures horizontal and vertical situational awareness that enables efficient, coordinated, and prioritized response operations (Campbell, Gonzalez-Escalada Mena and McAllister 2021).

Yet, a culture of silos persists within and between government ministries, emergency services, and key public and private sector agencies, perpetuating a reluctance to share information and a lack of cost-effective means of doing so. A similar mentality exists among international donors and external aid organizations when it comes to sharing results and findings from activities in countries. As a result, they experiment with systems for capturing and holding information for their own benefit rather than for rapid sharing and receiving. The same mindset is apparent in the resistance faced by CDEMA in encouraging member states to feed national disaster situational awareness data to the evolving regional CRIS database (Miles et al. 2020).

In all five countries, improving data collection, archiving, and sharing is a high priority. Key stakeholders struggle to find or access reports, recommendations, and datasets from projects conducted in recent years, wasting time while valuable information remains locked away in institutions. Sharing information during emergencies also relies on resilient mobile and internet infrastructure that can withstand shocks and has full country coverage. But the topography of Caribbean countries creates many blind spots that hamper effective communication between emergency responders.

There is an urgent need to improve national strategic government and senior private sector-level crisis communications systems and procedures and thus build public trust in government messaging on disaster mitigation, preparedness, and response. Key issues to address include the speed, effectiveness, and content of interagency and inter-ministry consultation and coordination, rapid cross-government (and cross-executive board) authorization, and effective preparation and delivery of strategic messages that

guide and promote local, national, and international activity while also building and maintaining trust and confidence in national leadership and decision making. Miles et al. (2020) find that those responsible for strategic crisis communications prefer to maintain reputational safety by adhering to bureaucratic processes rather than promoting rapid dissemination of messages in a communications environment dominated by social media and internet-based news. The public, on the other hand, tends to ignore government messaging and search for alternative information sources, which leads to misinformation that then must be corrected.

Facilities

Coordinating EP&R activities requires a structural presence of EOCs, response stations, purpose-built warehouses for emergency relief, and all-hazard shelters for command and control, moving emergency aid, or staging response teams and their equipment. These facilities are a core element in establishing a culture of preparedness and ensuring a dependable common operating picture and resilient services when other critical infrastructure and government services are disrupted. They help ensure a nexus for information, personnel, and equipment as an EP&R system matures through focused investment (Campbell, Gonzalez-Escalada Mena and McAllister 2021).

Although all five countries have a functioning national EOC, many have issues around modern communications, situational awareness capabilities, structural resilience of buildings, and inadequate facilities for extended use. The exception is Grenada, which is building a modernized national EOC and disaster relief warehouse that will also house its National Disaster Management Agency offices (Campbell, Gonzalez-Escalada Mena and McAllister 2021). But with EOC interoperability generally low, countries have no designated, purpose-built, and appropriately equipped alternative locations to house the national EOC, should it be rendered unusable (Miles et al. 2020). There are also few purpose-built warehouses for emergency relief supplies outside population centers, with most warehousing located on NEMO office sites or concentrated to serve urban populations.

All five countries lack purpose-built, all-hazard emergency shelters, and use schools, churches, community centers, and even private homes instead. While perceived as cost-effective, this approach is also problematic. As they were not designed as hazard shelters, these buildings might not be resilient enough to endure shocks; they also usually lack the necessary facilities for extended use (of more than three to four days). When school shelters remain occupied by disaster victims, it also delays the resumption of teaching, prolonging education losses (***chapter 10***) (Bellony and Powers 2021), and if shelters are not perceived as safe, people are reluctant to use them (Das 2019; Haque 1995).

While public buildings earmarked as emergency shelters are usually identified and assessed before the start of the hurricane season, in many countries, government officers have limited capacity and time to carry out this work. Assessments are usually done on paper and not digitized, and the data are therefore not analyzed or used to identify investment needs. And while some buildings may be deemed not fully appropriate for use as shelters, they are included in the list if no alternatives are available in the community. The COVID-19 pandemic has further reduced the limited availability of shelter space, as maximum capacity is adjusted downwards to allow for social distancing.

Equipment

When properly used and maintained, and combined with accurate information and capable personnel, EP&R equipment ensures timely information sharing and enables core agencies to deliver services safely and effectively (Campbell, Gonzalez-Escalada Mena and McAllister 2021). But none of the five countries provide enough equipment to emergency responders and the key public and private entities involved in emergency and disaster response activities. Deficiencies include specialist vehicles and equipment such as

4x4 vehicles, ambulances, fire trucks, and firefighting and rescue equipment, including PPE. For example, the island of Nevis has only one ambulance and Grenada lacks the ambulances and medical response teams it needs to provide an efficient emergency capability. Given the topography of some islands and the need to reach communities on more remote sister islands, maritime capability, including offshore and amphibious craft, is inadequate (Miles et al. 2020).

The five countries lack adequate equipment to deal with industrial oil spills, and have extremely limited capability to deal with toxic waste or hazardous materials. Many rely heavily on the private sector to provide equipment, manpower, and expertise when required. And rather than having prior agreements for providing services, they largely depend on goodwill. For example, St. Vincent and the Grenadines has limited equipment for emergency responders and no biomedical waste incineration facility, as highlighted by the COVID-19 crisis (Miles et al. 2020).

None of the countries has enough heavy plant or earth-moving equipment for clearing debris after a hurricane, earthquake, or similar disaster, improper disposal of which can have serious for safety, environmental and public health consequences. Nor do they have the equipment and supplies necessary for repairing roads, bridges, and other critical infrastructure. For example, St. Lucia's public works agencies lack even the most rudimentary equipment to repair roads and bridges and clear debris (Miles et al. 2020). As a result, communities cannot relocate easily from affected areas and may find themselves cut off from disaster response, essential supplies, and transportation hubs.

Personnel

A skilled and experienced workforce is the most valuable resource in any EP&R system. Countries need to establish a culture of preparedness that places the trust of public and political bodies in the agencies tasked with ensuring public safety and minimizing economic disruptions. Gaining this trust requires intensive and extensive training to ensure personnel acquire knowledge, develop skills, and gain practical experience, taking advantage of the best available plans, information, facilities, and equipment to ensure an interoperable, systems approach. It must also enable deep capability in focused areas of expertise to scale up personnel development from the individual to the team, and from the team to the culture of the agency and community (Campbell, Gonzalez-Escalada Mena and McAllister 2021).

Across the Caribbean, there is an ad hoc approach to building disaster management knowledge, developing competency for professional emergency planners and responders, personnel recruitment, and volunteer group tasking. NEMOs and their key stakeholders lack the necessary and appropriate levels of disaster management training and expertise and there are insufficient personnel with key technical GIS, ICT, hazard mapping, and logistics skills to meet the growing demand for scientific, technical, and professional advice (*chapter 8*). The lack of human capacity and technological expertise in the region is single largest constraint on leveraging the benefits of ICT for DRM (*box 11.1*). Many organizations involved in disaster response rely heavily on volunteers, without taking the necessary measures to ensure they have the right skills and expertise to perform the activities they are tasked with.

Without national disaster management training policies and structured training needs analysis, training solutions—many of which are provided by external donors—often conflict with, rather than enhance, established national and regional practices. There is also a perceived reluctance to test national emergency management plans with multiagency exercises, as failure is considered a potential threat to an organization's credibility or leadership. So, rather than provide a realistic assessment of disaster response capability, such tests resemble well-rehearsed events that carefully manage and eliminate issues like a lack of appropriate equipment, insufficient manpower, or misinformation, creating a false sense of readiness (Miles et al. 2020).

BOX 11.1 >>

ICT in disaster risk management

ICT can be and is used to support DRM practice in times of crisis, planning, and reconstruction. Jamaica, for example, has successfully implemented GIS systems for scenario planning; Trinidad and Tobago's Office for Disaster and Preparedness Management effectively uses Twitter for public communications; and Montserrat's EWS improvements have increased redundancy and unified the administration interface across multiple technologies. But implementation is uneven across the Caribbean, and regional integration is lacking. Successful projects, and the lessons learned and specialized skills that arise from them, are limited to individual countries and technologies.

The lack of human capacity and technological expertise is the single largest constraint on implementing ICT for DRM in the Caribbean, among both frontline staff and senior organization leaders. With a few exceptions, DRM organization leaders have been unable to articulate a transformational vision for using ICT in DRM, largely through their own lack of information on ICT issues. ICT infrastructure for gathering hazard and risk information, early warning alerts, quick response capability, and coordinating rehabilitation activities also require modernization. Mobile devices for field workers—including volunteers, who often have to use personal devices for their work, reducing willingness to participate in volunteer activities (Miles et al. 2020)—integrated GIS mapping tools for inhouse professionals, disaster management databases, and crisis management software should be standard tools in every DRM agency.

Overcoming these issues will require a greater culture of sharing between DRM collaborator agencies and other communities of practice and including DRM practitioners in discussions around national ICT planning. Government officials must increase their awareness of best practice for incorporating ICT within the DRM framework and learn from other successes. Implementing an ICT system should be accompanied by adequate organizational readiness assessments, with two-way information sharing to help ensure ICTs become an integrated part of DRM. Finally, all national ICT structures should include a DRR strategy, which is often not the case in the public sector.

Source: ECLAC 2014

Early warning systems

EWSs are a critical element of EP&R, primarily aimed at preventing loss of life and injuries of people, but also helping reduce the economic and material impacts of hazardous events through quick action. Timely, targeted, clear warning messages allow individuals, communities, governments, firms, and others to take timely action to reduce the potential impact of an approaching shock. Multihazard EWSs consider simultaneous and cascading hazard occurrence and compounding effects over time. EWSs can be conceptualized as integrated systems of four interrelated elements or pillars (see CDEMA 2018, for example):

1. Disaster risk knowledge, based on systematic data collection and disaster risk assessments
2. Detecting, monitoring, analyzing, and forecasting of the hazards and possible consequences
3. Official dissemination and communication of authoritative, timely, accurate, and actionable warnings and associated information on likelihood and impact
4. Preparedness and response capabilities

With the high frequency of shocks from natural hazards, there are several well-established national EWSs in the Caribbean, as well as a cascading regional to national EWS for specific hazards, including hurricanes, tsunamis, flash floods, and volcanic activities. The Regional Early Warning Systems Consortium was launched in 2019 to provide strategic direction to the development and sustainability of Multi-Hazard Early Warning Systems (MHEWS) from regional to community levels. The region has also adapted the

UN Office for Disaster Risk Reduction EWS Checklist to the Caribbean context (CDEMA 2018) to evaluate country capacity, develop recommendations for strengthening EWSs, and monitor progress.

This section provides a brief overview of the region's strengths and weaknesses under the four pillars outlined above, and adds a fifth aspect—end-to-end communication and feedback mechanisms—which refers to the connection, communication, and feedback mechanisms between those elements.

Disaster risk knowledge

Up-to-date and readily available information on hazards, exposure, and vulnerability is crucial to enable targeted warnings, since it contributes to the identification of the communities, persons, firms, and assets that are likely to be impacted by an approaching event. In most countries, the lack of well-defined standards, roles, and responsibilities around data collection, analysis, management, and sharing means that organizational arrangements and technical capacity are extremely limited, preventing quick access to important data (see *chapter 8* for further information).

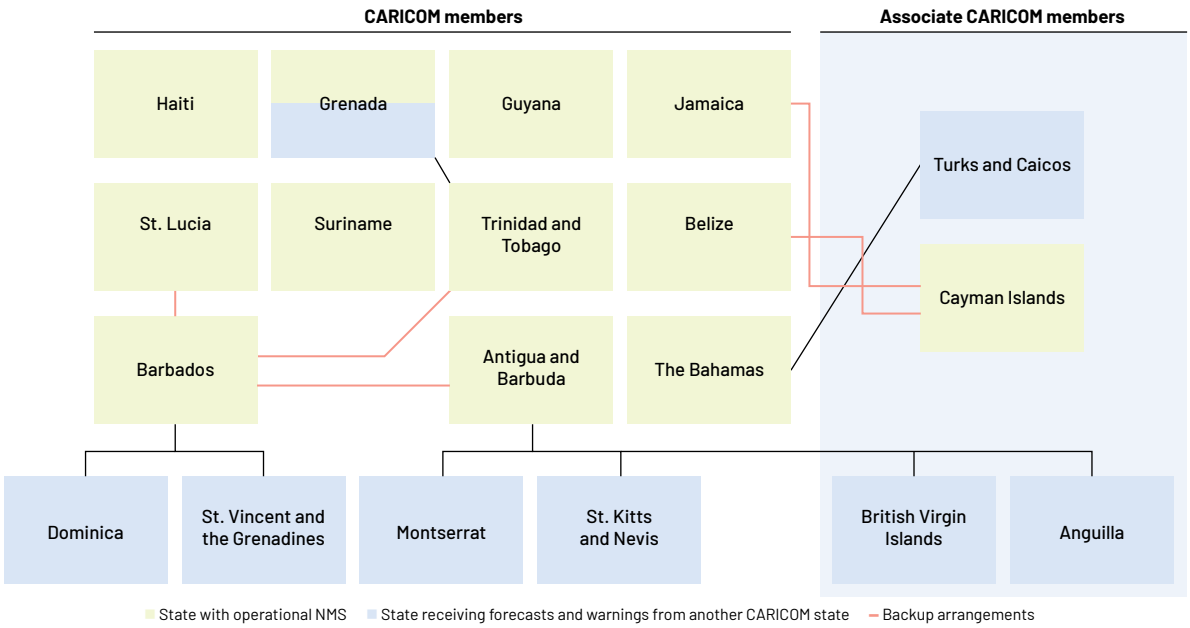
Detecting, monitoring, analyzing, and forecasting hazards

Round-the-clock monitoring of approaching events, accurate forecasting, and timely warnings are critical for enabling those affected to take adequate action. *Chapter 8* provides an overview of hydromet data collection and sharing; this section summarizes EWS-specific information.

In principle, national meteorological and hydrological services (NMHS) are responsible for monitoring and forecasting hydromet hazards like storms, flooding, and landslides; depending on local legislation, they may also be responsible for emitting warnings. But not all Caribbean nations have an agency that carries out all the functions of a national meteorological service (NMS), so some of the more advanced NMSs have taken on responsibility for preparing and issuing forecasts and warnings to neighboring states (*figure 11.2*).

FIGURE 11.2 >>

Forecasting and warning support arrangements between CARICOM states and associate members



Source: Adapted from World Bank, forthcoming

Note: Grenada has an operational NMS producing forecasts but receives tropical cyclones warnings from Trinidad and Tobago Meteorological Services.

In many countries, mandates of meteorological and hydrological services are outdated or incomplete, as most do not attribute responsibility for hydrological hazard monitoring and forecasting to a specific agency. For example, in Dominica and Grenada, water-related agencies only focus on water supply and sewerage services and do not operate around the clock. The water resource agencies in St. Lucia, Jamaica, and Trinidad and Tobago have a much broader scope around water monitoring, observation, and analysis, but they still do not operate 24/7. Only Haiti and Guyana have a combined hydromet service, enabling collaboration, coordination, and round-the-clock operations in both hydrological and meteorological areas.

Although no country provides comprehensive national hydrological forecasting and warning services, some—including Haiti, the Dominican Republic and St. Lucia—are developing a flash flood guidance system. This system integrates in-situ sensor networks and hydrological models with regional radar grid data and satellite products to prepare forecasts of potential flooding with a longer lead time than can be expected from in-situ monitoring stations alone. This is relevant because catchments in the Caribbean are often small, and there is little time between rainfall and flooding events.

There are several collaborative programs for forecasting extreme events with regional support. This includes the Tropical Cyclone Program under which the U.S. National Hurricane Center (as the designated WMO Regional Specialized Meteorological Center) has the mandate to provide up to six-hourly analysis and forecasts for all hurricanes identified in the Tropical North Atlantic/Caribbean Sea/Gulf of Mexico area, with a lead time of up to five days. The WMO Region IV Hurricane Operational Plan is a coordination mechanism between all NMSs in the Caribbean and the U.S. National Hurricane Center for forecast product use and distribution, forecast and warning protocols, and backup arrangements should any center in the region become unable to fulfill its role. It is updated on a yearly basis. The Severe Weather Forecasting Program, under development in the Eastern Caribbean, is facilitated under the regional office of MeteoFrance in Martinique and technically supported by the CIMH regional training center in Barbados.[3] This program aims at strengthening NMHS capacity to deliver improved forecasts and warnings of severe weather while making efficient use of the forecasting cascade from global to regional to national level. Storm surge forecasting systems have been successfully established in Haiti and the Dominican Republic, and there are plans to expand these throughout much of the Caribbean over the next five years; the Flash Flood Guidance System also offers an opportunity for regional rollout and enhanced collaboration.

Earthquakes, volcanoes, and tsunamis pose serious threats to almost all countries in the region, which has a long history of deadly earthquakes and volcanic activity. As they are difficult to predict, issuing early warnings for earthquakes and volcanoes is not straightforward. Scientists rely on networks of seismographs and global navigation satellite system devices to monitor earth movements to determine whether seismic activity is increasing. They also use seismic monitoring equipment to examine the movement of magma and predict when volcanos might erupt. The Caribbean Tsunami Warning Program (CARIBE-EWS), a system of tide gauges, monitors sea levels. UNESCO's Intergovernmental Oceanographic Commission has collaborated with the UK National Oceanographic Center, the CIMH, the University of Hawaii and CARIBE-EWS to install gauges across the region to monitor storm surges, tsunamis, and changes in sea level. The NOAA/National Weather Service Pacific Tsunami Warning Center in Hawaii issues tsunami forecast information for each country (usually NMS), which they then use to generate national tsunami warnings.

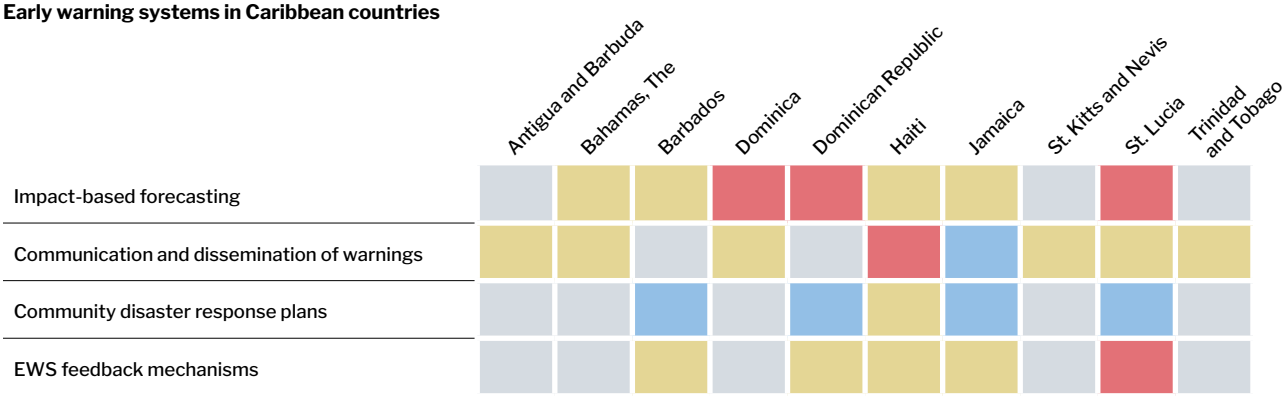
While forecasts and warnings globally have historically focused on "what the weather will be", it is recognized that information about inches of rainfall or expected windspeed is only actionable to a limited extent. Efforts now focus on trying to understand and communicate "what the weather will do". So, rather than simply focus on inches of rainfall or areas that may experience flooding, forecasting also identifies infrastructure, property, and persons exposed, enabling targeted warnings to be issued and detailed action

planning based on likely scenarios. Generally referred to as impact-based forecasting (IBF), this method is gaining traction with NMHSs around the world, and can be applied for all hazards.

In the Caribbean region, the CIMH has been leading the shift to IBF since 2007 through changes to its own operations; it has also been working with the U.S. National Weather Service and USAID Office of US Foreign Disaster Assistance over the last four years, through the Caribbean Weather and Climate Ready Nations program. Most countries in the region have yet to start the transition to IBF or are in very early stages of doing so. This includes Dominica, Dominican Republic, Haiti, and St. Lucia, which all receive a "nascent" score for IBF (*table 11.3*). The first national-level IBF pilot, which began with a partnership between Barbados Meteorological Services and the Department of Emergency Management, has already led to a pioneering partnership with the Ministry of Health and Wellness to co-develop an IBF dengue warning. The pilot is now expanding to other countries through a range of funding modalities, while several countries have also started to adopt elements of IBF—primarily by using simple matrices to convey the likely risks associated with pending weather—into their routine operations. In general, specialized EWSs are nascent, or have been established with some elements of IBF for Sahara dust, sargassum flows, fisheries, and coral reefs.

TABLE 11.3 >>

Early warning systems in Caribbean countries



Source: Based on World Bank (forthcoming) and personal communications with regional and national stakeholders

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; countries in blue (established) meet the standard entirely. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Warning dissemination and communication

Dissemination and communication systems are often among the weakest links of EWSs. The warning messages need to be delivered to everyone in the affected locations as well as to alert local, district, and national governmental agencies. To be successful, dissemination methods and systems should be multiple and robust and messages need to be consistent, reliable, and simple to understand for both authorities and the public. Communication is effective when warnings rapidly reach all persons at risk, and the messages are understood, clear, and actionable. It is therefore important to ensure adequate planning and use multiple communication channels that are tailored to specific types of emergency, especially short notice events. The choice and combination of communication channels must consider speed, coverage area, and relative ability to convey the content needed for effective public response, while also factoring in informal channels—such as family, neighbors, and places of worship—which remain the best motivators for public action.

Communicating warnings in the Caribbean is a national responsibility, often involving a network of actors that vary depending on the nature of the threat. However, few countries have warning communication policies and plans to support national, subnational, and local-level strategies that ensure coordination across warning issuers and dissemination channels. Warning dissemination roles are not always formalized or backed by legislation, policies, or budgets, while uncontrolled warning dissemination on social media from unauthorized sources is a growing concern.

Warning systems in the Caribbean still rely on traditional communication channels such as radio and television, usually reaching the entire population, including seasonal populations such as tourists and those in remote locations, therefore all countries for which data are available receive an "emerging" score (*table 11.3*). Despite the enormous warning dissemination potential of mobile networks, examples of their use for broadcast media alerts are limited to St. Lucia´s SMS Blast[4] and some past trials in Jamaica.[5] There is no evidence of studies or national-level strategies that systematically address last-mile connectivity to understand which population groups can be reached by different types of communications service, including mobile cellular services. Some countries—Barbados, Antigua and Barbuda, Anguilla, and Trinidad and Tobago—are in the initial phase of implementing international standards like the Common Alerting Protocol (CAP), a simple standardized format for exchanging all-hazard emergency alerts and public warnings over all kinds of networks.

The extent to which people respond to a warning message is influenced by many factors, including individual characteristics and perceptions, whether the message comes from a credible source, how the message is delivered, and the message content itself. Warning alerts must be clearly recognizable and consistent over time and include follow-up actions when required, and information on when the threat has ended. But assessing these factors—and the way people, particularly vulnerable groups, respond to information that they are at risk, and the circumstances under which they are most likely to take appropriate protective action—is not consistent across the Caribbean, which is a clear limitation for implementing effective EWSs.

Preparedness and response capabilities

Preparedness and response capabilities focus on using enhanced risk education and engagement to enable institutions and people—particularly those in vulnerable conditions—to act early and respond effectively to a warning. For this, it is essential that people understand the risks, respect and trust the national warning service, and know how to react to warning messages. Actions to achieve this include taking the necessary disaster preparedness measures, such as drawing up response plans, implementing public awareness and education campaigns, and conducting exercises and drills. While a broader overview is provided in the EP&R section, this section focuses on EWS-specific aspects.

The region has a high level of preparedness institutionalization, knowledge, and experience at regional, national, and local levels. Shortcomings include out-of-date legislation and plans, a focus on hurricanes with insufficient attention to other hazards, low community engagement and ownership, insufficient funding, and limited sex- and age-disaggregated data to target vulnerable groups.

At community level, many civil society organizations, churches, and NGOs participate in preparedness activities. In every Caribbean country, the Red Cross is by statute auxiliary to government, sitting on national emergency management councils, and working closely with NDMOs. It also manages the largest, most pervasive, and systematically trained network of volunteers, making it particularly relevant at local and community levels. Several countries use a participatory approach when revising or testing plans, but note that, with more extensive involvement of multiple stakeholders, community representation tends to be moderate to low, and does not always include representation of different vulnerable groups, which is essential for the knowledge feedback loop and inclusion of their needs.

Attention to special needs residents in disasters varies across the region, but responsibility typically lies with family or friends except where there is no such "care giver". It is usually women who are responsible for vulnerable family members, including children and the elderly. This increases their own vulnerability—for example, when it comes to recovering livelihoods (Erman, de Vries Robbé, Thies, Kabir and Maruo 2021). Local community-based organizations, churches, and NGOs sometimes offer special needs services—for people with sight or speech disabilities, the infirm, shut-ins, and so on—but this is not part of the official community response measures.

There are widespread shortcomings in the Caribbean in terms of regular drills and simulation exercises, and ex-post assessment to continually improve the effectiveness of forecast-based action planning and community-level implementation. Public education and awareness approaches to strengthen community and institutional ability to respond to natural disasters at all levels, include campaigns, participatory learning, formal school-based interventions, and informal education programs.

Although most countries have conducted public awareness campaigns covering various hazards in recent years, public gender-sensitive awareness or education campaigns tailored to the specific circumstances of vulnerable groups are limited. Almost half of the CARICOM countries have completed some community-level multihazard communication strategy to support community EWS, including participatory approaches that have been useful for strengthening prevention at this level. But public awareness and education for special needs residents is often addressed by special interest groups such as women's or other gender organizations, youth groups, infirm and differently abled associations, and NGOs. Due to sparse funding, these are usually limited to national-level advocacy and rarely coordinate with state disaster organizations. Few have adequate capacity for disaster issues or meeting practical or resource needs at community level before and during an emergency.

End-to-end communication and feedback mechanisms

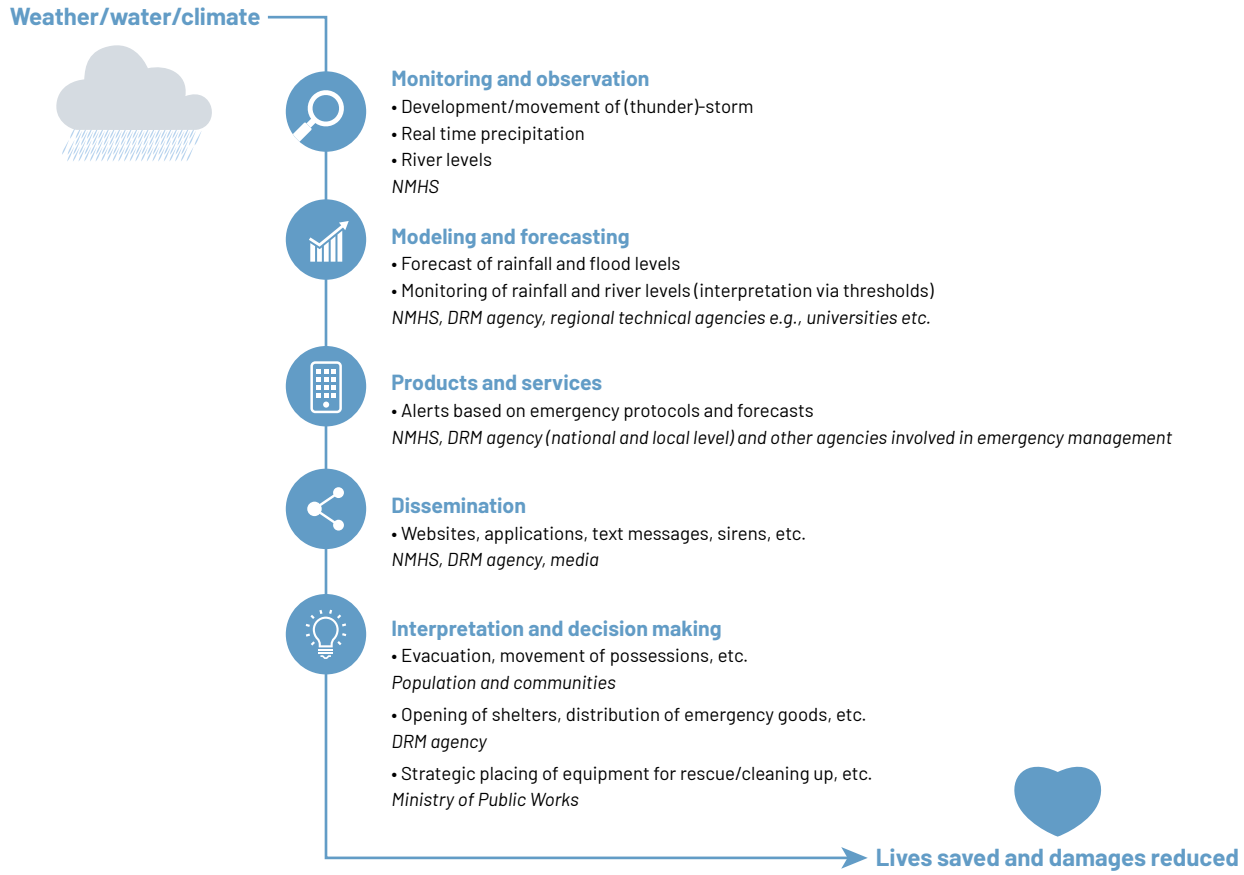
While the four pillars discussed above help explain the different elements of an EWS, they do not cover the coordination, collaboration, and feedback mechanisms required between multiple stakeholders with extremely different backgrounds, mandates, and terminologies. So, while the NM(H)S is in charge of monitoring and forecasting, interpreting the data needs to be a joint activity with NDMOs. It is then up to the NDMOs or another legally mandated body to disseminate the information in collaboration with the media. Once households, firms, or other government organizations receive the information, they need to be able to interpret it correctly and react adequately (***figure 11.3***). Every event is an opportunity to strengthen collaboration and communication between everyone involved in the early warning chain. It is therefore important to evaluate successes and shortcomings after an event, identify lessons learnt, and feed this information back into procedures to strengthen them.

In the Caribbean, communication and coordination between different actors, particularly NMHSs and NDMOs, is at an initial phase. In most cases, standard operating procedures and protocols have yet to be established and systematic feedback mechanisms along the entire EWS chain are not yet in place in any of the countries, resulting in nascent and emerging ratings for "EWS feedback mechanism" (***table 11.3***). And, while procedures exist at regional level, they are not formally described and reviewed after events.

The indicators in ***table 11.3*** evaluate only a few aspects of EWS; ***table 11.4***, on the other hand, provides a high-level description of nascent, emerging, and established EWSs in the Caribbean, with the resulting benefits that can be expected.

FIGURE 11.3 >>

Early warning systems chain



Source: Adapted from Kappes, Charles and Cox 2018

TABLE 11.4 >>

Defining terms: nascent, emerging, and established EWS

Nascent	Emerging	Established
» **The EWS has many weaknesses**—it provides very general information with little lead time for recipients to take preventative action; its message is not clear or specific enough for recipients to take effective action; and/or recipients are not well enough prepared to quickly and effectively react » There is a **limited reduction in affected persons, fatalities, and damages or losses**, and occasionally, there is no reduction at all due to an interruption in the EWS chain » **No or very limited communication or feedback mechanisms are in place** to capture lessons learnt, continuously strengthen the EWS and evaluate performance of the EWS after events	» **The EWS is generally robust**— it provides general information with less than optimal lead time for recipients to take preventative action; its message provides actionable information but is not tailored to different stakeholder groups; and, although recipients are to some extent prepared to react to the general messages, the local interpretation is left to them as no tailored messages or warnings are provided » There is a **reduction in the number of affected persons, fatalities, and damages/losses** » **Evaluations may take place after major events** to make adjustments in future, but there are no established feedback mechanisms for an ongoing evaluation of EWS performance	» **The EWS has well-developed components that are connected to a seamless end-to-end system**—it provides clear and tailored messages based on accurate forecast information with sufficient lead time to specific stakeholder groups that are well trained to react quickly and efficiently » There is a **significant reduction in fatalities, persons affected, and damages/losses** » **Feedback mechanisms are in place** that allow all involved agencies and actors to analyze what worked well and what needs to be adjusted, and make required changes to further strengthen the EWS

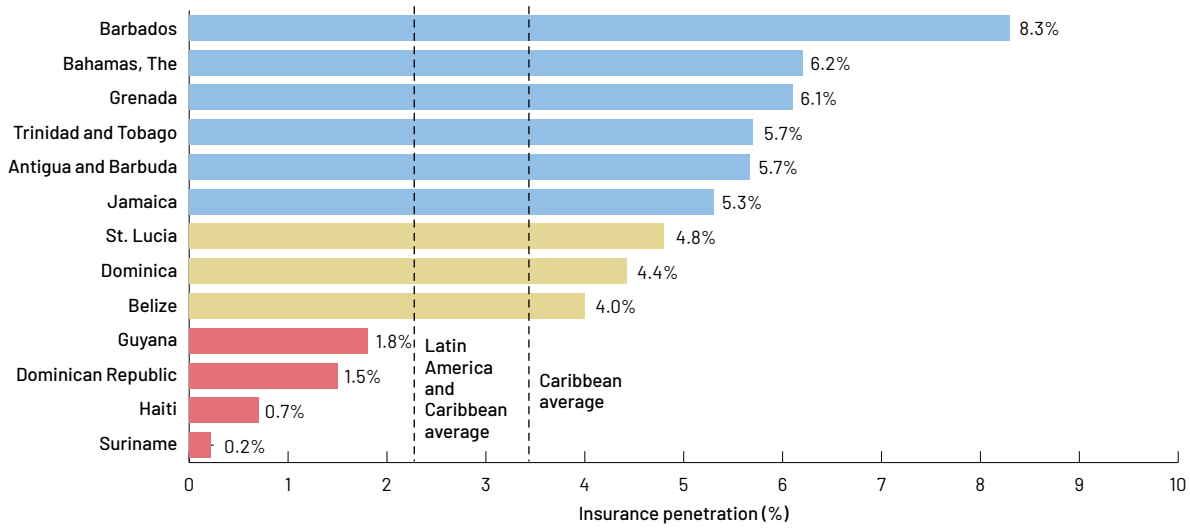
Notes: This classification needs to be applied separately for each type of EWS, such as a hurricane EWS, a severe weather EWS, a coastal flooding EWS, a flash flood EWS, and a tsunami EWS. Even an established EWS can result in no or a very limited reduction of number of persons affected, fatalities, and damages/losses, if confronted with a very rare high-impact event that the EWS was not built for, and that people were not trained for. With climate change, such very rare high impact events are becoming increasingly frequent.

Insurance and other financial instruments

Private sector resilience would benefit from risk-sharing instruments that mitigate economic costs faced by firms and households in the aftermath of a disaster event. However, insurance penetration in the Caribbean, while varying substantially across countries, is generally low, ranging from a high of 8 percent of GDP in Barbados to under 1 percent in Haiti and Suriname (*figure 11.4*).

FIGURE 11.4 >>

Insurance penetration in Caribbean countries



Source: Masetti 2021

Notes: Premiums are presented as percentage of GDP. Countries in blue (established) are those where insurance penetration is ≥5 percent of GDP; countries in yellow (emerging) are those where insurance penetration is <5 and ≥2 percent of GDP; countries in red (nascent) are those where insurance penetration is ≤2 percent of GDP.

Low insurance penetration in the Caribbean is the result of a combination of supply and demand-side impediments. Supply-side constraints stem from an underdeveloped insurance industry that does not fully conform to international best practice, which inhibits its ability to offer adequate coverage to the private sector. The insurance sector relies heavily on reinsurance, particularly for catastrophic protection, but in some Caribbean countries, reinsurance and captive insurance companies tend to underwrite overseas firms rather than protect the local economy. In other countries, international firms meet over 90 percent of domestic insurance demand, and the international reinsurance sector, as risk capital provider, plays a key role in mitigating domestic insolvency risks. Coverage also mostly relates to nonlife instruments, such as motor insurance, while property insurance and other instruments that are better suited to protect against disasters are scarce.

Demand-side constraints to higher insurance uptake are linked to limited awareness and understanding of how insurance works, despite the repeated occurrence of disasters. Basic features such as deductibles and the concept of underinsurance are not well understood, so people are quick to cancel if, for example, they have not claimed in a year. There is therefore a tendency to self-insure, with firms or individuals bearing the risk themselves instead of obtaining third-party insurance, and only taking out insurance when strictly required—for example, with a loan or mortgage. *Box 11.2* shows how the government of St. Lucia promoted the uptake of insurance among low-income households and small-scale farmers after Hurricane Tomas.

BOX 11.2 >>

Homeowner insurance in St. Lucia

Only about 10 percent of the St. Lucian population has homeowners' insurance, so after a natural disaster, most households bear the total cost of reconstruction. When near-poor households are impacted, they are 50—90 percent more likely to experience prolonged impoverishment due to the loss of housing services, emphasizing their need for homeowners' insurance.

Subsidized homeowners' insurance enables the timely reconstruction of homes and reduces the financial burden on households. It also serves as a valuable risk transfer mechanism for small states, providing an immediate response to households in need while reducing postdisaster management expenditures and the loss of human capital in the long term.

Following the devastating impacts of Hurricane Tomas in 2013, the government of St. Lucia promoted insurance options for low-income households and small-scale farmers in the form of a microinsurance program introduced by the Eastern Caribbean Global Insurance Company and developed under the Munich Climate Insurance Initiative's Climate Risk Adaptation and Insurance in the Caribbean Project. Under this initiative, there are two parametric weather index-based risk insurance products, one aimed at individuals and the other at lending institutions. The livelihood protection policy supports vulnerable, low-income households with recovery from heavy rainfall and/or strong winds and provides cash payouts immediately after extreme weather events, enabling people to rebuild quickly. It also offers a product for rural development banks, credit unions, and other lending institutions that protects their loan portfolio and prevents loan defaults after extreme weather events.

Although the microinsurance program did not perform as intended, there are other ways to incentivize households to buy and maintain insurance. For example, a subsidized program could encourage homeowners to maintain their policy incentives through benefits such as reduced insurance premiums after three years, cash rewards, or tax credits. By reducing the burden of housing recovery costs for the economically vulnerable, subsidized homeowners' insurance would prevent households from falling into or staying in poverty. It provides an immediate targeted response for households after a natural disaster, while postdisaster recovery efforts take time to identify and allocate funding to households in need.

While the government of St. Lucia would need to bear part of the cost of homeowners' insurance, it would reduce government disaster response and provide a more effective response to natural disasters. Households would receive a payout equivalent to the damages incurred during the natural disaster with little to no delay, reducing the likelihood of impoverishment for economically vulnerable households and maintaining overall household well-being.

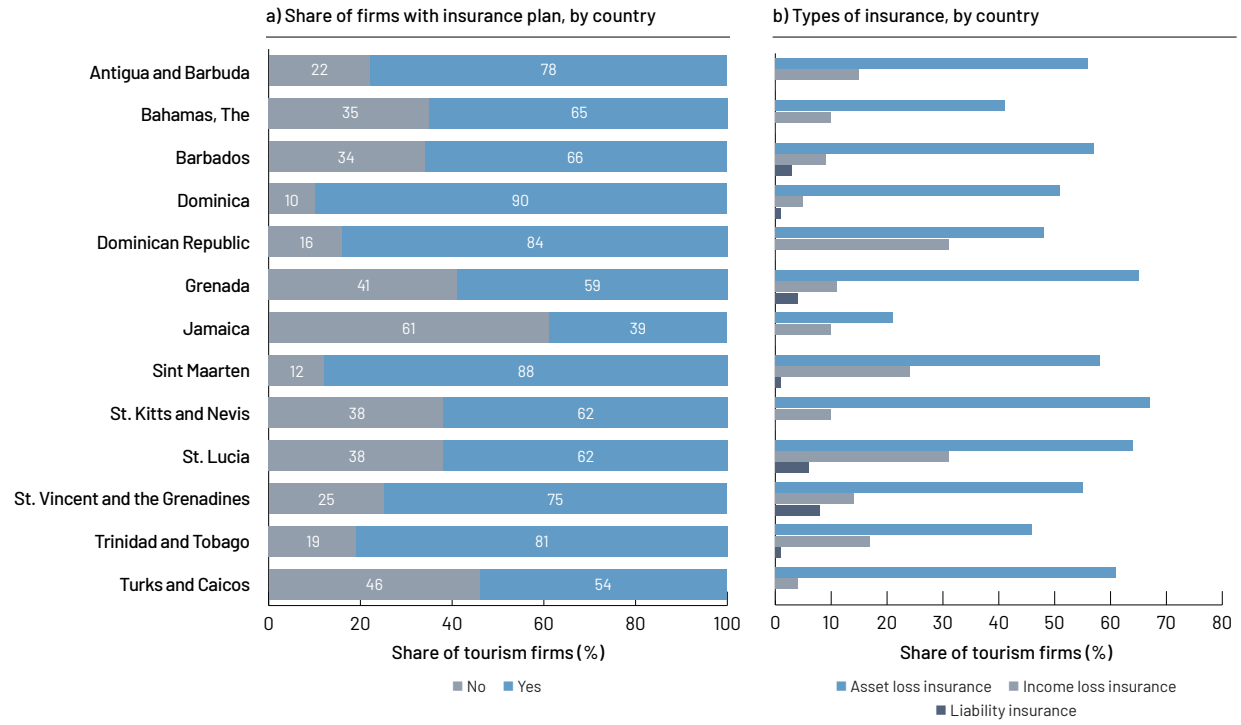
Source: Walsh and Jagdeo, forthcoming

Focus on the tourism industry

While overall private sector insurance coverage is low, Erman, de Vries Robbé, Browne, and Solis Uehara (2021) find that coverage among firms in the tourism industry is relatively high: 63 percent of surveyed firms report having an insurance plan with disaster coverage (*figure 11.5a*). But takeup varies between countries, from 90 percent of firms in St. Lucia and 88 percent in Grenada to 39 percent in Jamaica. Results from the study also show that firms tend to favor asset loss insurance; income loss and liability insurance are less popular (*figure 11.5b*).

FIGURE 11.5 >>

Insurance takeup among Caribbean tourism firms



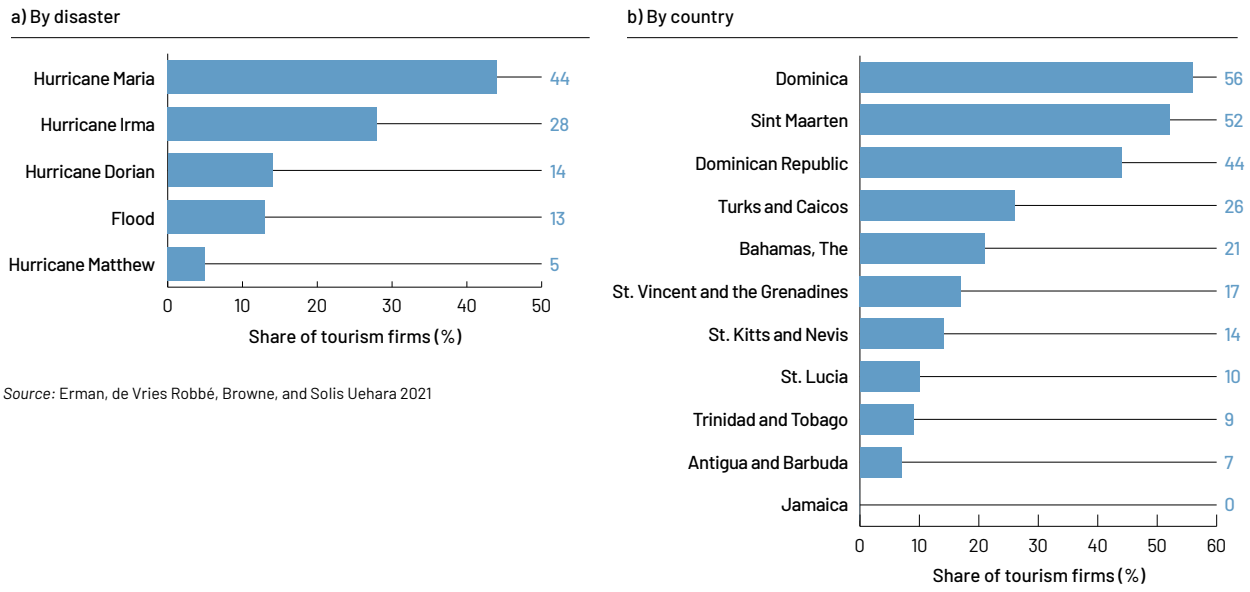
Source: Erman, de Vries Robbé, Browne, and Solis Uehara 2021

Despite this high coverage among tourism firms, only 23 percent of those affected by disasters in recent years indicated that their recovery relied mostly on insurance. If including it as the second most important support for recovery, this increases to 28 percent of firms. Among those that experienced direct damage to property and inventory, 50 percent reported being able to cover 10–100 percent of damages with insurance. Coverage is inherently related to country and intensity of disaster, with the average percentage of covered damages ranging from 30 percent for Hurricane Matthew to 94 percent for Hurricane Dorian. On average, insurance covered 62 percent of total costs.

The likelihood of using insurance as a response increases with the severity of a disaster (*figure 11.6a*). So, although more firms reported direct damages from Hurricane Irma, they were more likely to use insurance as a response to Hurricane Maria. In Dominica and the Dominican Republic, 52 and 44 percent of firms, respectively, received payout from insurance after Hurricane Maria. In Sint Maarten, 52 percent of firms reported using insurance after Hurricane Irma (*figure 11.6b*).

FIGURE 11.6 >>

Caribbean tourism firms relying on insurance to recover from a storm event



Source: Erman, de Vries Robbé, Browne, and Solis Uehara 2021

Shock-responsive social protection systems

Adaptive social protection refers to mechanisms that allow social protection programs, services, and systems to contribute to addressing *covariate shocks*,[6] such as natural disasters and epidemics, through preventive, preparedness, and response actions. That is, it adapts and uses the capacity of the social protection sector to enhance the resilience of households, and of the poor in particular. As discussed in previous World Bank reports (Hallegatte et al. 2015, 2017; Hallegatte, Rentschler and Rozenberg 2020), adaptive social protection can be a powerful instrument in the hand of governments to mitigate the negative impacts of disasters on the poorest population. And while adaptive social protection remains a fairly new policy area, Caribbean governments have been increasingly leveraging social protection systems to support people when they are affected by shocks.

Planning

In times of disaster, social protection systems are used ad hoc, without proper planning. To effectively support people affected by covariate shocks, these systems must be able to adapt and quickly scale up capacity when needed. Adaptive social protection systems build resilience through direct investments that support households' capacity to prepare for, cope with, and adapt to shocks, protecting their well-being and ensuring they do not fall into poverty or become trapped in poverty as a result of the shock (Bowen et al. 2020). However, despite innovative experiences, Caribbean countries continue to use social protection on an ad hoc basis and without proper planning.

Some countries have developed cash transfer programs that also target people affected by natural disasters. However, compared to established flagship cash transfer programs, the scale of these programs —and their capacity to scale up when faced with large-scale shocks—is limited. A notable exception took place in Jamaica, which used its flagship cash transfer program, PATH, to provide one-off grants in response to Hurricane Dean in 2007. More than 90,000 PATH-registered households received roughly $28

and approximately 80,000 pensioners and elderly people received $72, which helped meeting basic needs and prevented negative coping. Nonbeneficiaries screened through a damage assessment process using PATH's payment mechanism also received cash grants (Williams, Lamanna and Jones 2016).

There are examples of in-kind transfers in response to natural disasters, such as the Dominican Republic's *comedores económicos* (economic kitchens), which sell subsidized cooked meals; but these operate on demand without any targeting mechanism. School feeding programs are widely available in the region, but have rarely been used to provide additional meals or take-home rations to children in the aftermath of natural disasters. One exception is Trinidad and Tobago, where the School Nutrition Program provided food and meals to people affected by floods in 2013, beyond the children attending those schools (Beazley and Ciardi 2020).

There has been some progress in labor market policies. Sint Maarten's Emergency Income Support and Training Program has expanded from its initial focus on the hospitality sector after Hurricane Irma in 2017, both in terms of coverage, reaching almost 2,000 beneficiaries by 2020, and training courses. For example, it now includes construction training, which is key for future preparedness. Dominica's National Employment Program was expanded in response to Hurricane Maria in 2017, providing jobs for a substantial proportion of people left unemployed by the hurricane (Beazley 2018).

Adaptive social protection

While adaptive social protection is increasingly visible, the state of readiness is mixed. To assess the performance and readiness of social protection systems, this section follows the World Bank's global framework for adaptive social protection (Bowen et al. 2020) and uses the TLS to show different levels of maturity to assess social protection systems across three key system dimensions:

- **Institutions:** Recognizing the paramount importance of governments leading the adaptive social protection agenda, this dimension includes: policies and legislation governing social protection, DRM, and other related sectors; institutional capacity; and institutional arrangements, which are vital for effective horizontal and vertical coordination across and between government agencies, and with nongovernment and external actors.

- **Delivery:** Including the building blocks related to delivering benefits, services—from program design to delivery systems—and information systems, this dimension relates to the ability to ensure that social protection programs, services, and information systems are adaptive and capable of responding to nuanced needs in different shock contexts.

- **Financing:** Including metrics related to the predictability and sustainability of social protection financing and specific disaster risk financing arrangements, this dimension relates to ensuring that social protection financing needs emerging from these contexts can be met.

The conceptual framework defines three maturity levels for social protection systems, with countries ranging from those with nascent systems that have low institutional capacity, limited program offerings and coverage, rudimentary systems, and ad hoc financing arrangements, to those with more established institutions, instruments, and performance along these metrics (*table 11.5*, World Bank 2020b). In between, countries operate at an emerging level of maturity, having moved away from nascent systems, but not yet achieving the maturity and performance of established systems.

TABLE 11.5 >>

Defining terms: nascent, emerging, and established social protection systems

Nascent	Emerging	Established
» **Institutions**—have low and constrained capacity; institutional arrangements are weak; and administration is inefficient and/or costly » **Delivery**—there is a limited mix of SP programs; the main safety net program has limited coverage; delivery mechanisms are rudimentary; and social protection information systems (SPISs) are largely absent so data management is mostly paper based » **Financing**—is unpredictable and depends on external financing	» **Institutions**—have stronger capacity, though that is centered on a few core functions; institutional arrangements are defined, but outdated and/or ineffective; and administration is inefficient and/or costly » **Delivery**—there is a mix of preventive, promotive and protective programs; the main safety net has modest coverage; benefit delivery is reliable, but inadequate; SPISs are centered on a single program, beneficiary registries or social registries with low coverage, and are not interoperable or lacking bi-directional data sharing » **Financing**—is generally reliable, but coverage is modest	» **Institutions**—have strong capacity for all core functions; there are well-defined institutional arrangements supported by policy and legislation; administration is generally efficient; and institutional leadership is strong for social protection goals » **Delivery**—there is an established mix of preventive, promotive and protective programs; the main safety nets cover most of the poor; delivery of benefits is adequate and happens in multiple ways; social registries cover most of the population; SPISs are interoperable and/or integrated, with bi-directional data sharing; and social protection programs demonstrate good outcomes for poverty reduction and human capital building » **Financing**—is reliable and sustainable, supporting the financial inclusion of households

Source: Adapted from World Bank 2020b

Most Caribbean social protection systems have characteristics associated with nascent and emerging maturity levels. This framework offers a generic guide for Caribbean countries: it does not intend to establish a unique and one-size-fits-all approach to developing adaptive social protection systems. It is also important to note that a country can be nascent on one dimension and established on another—for example, if it has established social protection legislation and good institutional arrangements but program coverage remains low and information systems rudimentary. Any guidance should therefore be adapted and tailored to each country context to help prioritize the dimensions that are operating at nascent levels and require more investment.

For adaptive social protection to help address covariate shocks through preventive, preparedness, and response actions, some foundational processes, mechanisms, and systems must first be in place. These are essential for both routine service delivery and adaptive social protection. It is important to note that countries also vary in the maturity of their foundational social protection systems, which often impacts the extent to which they can adapt. Given these nuances, the traffic light assessment is therefore divided to distinguish between foundational social protection investments (*chapter 7*) and investments related exclusively to adaptive social protection, presented here.

Institutions

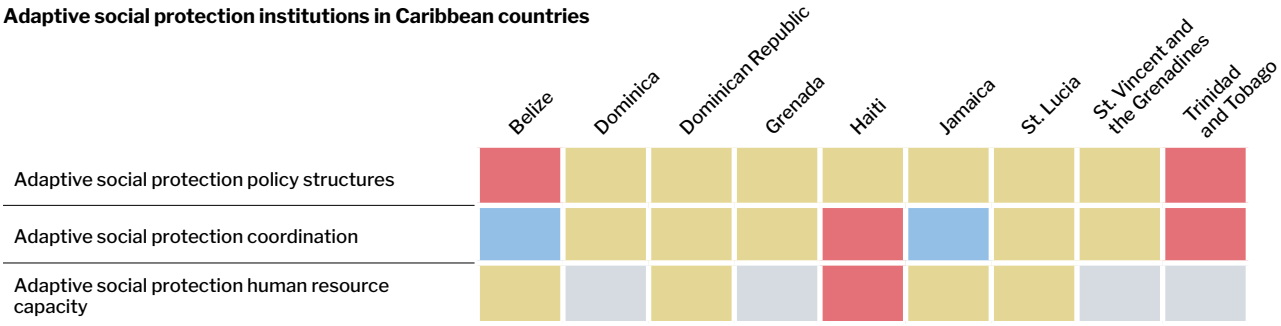
With the notable exception of the Dominican Republic, which has a comprehensive protocol establishing the role of social protection and other sectors in response to climatic shocks, the institutional setup for adaptive social protection is nascent in the region (Beazley and Williams 2021). The main challenge systems face is associated with capacity constraints and limited linkages between social protection and DRM. Although there is clear and strong government leadership in both sectors, interoperability between them is limited in most Caribbean countries. DRM policies typically include few provisions for ministries and agencies responsible for social protection, and those that do, focus mostly on relief. This is a consequence of both outdated DRM policies and adaptive social protection being a fairly new policy area, so interaction between the sectors has been limited. Leading social protection and DRM agencies also have limited capacity to coordinate and articulate actions within their own sectors. For example, Dominica's coordinating DRM agency had only three staff members in 2017 (Beazley 2018); Grenada has

allocated no financial resources to mainstreaming DRM in different ministries and agencies (World Bank 2017); and, despite recently expanding its DRM agency's mandate from emergency response to include resilience activities, the government of St. Lucia has allocated it limited resources (Marzi and Ciardi 2019; World Bank Group 2018). Coordination arrangements between social protection and DRM are generally weak, and contingency human resources and institutional arrangements for adaptive social protection to support DRM actions are lacking.

Cross-sectoral coordination mechanisms promote effective coordination internally across different levels of implementation and externally across sectors, and human resource capacity to support adaptive social protection actions is generally adequate. Most countries earn an "emerging" score for the institutions indicators, although Belize and Trinidad and Tobago lack an established social protection policy or strategy to guide the sector, so score "nascent" for that indicator (*table 11.6*). Belize and Jamaica receive an "established" score, however, for coordination. In Belize, the Ministry of Human Development has a clear role in the national emergency management structure to manage and distribute relief and provide psychosocial services, and the national emergency management system includes clear sectoral coordination arrangements through national committees. Jamaica has a clear institutional framework for emergency management, including a direct role for the Ministry of Labor and Social Security as chair of the Humanitarian Assistance Committee (HAC) under the country's National DRM Council. Coordination arrangements are replicated at parish level and the HAC includes nongovernment actors to ensure coordination within and externally to government in disaster response.

TABLE 11.6 >>

Adaptive social protection institutions in Caribbean countries



Source: Based on data from Beazley and Williams 2021

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; countries in blue (established) meet the standard entirely. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Delivery

Social protection program delivery includes the business processes and systems required to implement it, and typically includes four phases (Lindert et al. 2020):

1. Assessing potential demand for the program through outreach activities and needs assessments
2. Enrolling beneficiaries, determining the eligibility of applications and the benefit package, and onboarding beneficiaries
3. Providing benefits and services
4. Managing and monitoring the program.

While phases 1 and 2 typically take place at the beginning of each implementation cycle, 3 and 4 are continuous. Information systems and delivery mechanisms constitute the backbone of program delivery.

The former, which include processes for collecting, storing, and sharing data, support decision making around needs assessments and eligibility and provide information for monitoring and routine operations. The latter include outreach, intake, registration, enrolment, onboarding, payments, monitoring, and grievance redressal mechanisms.

There are two main types of SPIS: beneficiary registries, which support the management of specific programs and contain information on those enrolled in specific programs, and social registries, used to assess eligibility and containing detailed socioeconomic and demographic data of both beneficiaries and nonbeneficiaries (Barca 2017; Leite et al. 2017). Social registries are promising for adaptive social protection, since they could inform responses to reach nonbeneficiaries through horizontal expansions of social protection programs or new programs relying on these data (Barca and Beazley 2019).

Most Caribbean countries' SPISs are nascent, emerging, or somewhere in between; none of their systems scored "established" (Beazley and Williams 2021). There are several reasons for this, mainly: the lack of interoperability and data sharing between DRM and social protection; postdisaster household assessments that rely on paper-based data collection; and limited information systems for storing and analyzing data. Most countries have electronic registries, although flagship cash transfer programs in Dominica and St. Lucia still rely on paper- or Excel-based registries (Beazley, Ciardi and Bailey, forthcoming; World Bank 2020a). Very few countries have social registries that store socioeconomic and demographic household data (Barca 2017; Leite et al. 2017). And when these registries do exist, they usually serve a single program, as in Dominica, Grenada, Jamaica, and St. Lucia (*table 11.7*). Interoperability and data sharing across programs and registries are also limited, and many registries suffer from data quality issues, particularly with regard to regular updates (Beazley, Ciardi and Bailey, forthcoming; World Bank 2020a). However, Belize, Jamaica, St. Lucia, and St. Vincent and the Grenadines are all planning reforms to move towards more integrated and multiprogram registries, and Belize, Jamaica, and St. Lucia also plan to develop integrated SPISs.

TABLE 11.7 >>

Social and beneficiary registries in Caribbean countries

	Social registry		Beneficiary registry		Integrated SPIS
	Single program	Multiple program	Single program	Multiple program	
Belize		✓		✓	
Dominica	✓		✓		
Dominican Republic		✓		✓	
Grenada	✓		✓		
Haiti		✓	✓		
Jamaica	✓		✓		
St. Lucia	✓		✓		
St. Vincent and the Grenadines				✓	

Source: Beazley and Williams 2021

Notes: For the Dominican Republic, the *Sistema Unico de Beneficiarios* (SIUBEN) collects partial information on the individuals that receive some sort of benefit (but not on the benefits themselves); for Haiti, beneficiary registries are donor-managed program registries.

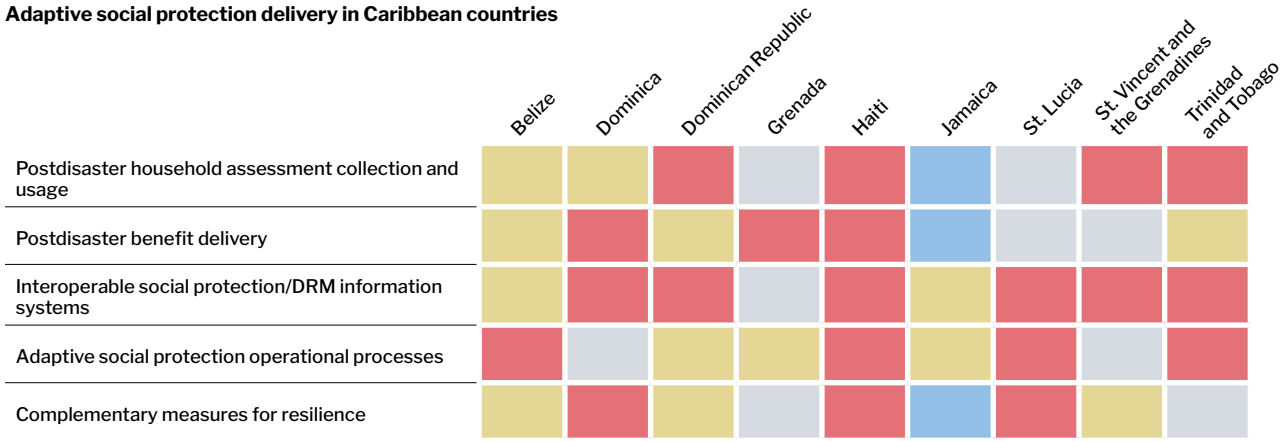
The maturity level of adaptive social protection delivery aspects in the Caribbean is between "nascent" and "emerging" (*table 11.8*, Beazley and Williams 2021). Although there are substantial shortages around the design and documentation of key processes (associated with nascent systems), payment delivery mechanisms are fairly effective (associated with emerging systems). But overall, delivery mechanisms' rigid structures for identifying beneficiaries and lack of protocols for reaching people affected by shocks means they are not ready to flex and respond for adaptive social protection. Many flagship social safety nets and smaller-scale cash transfer and school feeding programs lack adequate operation manuals and documentation on their processes, including eligibility criteria and targeting procedures (World Bank 2020a). For example, Dominica and Guyana's flagship cash transfer programs rely on subjective assessments by social workers and other actors for poverty targeting (UNICEF 2009b, 2009a, 2010, 2011).

Regardless of whether they are rudimentary or more advanced, payment mechanisms do not have contingency protocols or strategies in place to guarantee service delivery during crises. They are typically limited to a single delivery mechanism, and where alternative mechanisms exist, they do not have enough coverage and capacity to scale up rapidly (World Bank 2020a). But regardless of method, payment systems of cash transfer programs have demonstrated to be regular and predictive (Barca et al. 2019).

Countries use a variety of payment methods, including bank or credit union transfers, checks, prepaid cards, and cash. And although there are efforts to switch to electronic payment delivery, countries are not leveraging the opportunities offered by bank and credit union penetration and mobile money to improve the scale of electronic payment delivery (Pulver 2017a, 2017b, 2017c, 2018). For example, despite demonstrating high levels of credit union penetration, Dominica and St. Vincent and the Grenadines still rely on cash payments. Financial inclusion—a critical component of resilience that helps connect poor households to the financial sector, improve financial literacy, and encourage savings and prudent financial management—is not a high priority at policy or sectoral level.

TABLE 11.8 >>

Adaptive social protection delivery in Caribbean countries



Source: Beazley and Williams 2021

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point. No country scored blue (established) for any of these indicators. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

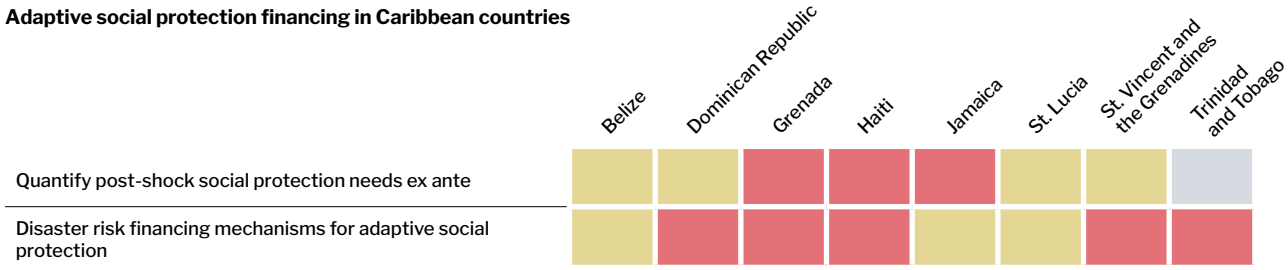
Financing

While financing for regular benefits is generally predictable and social protection spending in the region compares favorably with global trends (*chapter 7*), financing for adaptive social protection has often been reactive (World Bank 2020b). As a result, most countries score "emerging" for their adaptive social protection financing strategies (*table 11.9*). Although they combine different financing instruments, these are not optimized to address the region's risk profile or linked to social protection. Financing for postdisaster social protection needs is often based on ex post instruments, such as budgetary reallocation, loans, and humanitarian aid. And when budgetary adjustments are made, these are often discretionary and not based on established emergency budget procedures (World Bank 2020b). The World Bank's Contingent Emergency Response Component (CERC) (*box 11.3*) gives countries quick access to undisbursed funds from existing investment project financing as loans for emergency response. Dominica used a World Bank loan to finance direct cash transfers to farmers and fishermen affected by Hurricane Maria (World Bank 2020c), and Belize, Dominica, and Haiti have used them for their COVID-19 social protection responses.

The existence of risk financing arrangements does not guarantee their use for adaptive social protection. Most Caribbean countries have no established mechanisms for financing adaptive social protection, particularly for scaling up programs in response to shocks (World Bank 2020c), and all countries score either "nascent" or "emerging" for financing indicators (*table 11.9*). Funding for adaptive social protection so far has mostly been ad hoc, decided and allocated during emergencies (Beazley and Williams 2021), and investments have included an optimized mix of contingency financing options in line with the country's risk profile and estimated financing needs and pre-established adaptive social protection funding mechanisms.

TABLE 11.9 >>

Adaptive social protection financing in Caribbean countries



Source: Beazley and Williams 2021

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point. No country scores blue (established) for any of these indicators. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Social protection systems during the COVID-19 pandemic

Although many programs are still being implemented and evolving, experiences in the region demonstrate that the COVID-19 pandemic has led to the adaptation of existing social protection systems. Many countries have expanded their cash transfer programs, mostly vertically (increasing the benefit value) and sometimes horizontally (expanding the number of beneficiaries). Barbados, Belize, the Cayman Islands, the Dominican Republic, Jamaica, and Trinidad and Tobago have topped up benefit values, while programs in St. Kitts and Nevis, Sint Maarten, and St. Lucia have increased their number of beneficiaries. The Bahamas, Belize, the Dominican Republic, Haiti, Jamaica, St. Lucia, Trinidad and Tobago, and St. Vincent and the Grenadines have also launched new cash transfer programs, offering unemployment assistance and targeting badly hit sectors like tourism, or poor and vulnerable households that are excluded from the safety net.

Countries have also adapted school feeding programs following school closures, with new approaches including providing take-home rations (Belize and the Dominican Republic), food vouchers (Cayman Islands), and cash or food assistance through other programs (Jamaica and Trinidad and Tobago). Almost all countries have delivered food packages to vulnerable households. To lift the financial burden of a reduced income on households, the British Virgin Islands, Guyana, St. Lucia, and St. Kitts and Nevis have relaxed utility payments and other financial obligations, while Jamaica, The Bahamas, Guyana, and St. Vincent and the Grenadines have advanced the delivery of old age pensions. However, other countries require a minimum of three years' continuous employment to qualify for social insurance payouts, disqualifying many workers (particularly in the tourism sector), given the number of firms still recovering from Hurricane Maria in late 2017. The Dominican Republic, Grenada, St. Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, and Trinidad and Tobago have variously created, increased, or adapted social security benefits in response to the crisis. Barbados has relaxed social security application requirements.

Various measures have been implemented to support firms in the formal sector, mostly wage subsidies (Belize, the Dominican Republic, Jamaica, and Sint Maarten), waiving or subsidizing social security contributions, and providing one-off grants. Jamaica provided one-off $700 conditional grants to small firms, while Belize's MSME Support Program offers $1,250 grants, wage subsidies, and soft loans to facilitate continued operations and employee retention during the crisis. Although there are few examples of direct job creation in response to the crisis, Barbados recently approved the COVID-19 Relief Program to address interrupted earnings and livelihoods. The program will provide 12-month employment contracts to unemployed persons to carry out a range of jobs linked to COVID-19 and social responses, and to support development priorities in sectors such as infrastructure and the environment.

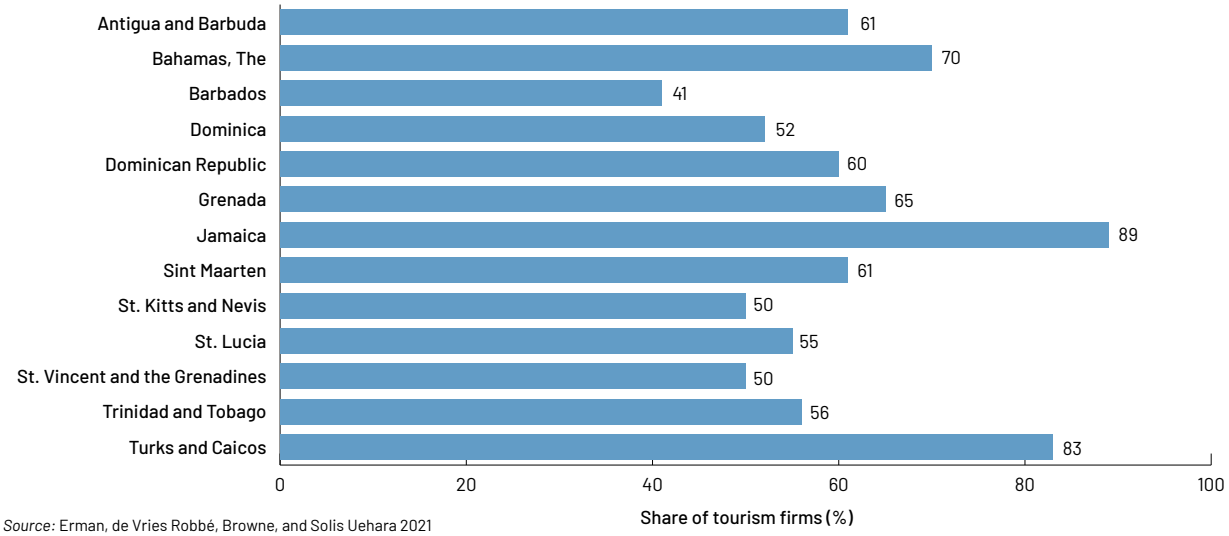
Business continuity plans and financial preparedness

Although individual firms' ability to cope with a shock and continue to produce in the aftermath of a disaster depends on many factors, there is a lot they can do to become more resilient (Rose 2009). Identifying threats, assessing risks, and considering mitigation options allow them to invest in prevention—for example, by adding a generator in case of power outage, investing in movable flood protection, or elevating critical equipment—and prepare for residual risk. A business continuity plan ensures a firm's management and workers know how to maintain or restore production as fast as possible in the event of a disaster. It should contain information on how to proceed if critical supplies cannot be procured, how to maintain activity if people have to work from home, what to do when internet or other forms of ICT are interrupted, and how to manage the needs of workers who are personally affected by the disaster through injury, loss of friends or relatives, or loss of home (Hallegatte, Rentschler and Rozenberg 2020).

A tourism firm survey (Erman, de Vries Robbé, Browne, and Solis Uehara 2021) found that 60 percent of firms in the Caribbean (61 percent of hotels, 65 percent of restaurants and 51 percent of tours/attractions/rentals/taxis) have a business continuity plan. This type of planning is most common in Jamaica (89 percent of firms) and Turks and Caicos (83 percent), and least common in Barbados (41 percent), St. Kitts and Nevis (50 percent), and St. Vincent and the Grenadines (50 percent) (*figure 11.7*).

FIGURE 11.7 >>

Tourism firms with business continuity plans in Caribbean countries



Source: Erman, de Vries Robbé, Browne, and Solis Uehara 2021

Building back better

Disasters represent both a crisis from which to learn and an opportunity to do things better (Wilkinson, Twigg and Few 2018). During reconstruction, it is possible to locate and design assets in a way that keeps risk at an acceptable level and considers the effect of climate change and the uncertainty around both. Countries can also use the reconstruction process to upgrade and increase the productivity of assets—for example, by using the most recent technologies or adapting old infrastructure systems to current and future needs, which can generate further economic benefits, making it more attractive to invest in a better recovery and

reconstruction process (Hallegatte, Rentschler and Walsh 2018). To reduce future risks and the ongoing impacts of recent disasters on well-being, faster and stronger recovery is critical to build back better.

Building back faster

Almost three months after the devastation caused by Hurricane Maria, over 80 percent of the houses on Dominica still had inadequate roofing and 90 percent of the population lacked access to electricity (United Nations 2017). Power and water supplies were disrupted for months, and telecommunications systems in some areas took over a year to restore (Government of the Commonwealth of Dominica 2020). This resulted in continued well-being losses for the general population and revenue reductions for businesses.

Quickly reinstating access to basic services is a critical factor in preventing losses from extending over weeks and months. But as the speed of recovery depends on the ability to plan and implement the reconstruction process efficiently, planning before a crisis saves valuable time (Hallegatte, Rentschler and Rozenberg 2020). According to Powell, Chakalall and Hori (2020), however, 70 percent of CDEMA member states lack national or sectoral predisaster recovery plans or frameworks despite having access to CDEMA's model national recovery framework, which could serve as starting point. One lesson from past natural disasters is that Caribbean governments must strengthen postdisaster decision making, budget execution, and organization. This would ensure prompt postdisaster action, reducing time lost on deciding what needs to be done, as the political economy in many Caribbean countries means that politicians are involved at all levels of decision making, making it difficult to move quickly during the reconstruction phase. Quick solutions are crucial to meet people's basic needs, but it is important to not let temporary solutions become the new normal, as this could increase vulnerability. Well-planned, long-term resilient reconstruction, on the other hand, can bring about a fast recovery.

The fast procurement of goods and services is a critical aspect for swift disaster response and early recovery. As such, expedited procedures are usually applied, though it is important to ensure accountability, transparency, and overall value for money, considering quality, cost, and time of delivery. Disaster-resilient and responsive procurement is based on adequate planning so that when a disaster occurs, agencies have the information they need on adequate suppliers and transparent expenditure procedures.

But emergency procurement planning and procedures are relatively weak in the region. Although many countries have undergone a planning exercise during the development of the CERC operations manuals (***box 11.3***), responsible agencies do not systematically undertake market research or prepare procurement plans, sourcing strategies, or other initiatives to optimize purchases for disaster relief, response, and recovery.

BOX 11.3 >>

Contingent Emergency Response Component

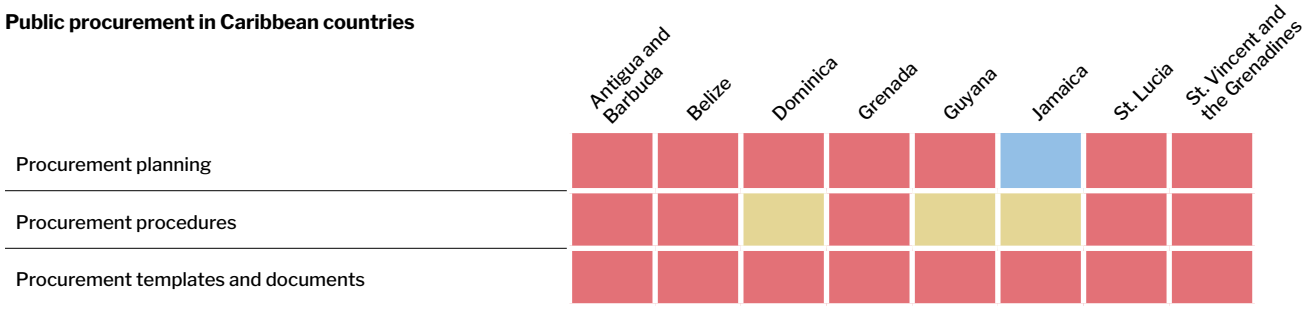
CERCs are contingent financing instruments that form part of many World Bank lending operations in the Caribbean and other disaster-prone countries. They can be activated in case of an emergency by an official request from government, following the official declaration of emergency or equivalent as agreed with the bank. Implementation of the CERC follows a previously prepared and approved operations manual, which outlines the procurement method for each expenditure category (works, good, and consulting services) and contract value threshold. It also usually includes a list of critical items/imports and possible suppliers. Advance procurement can also be undertaken, establishing standby arrangements to allow for tendering and signing of draft contracts, with implementation triggered when an emergency occurs.

Source: OPCS 2009

Procuring entities with disaster relief and response responsibilities all score "nascent" or "emerging" and generally lack standard operating procedures, handbooks, or other manuals to guide procurement in postdisaster situations, making disaster responses ad hoc, expensive, and less transparent (*table 11.10*).

TABLE 11.10 >>

Public procurement in Caribbean countries



Source: Based on data from April and Zrinski 2021

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point. No country scores blue (established) for any of these indicators. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Building back stronger

In the aftermath of a disaster, there are often high levels of urgency to rebuild, which leaves little time and few resources to rethink the design or spatial footprint of cities, infrastructure, and systems. However, if implemented under the same lack of risk-informed land use plans, outdated building codes, and lack of enforcement that led to the creation of risk in the first place (*chapter 9*), reconstruction will miss an opportunity to increase multi-hazard resilience with a forward-looking perspective that takes climate change effects into account.

The foundation for building back stronger is best laid before a disaster, by strengthening the institutional and technical capacities of public and private sectors to ensure there is enough design, construction, and quality assurance capacity in a postdisaster situation. This should extend from individual builders and carpenters to contractors and government building officials (Hallegatte, Rentschler and Walsh 2018). Political commitment at all levels is central to this, via ongoing dialogue and communication (GFDRR 2020). However, this is often limited before disasters, and extreme events can open a window of opportunity to pass previously prepared legislation, enact specific guidelines, or enable the use of supporting hazard, risk, and other information. According to Hallegatte, Rentschler and Walsh (2018), stronger reconstruction would reduce overall well-being losses from natural disasters by more than 40 percent in Antigua and Barbuda, Dominica, and Trinidad and Tobago.

Relocating households or entire settlements is a particularly delicate aspect of recovery. Where high levels of hazard exposure cannot be managed through construction or mitigation practices, reconstruction is impossible. But in many Caribbean countries, risk-informed land use planning—vital for identifying adequate areas for relocation—is not available. As a result, identifying suitable areas may take significant time; and if done without the required multihazard analysis, it could create high levels of risk. Relocating populations is also a sensitive topic. Despite experiencing a shock, leaving a familiar neighborhood behind is not usually the solution of choice and it may have adverse impacts on households' livelihood assets. As such, a participatory process is required to find an adequate alternative.

To guide and speed up the relocation processes after a shock, preparative steps can be carried out, including developing a legal and scientific basis for determining when relocation is necessary and implementing planned relocation while ensuring that the process fully protects, respects, and responds to the rights and needs of affected populations (UNHCR 2014). After Tropical Storm Erika, Dominica had to relocate two communities; and when Hurricane Maria damaged or destroyed over 90 percent of the housing stock in 2017, the lack of a substantive housing policy meant that the government was essentially "starting from scratch" with regard to designing and rebuilding roofing. Having a housing policy in place with designs that have been vetted and tested to ensure they are resilient against multiple hazards is crucial for alleviating some of the damage and loss sustained. Engaging with local stakeholders and enabling people to voice their opinions on designs before disasters would also help improve the policy. Having a preapproved housing policy removes the need for guesswork on the best type of housing once a storm hits. The lack of such a policy slowed down the reconstruction process in Dominica and Sint Maarten after Hurricanes Irma and Maria. Following Hurricane Maria, the Government of the Commonwealth of Dominica committed not only to the relocation of those that could not reconstruct their home in the same place due to high exposure, but also to the resettlement of all individuals living in physically vulnerable locations by 2025 (Government of the Commonwealth of Dominica 2020).

With sea level rise, however, resettlement approaches based on current risks are likely to be inadequate. Making resettlement a strategic option that leaves people, communities, and the environment better off requires much higher coordination between stakeholders (including governments, scientists, communities, and intermediaries like NGOs and financial institutions) and continuous planning. Given the uncertainty around future climate impacts, key issues are how to best incorporate local needs, knowledge, and preferences into planning processes and ensuring choices are flexible and revised over time.

Endnotes

1. Additional details on the framework and diagnostic methodology can be found in GFDRR and GSURR (2017).
2. https://www.gfdrr.org/sites/default/files/publication/R2R_RapidDiagnosticUserGuide_2017.pdf.
3. https://www.gfdrr.org/en/cdema-disaster-preparedness-and-response-capacity-assessment-and-technical-assistance.
4. https://community.wmo.int/swfp-eastern-caribbean.
5. https://www.smsblaster.com/networks/stlucia/.
6. Personal communication from the director the Meteorological Service in Jamaica, Evan Thompson.
7. *Covariate* shocks affect a large number of households or individuals; otherwise, shocks are *idiosyncratic*. This report focuses on covariate shocks.
8. Interviews with World Bank experts who were involved in the immediate response to Hurricane Maria.

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12

CHAPTER 12 >>

Anticipate and manage macrofiscal and financial issues

Managing macrofiscal and financial issues is a key element in building blocks for resilience in the Caribbean.

Natural and economic shocks directly affect economic activity and tax revenues, while strong impacts on major sectors (especially exporting ones) can affect a country's trade balance and capital flows (*chapter 4*). The combination of these factors may result in new risks for macroeconomic stability, public finances, debt sustainability, and the financial sector, which in turn affect countries' ability to respond to natural disasters and external shocks. Governments will need to use the right policy tools to manage these risks, considering the many channels involved.

The challenges to the macroresilience of Caribbean countries, which are mostly SIDS, arise partly from their small size and the interplay of several related factors. As discussed in *chapter 4*, small Caribbean countries lack economies of scale, which often makes them heavily dependent on a few major sectors. This exposes them to sector-specific shocks and global business cycles. Their small size constrains institutional capacity and resources to react to external shocks and contain the economic consequences. Institutional characteristics affect the efficiency and effectiveness of resources mobilized after a shock. With limited returns to scale, the public sector in the Caribbean is often understaffed, while migration to larger economies exacerbates difficulties in finding and keeping high-skilled public employees.

As well as having high exposure to external shocks and insufficient institutional arrangements to absorb the impacts, policy space in the Caribbean is constrained to react to residual macroeconomic impacts. Building ex ante resilience against external shocks into the macroeconomic system and climate-resilient infrastructure does not provide full insurance against external shocks; so ex post responses to residual impacts are equally important. As Caribbean social protection systems for households and the insurance market for enterprises are less developed than in other Latin American countries,[1] households and firms are more exposed to external shocks. As a result, public policies play a bigger role in guiding and facilitating recovery in the private sector and the overall economy. This chapter explores key policy tools that governments can use to enhance resilience to natural disasters and external shocks in the Caribbean. It draws on sectoral background papers prepared for this report—namely Justiniano et al. (2021), Li (2021), and Masetti (2021).

Monetary policy

An independent and effective monetary policy can be an effective tool for macroeconomic resilience. The stability of macroeconomic aggregates (GDP, employment)—one of the most important mandates of monetary policy—is mainly achieved through price stability and impacts on the financial sector, including setting interest rates or managing money supply. However, a fixed or managed exchange rate regime, as preferred by export-oriented economies due to its more stable exchange rate, leaves little room for monetary policy to react to shocks other than exchange rate volatilities.

The independence of monetary policy is challenged in the Caribbean region, constraining the conduct of "leaning against the wind" policies.[2] With global interconnectedness increasing significantly, the main tradeoff for macroeconomic policy is between free capital flows and monetary policy independence (*box 12.1*). Given countries' small size and external balance deficit, capital flows are critical for liquidity and investment in the region, decreasing the independence of their monetary policy. And in small open economies, which are heavily affected by the international environment, the central bank has limited influence on borrowing costs and liquidity conditions. In these cases, "leaning against the wind" monetary changes are less effective and may even exacerbate the imbalances, especially amid excessive global liquidity and large external economic change (BIS 2016).

The effectiveness of monetary policy also crucially depends on financial infrastructure—including financial assets, financial markets, and financial intermediaries—especially in response to external shocks to the real economy. Monetary policy works mainly and initially on the financial market through various tools, including forward guidance and market communication, policy rate adjustment, and open market operations by selling or buying government securities. The way these tools interact with the financial sector and reach the real economy depends on the transmission channels; and a lack of symmetric information and mature market communication skills will make financial intermediaries and private sectors react in a different way from the policy intentions.[3] In the Caribbean, lending standards for small businesses, which are most vulnerable to shocks, are high and require fixed assets as collateral. For example, in the OECS region, some firms have reported collateral requirements of more than 100 percent of the loan value to secure a loan; the range of assets accepted as collateral is also often limited to those that small business owners do not own (Holden and Howell 2009). Other forms of external finance—such as trade credit, equity finance, or venture capital—are not common sources of working capital. This exacerbates the financial accelerator mechanism and diminishes the effectiveness of monetary policy.

BOX 12.1 >>

The other two of the "impossible trinity"

The Mundell-Fleming model suggests that an economy cannot simultaneously maintain exchange rate stability, free capital movement, and an independent monetary policy—that is, the macroeconomic policy trilemma or "impossible trinity". By the 2000s, the orthodox view preferred the framework of flexible inflation targeting, wherein monetary policy focuses on domestic price stability, while interest rates and exchange rates adjust to external shocks.

However, there have been discussions to revisit this conventional thinking of central banks, especially on the benefits of a flexible exchange rate regime,[a] at least in Caribbean countries. One major assumption underpinning the choice of flexible exchange regime is that central banks practice independent monetary policy and keep their "own house in order" through flexible inflation targeting. Under this assumption, they achieve economic stability under external shocks through interest rate adjustments and associated movements in exchange rates. However, this fails to consider the practical scenarios where exchange rate movements are not enough to offset external shocks, or the costs associated with drastic exchange rate changes outweigh the benefits. This is especially true for the Caribbean region, with its deep connections with international markets through large capital flows and a high reliance on international trade.

Rey (2015) argues that the global financial cycle has transformed the exchange rate stability-free capital movement-independent monetary policy trilemma into a dilemma. As global interconnectedness has increased significantly, the tradeoff is now only between independent monetary policy and free capital movement, regardless of exchange rate regimes. This theory recommends that countries should target policies at the main sources of external shocks.

Although free capital movement brings the benefits of advanced technology, higher investment, greater competition, and at times smoothed domestic credit cycles, it also comes with risks of large swings in capital flows. These are particularly amplified in countries with less credible governments, less developed financial markets, and weaker macroprudential frameworks to withstand the financial volatility. When the downside risks materialize, these countries may end up with greater economic volatility and even economic crisis.

As such, this report discusses monetary policy among the trinity, as part of macroeconomic resilience building. In the discussion, there are no "good" or "bad" policies; only "appropriate" policy choices for the exchange rates and capital account controls, given the country context. Specifically, a benefit-cost analysis of a flexible exchange rate regime and free capital flows depends on the level of other variables discussed in this chapter, including governance quality, financial market development, diversification, and so on.

[a] The classification is based on IMF exchange arrangements and exchange restrictions. A flexible exchange rate here refers to floating exchange rate arrangements, meaning that the exchange rate is market-determined. Exchange rate arrangements in the Caribbean range from *floating* (Jamaica), to *conventional peg* (Barbados and The Bahamas), and *hard peg* (currency board for OECS countries)

Fiscal policy, debt, and fiscal space

Countercyclical fiscal policy has gained increasing attention in response to external shocks. Governments' ability to implement effective fiscal stimulus was crucial after the 2008 global financial crisis and again during the COVID-19 pandemic. Although traditionally less timely than monetary policy, fiscal policy can be more targeted than the blunt tool of monetary measures. Aghion, Hémous and Kharroubi (2014) find that *procyclical fiscal policies*—that is, policies that are expansionary in booms and contractionary in recessions—reduce growth, while *countercyclical fiscal policies* boost it. In other words, properly conducted fiscal policy can support growth by smoothing the business cycle. Banerjee and Zampolli (2019) conclude that fiscal policy can dampen credit growth without compromising output. As already discussed, given that most Caribbean countries have a pegged exchange rate and open capital account, they tend to set relatively passive monetary policy to maintain a stable exchange rate and align with the international market.

Fiscal policy, on the other hand, is a more effective tool for addressing economic challenges in times of adverse shock. Resilience calls for fiscal space that is large enough to respond effectively to an economic downturn. Fiscal policy affects the overall economy during downturns, usually through two channels: reducing taxes and increasing spending. Alternative policies include providing targeted relief to sustain businesses and individuals, and more traditional stimulus to generate aggregate demand—for example, through public infrastructure projects. Optimal fiscal responses to external shocks are drawn from extensive research, the results of which depend on various conditions, including: the composition of a government's balance sheet; the fiscal multiplier; the sources of shocks; data availability; and the behavior of the private sector and international markets.

Fiscal space, which broadly measures the government's ability to use fiscal policy, is a complex concept. The IMF defines fiscal space as the room for undertaking discretionary fiscal policy relative to existing plans without endangering market access and debt sustainability (IMF 2018). However, borrowing ability and financing needs are both forward-looking and dynamic, requiring a multidimensional assessment of how much a government needs and wants to borrow (demand side), and how much financing the market can provide, given a government's institutional quality, growth potential, and other future structural challenges (supply side).

High sovereign debt levels limit countries' capacity to act on the complex and costly investments required to manage disaster risks effectively (***chapter 4***). The public debt level is one of the most important indicators for debt sustainability and a government's capacity to repay external debt (Abbas et al. 2011; Jaimovich and Panizza 2010; Panizza 2008), and associated levels of debt service determine fiscal space. Composition of government debt and data on contingent liabilities, revenues, and government investment and consumption are also important factors affecting debt sustainability. Debt as a percent of GDP, which already exceeded the 60 percent "prudent" benchmark in many Caribbean countries, increased further in 2020 due to the COVID-19 pandemic. In 2019, the average debt level was 70.8 percent of GDP; in Barbados, Belize, and Jamaica, it was over 90 percent. Besides limiting fiscal space to cushion risks, high debt levels threaten fiscal sustainability, increase borrowing costs, and discourage private investments.

Lower debt levels would make it less difficult for governments to access debt markets and respond more aggressively to a recession or financial crisis by reducing tax collections or increasing spending. Put another way, prudent fiscal policy can act as insurance against future economic downturns (Romer and Romer 2019). Many Caribbean countries also benefit from bilateral or multilateral concessional financing at times of crisis. High debt levels and concerns over solvency compromise a country's creditworthiness and ability to borrow. Financing availability and costs are also sensitive to sudden changes in international liquidity conditions, which exacerbate the already high debt risks.

Market perception of sovereign risk is another important aspect of market access. Although usually measured by sovereign spreads or sovereign ratings (Kose et al. 2017), a large body of literature has investigated multiple determinants of sovereign ratings. For example, membership of a currency union affects credit default swaps (Ghosh, Ostry and Qureshi 2013), and climate change vulnerability affects sovereign credit ratings (Cevik and Jalles 2020). The direction of causality between fiscal space and market perception also seems ambiguous, with abundant literature finding that fiscal space is one of the determinants of sovereign risks (Aizenman, Hutchinson and Jinjarak 2013). The assessment of fiscal space should also consider fiscal rules (*box 12.2*).

Availability of fiscal space is threatened by the presence of contingent liabilities associated with large public bodies and state-owned enterprises (SOEs). In terms of revenue, expenditure, and employment, the public bodies and SOE sector—which includes statutory entities and authorities as well as government-owned limited liability companies—play an important role in Caribbean economies. However, management of the sector, which encompasses developmental, regulatory, social, and commercial activities,[4] is generally characterized by major weaknesses. With many entities incurring losses and heavily indebted, they could represent a call on the budget, which could sharply increase public debt levels. Financial difficulties in SOEs may also lead to the failure of core public services, such as water and electricity provision (*chapter 9*); and if they default, it could impact the financial sector.

But while most countries recognize the risks from this sector, systematic country data to evaluate SOEs and incorporate SOE contingent liabilities into fiscal or debt risk analysis are limited. For example, in Grenada, SOE contingent liabilities include nonguaranteed SOE debt (EC$501.1 million, or 16.5 percent of GDP at the end of September 2018) and other liabilities, including from the national pension scheme. Although quarterly reporting and recognition of contingent SOE liabilities have improved significantly, SOE debt is not incorporated in public debt calculations, despite this being a requirement under the Fiscal Responsibility Framework.

In Barbados, for example, the 58 SOEs exhibited suboptimal levels of liquidity, high levels of debt, and low-cost recovery. Transfers to SOEs amounted to 8 percent of GDP in 2017, and a 6 percent target has been set for 2021. Government subventions accounted for 20–30 percent of revenue. In January 2019, the government adopted the new Financial Management and Audit Act, and granted the Ministry of Finance greater authority to oversee SOEs. Together with other reforms, this act is expected to reduce the burden of SOEs on the budget through stronger oversight, improved reporting, reduced costs, and enhanced revenue.

While having enough fiscal space would help a fiscal response in a crisis, governments should use a long-term framework to consider their overall fiscal strategy, according to their goal and country context. As an economic stabilizer, fiscal policy is used more proactively during a crisis, as shown after the great depression, global financial crisis, and the COVID-19 pandemic. In normal times, countries scale back the size and function of government, with markets taking on an enhanced role in allocating goods and services. When fiscal programs last beyond the initial intention of crisis responses, it can distort the market and affect long-term growth.

Thus, it is important to consider more components of fiscal policy within any given fiscal space. For example, the responsiveness and scope of a fiscal autostabilizer—that is, tax rates and transfer payments mechanisms—can be enhanced to decrease the use of discretionary policies during a crisis. The timing of fiscal responses also affects the effectiveness and efficient use of fiscal space, so the speed of implementing a program or accessing finance could be different. For example, access to government contingency funds might be faster than disbursement from commercial insurance. Finally, different fiscal programs can have impacts with various timespans. So, when a crisis is expected to be prolonged, governments might favor large infrastructure projects, which can take years. In other circumstances, they often prefer shovel-ready projects for more immediate impacts.

BOX 12.2 >>

Fiscal rules in the Caribbean

Well-designed fiscal rules that impose long-lasting numerical limits on fiscal policy can provide the discipline needed to sustain fiscal space. There are generally four types of fiscal rule, which fit a country's institutional capacity and government size: debt limit, overall budget balance, structural balance, and expenditure growth. The primary objective of fiscal rules is ensuring debt sustainability, though effectiveness depends on a government's commitment and public governance quality. Aaskoven and Wiese (2018) show that both national and supranational fiscal rules have a larger effect on sustained debt reduction if implemented within an appropriate institutional framework. Nerlich and Reuter (2015) also present strong evidence of fiscal rules being associated with higher fiscal space. Empirical studies find that the fiscal rules contribute to higher market confidence and fiscal policy predictability, which also lower output volatility (Fatas and Mihov 2006) and sovereign interest rate spreads (Iara and Wolff 2014), resulting in greater fiscal maneuverability (Nerlich and Reuter 2015).

Despite the benefits, fiscal rules also bring risks. A rules-based fiscal policy reduces fiscal flexibility, even with certain consideration of exceptional shocks. It is especially prominent when prolonged economic depression, deflationary pressures, and new investment opportunities are hard to incorporate in ex ante rule designs (IMF 2016). To make this increasingly complex environment more flexible, fiscal rules have been revised with steady modifications. But the literature has shown some perverse effects. For example, limiting the scope of fiscal support in the recovery from the global financial crisis can lower potential GDP and compromise debt sustainability (European Fiscal Board 2019). Blanchard, Leandro and Zettelmeyer (2021) propose that no fiscal rule can be flexible enough for the EU, which should adopt a standard rather than a rule.

In weighing the benefits and costs of fiscal rules, anchoring fiscal credibility over the medium term and accessing financing are key factors for fiscal space in most Caribbean countries. The domestic financial market is relatively less developed, and the region is less able to tap international capital markets. These challenges are coupled with the frequent occurrence of natural disasters and threats from climate change. The factors either significantly increase financing costs or compromise investment prospects for investors. A consistent and rules-based fiscal policy will help maintain policy credibility and market confidence.

In this context, adopting and strengthening the design and effectiveness of the appropriate rule should be a priority for the Caribbean, where countries have made significant progress in adopting fiscal rules (***figure B12.2.1***). Even after considering the content of the fiscal rules—including enforcement, escape clauses, and oversight—Caribbean countries are still frontrunners in the area. The benefits of following the rules are also prominent (***figure B12.2.2***). After enforcing fiscal rule in 2010, Jamaica reduced its debt from 151 percent of GDP in 2010 to 94 percent by 2019, while Grenada's 2014 Fiscal Responsibility Law reduced its debt by 48 percent to 60 percent of GDP in 2019.

FIGURE B12.2.1 >>

Fiscal rules in the Caribbean and the rest of the world

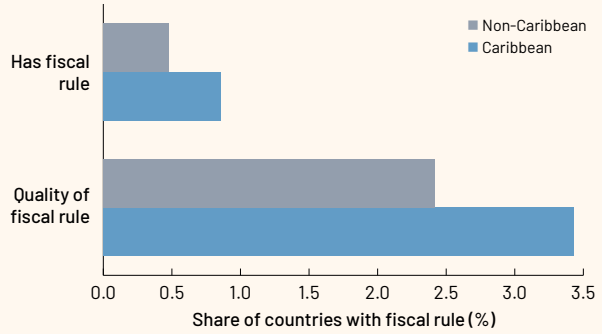
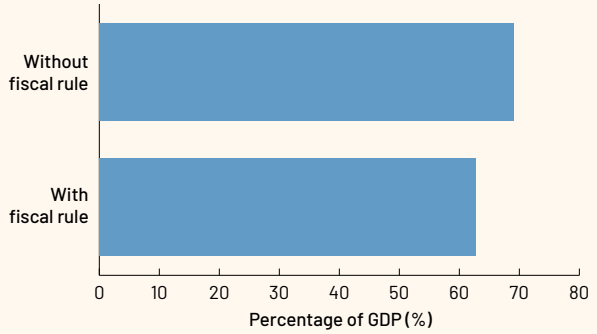


FIGURE B12.2.2 >>

Share of debt in countries with and without fiscal rule



Source: Based on data from IMF Fiscal Rule Dataset[5] and World Bank, World Development Indicators[6]
Note: Non-Caribbean refers to the rest of the world.

To measure countries' resilience in terms of capacity to mobilize monetary policy and countercyclical fiscal policies, this chapter uses the following indicators (*table 12.1*):

- Foreign reserves, measured as the ratio between foreign reserves and months of merchandise imports
- Monetary policy independence, measured using the correlation between the home and base country policy rates (see Aizenman, Chinn and Ito 2008)
- Public debt level, as a ratio to GDP (percent)
- External debt, as a ratio to GDP (percent)
- Fiscal balance, as percent of GDP
- Average effective interest rate, as total interest payment divided by total public debt from previous year
- Fiscal credibility, using the IMF Fiscal Rule Dataset[5] (see also Schaechter et al. 2012)

These indicators reflect a government's financing space for conducting countercyclical measures and capacity to backstop banks after exhausting the private sector's loss-absorbing capacity, in the form of equity or bail-in-able debt (BIS 2016).

TABLE 12.1 >>

Caribbean countries' ability to deal with external shocks through monetary and fiscal policy (2016–18)

	Foreign reserves	Monetary policy independence	Debt level	External debt	Fiscal balance	Average interest rate	Fiscal credibility (score)
Antigua and Barbuda	3.5		90.1	40.4	-12.5		4.0
Bahamas, The	2.8	0.50	55.5	24.8	-33.2	4.3	
Barbados	1.7	0.80	145.4		-13.2	5.2	
Belize	3.1	0.30	96.3	72.6	-17.1	3.4	
Dominica	6.7		75.6	51.0	-7.1		4.0
Dominican Republic	3.2	0.27	48.6	38.6	-22.8		
Grenada	3.6		72.0	50.7	18.1		5.0
Guyana	2.8	0.74	51.7	34.5	-15.5		
Haiti	5.8	0.32	39.3	25.3	-5.3		
Jamaica	5.3	0.60	104.7	102.0	2.0	6.1	5.0
St. Kitts and Nevis	6.5	0.36	60.1		10.2	5.2	4.0
St. Lucia	3.3		60.9	30.0	-8.8	5.3	4.0
St. Vincent and the Grenadines	4.8	0.36	77.6	42.8	-0.3	3.6	4.0
Suriname	2.5	0.12	74.3	98.0	-53.8		
Trinidad and Tobago	10.1	0.28	40.6	63.4	-37.3		

Sources: Based on data from World Bank, World Development Indicators;[6] IMF 2021; Aizenman, Chinn and Ito 2008; IMF Fiscal Rules Dataset 2016;[5] Schaechter et al. 2012

Notes: Here, the TLS is based on the ranking of average values of each indicator between 2016 and 2018, with the exception of "average effective interest rate", which is the average between 2013 and 2015 (latest available) and the fiscal rule score for 2015 (latest available). The higher the ranking, the more resilient the country is for that indicator. Countries in blue (established) are in the highest third of all Caribbean countries for that indicator; those in yellow (emerging) are in the middle third; and those in red (nascent) are in the lowest third. The figures in the table are the respective values of each indicator, rather than rankings. The gray cells show that there are not enough data available to make a rating.

Table 12.1 compares the relative performance of Caribbean countries for the indicators described above, using the averages of the most recent data since 2015. Together, they represent a country's capacity to respond to shocks. The main takeaway is that every country is in the leading group for at least one indicator, meaning that each country is equipped with some level of macroeconomic capacity to respond to shocks.

However, some are less equipped overall than others. For example, Antigua and Barbuda is categorized as "nascent" or "emerging" for all indicators except monetary policy independence, while St. Kitts and Nevis scores "emerging" to "established" for all indicators. The other take away is that no country is leading on all aspects of macroeconomic resilience, suggesting they have been using different strategies to build resilience. For example, Jamaica's economy is well placed in terms of monetary policy independence and fiscal credibility stemming from a fiscal rule, but faces high levels of public and external debt and has a high average effective interest rate, which may constrain its ability to borrow in case of a natural disaster.

Disaster risk financing strategies

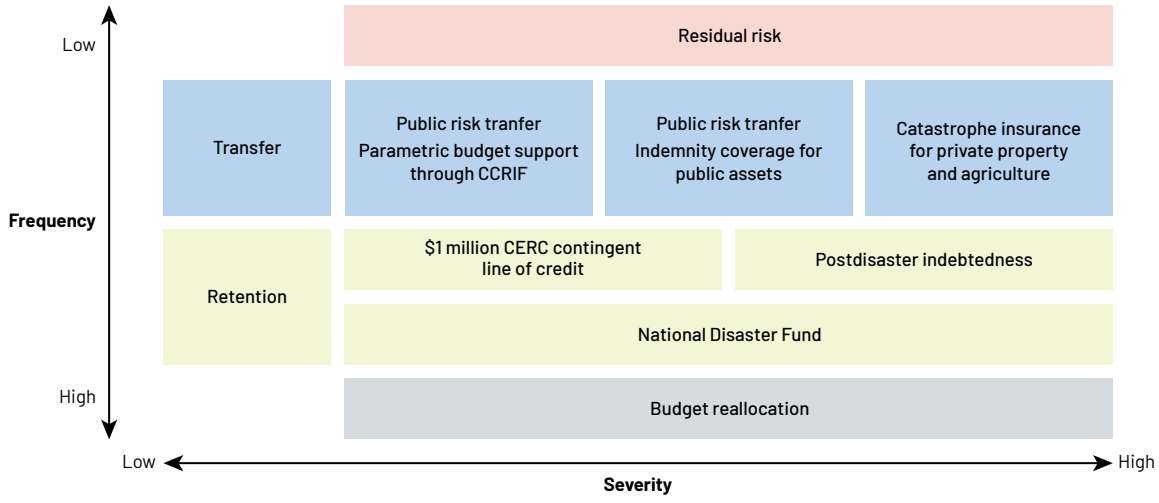
Disaster risk financing is an important financing cushion designed to address natural disaster shocks. When a disaster or other environmental shock hits, the immediate financial needs related to emergency response, humanitarian support, and longer-term recovery and reconstruction can have a strong impact on public finance. In parallel, tax revenues often drop during the crisis and recovery phases. Mobilizing resources in a postdisaster situation therefore requires specific financial solutions, which need to be arranged in advance to be readily available when a disaster hits.

External post-shock aid and budget mobilization have historically been the main source of financing for disaster responses in the Caribbean. However, this typically leads to high debt and unpredictability of government budgets. With an uncertain global outlook, international aid from major donors becomes less reliable. On the other hand, financing arrangements and institutional design are more predictable and can help an economy rebound faster, despite coming at a higher cost.

Figure 12.1 illustrates the World Bank's multilayer risk approach (World Bank 2017). It combines different financial instruments for different layers of risk, depending on the severity and frequency of natural disasters, and provides a cost-effective approach for governments to address expected funding needs in the wake of disasters.[7]

FIGURE 12.1 >>

Multilayer risk approach to financing disaster risk



Source: World Bank 2017
Note: CCRIF = Caribbean Catastrophe Risk Insurance Facility, CERC = Contingent Emergency Response Components.

A comprehensive disaster risk financing strategy helps alleviate the financial burden of disaster response and ultimately ensures the sustainability of public finances. To efficiently manage the public contingent liabilities, the theoretical framework can be synthetized by three interconnected pillars, discussed in this section:

1. Identifying and quantifying public contingent liabilities
2. Improving public financial management
3. Implementing a financial protection strategy

Identifying and quantifying public contingent liabilities

Natural disasters can damage public infrastructure, generate spending for relief and recovery, or require governmental assistance for the most affected. These response costs are either direct or indirect public contingent liabilities. Because impacts from these disaster and climate-related shocks can affect many sectors and essential services, governments need to streamline and mobilize resources for emergency response, recovery, and reconstruction of public infrastructure and services. This fiscal risk, defined by the contingent liabilities, can pose a significant dent in a government's financial sustainability.

A first step in devising a comprehensive disaster risk financing strategy is for the government to better understand what is at risk, which will allow it to quantify the levels of direct (explicit) and indirect (implicit) contingent liability faced by public entities. While explicit contingent liabilities are relatively easy to estimate, implicit liabilities—such as the government's expected humanitarian and financial support to affected populations—are linked to other expectations or forms of commitment, making them more difficult to estimate (Hallegatte, Rentschler and Rozenberg 2020). Appropriate risk information allows public decision makers to estimate or assess the cost of disasters and make informed investment decisions when allocating resources, choosing, and strategically using financial instruments, and liaising with the private sector.

GFDRR has developed country disaster risk profiles (*chapter 1*) that quantify probabilistic hazard economic damages from hurricanes and earthquakes. In many cases, this work is taken further to quantify economic damages from all hydromet events, and the estimated portion of the government's direct contingent liabilities, or other government priorities.

As well as understanding the probabilistic risk of hazards, governments need a clear picture of historical impacts and disaster-related costs. Often, the international community and governments focus damage and loss collection efforts on catastrophic events. But many Caribbean countries face less intense localized hazards with attritional impacts that are nonetheless disruptive to annual budgets. Having a centralized and well-maintained database of hazard impacts and their corresponding economic impacts, as well as a way to track and report on postdisaster expenditures, is key to understanding the true costs of natural hazards.

Improving public financial management

Before a disaster, governments should seek to manage risks appropriately, making prudent investments in risk reduction and preparedness. When a disaster occurs, a government's primary objective is typically minimizing loss and facilitating the speedy recovery of affected areas and populations. This requires immediate disbursement of liquidity where it is most needed, and therefore a responsive and orderly public financial management (PFM) system[8] that addresses the legal and administrative aspects of doing this quickly and transparently (Justiniano et al. 2021; World Bank 2019). Disaster-resilient, responsive public financial management promotes proactive and planned DRR and climate change adaptation and a timely and fiscally prudent response and recovery from natural disasters and other shocks and stresses (April and Zrinski 2021).

This section uses the TLS to assess Caribbean countries' performance across five pillars for integrating disaster resilience and responsiveness into PFM systems, processes, and institutions: legal and institutional foundations; budgeting and planning; budget execution and control; public procurement; and public investment and asset management (World Bank 2019). *Table 12.2* presents the definitions of the three different maturity levels of PFM systems and *table 12.3* summarizes the performance of countries for which data were available using different indicators. Public investment and asset management are discussed in *chapter 9*.

TABLE 12.2 >>

Defining terms: nascent, emerging, and established PFM frameworks

Nascent	Emerging	Established
» Few PFM functions support disaster resilience and responsiveness and those that do are likely to be incidental rather than part of a coherent strategy » This may indicate a low or limited level of awareness of postdisaster response and recovery as a functional imperative of the overall PFM system » Significant improvements are needed to facilitate efficient and effective response to disasters	» Disaster resilience and responsiveness are integrated into some to several key PFM functions but could be enhanced » Many PFM processes are carried out with the intent to facilitate disaster response and recovery, but this approach is not yet systematic: further institutional strengthening and coordination may be required for a fully functional imperative » The PFM system would benefit from further strengthening to facilitate response to disasters	» Disaster resilience and responsiveness are integrated in all key PFM functions, forming a component of the PFM system and organizational culture » Almost all PFM processes are undertaken strategically to expedite disaster response and recovery, and are streamlined, coordinated, and automated where possible » New disaster response and recovery measures are easily integrated into existing PFM processes

TABLE 12.3 >>

PFM in Caribbean countries

Pillar	Indicator name	Antigua and Barbuda	Belize	Dominica	Grenada	Guyana	Jamaica	St. Lucia	St. Vincent and the Grenadines
Legal and institutional foundations	PFM rules and regulations								
	Institutional arrangements for PFM								
Budgeting and planning	Resource planning								
	Budget appropriation								
	Gender-sensitive resource allocation								
Budget execution and control	Expenditure controls								
	Expenditure tracking								
	Auditing practices								
Public procurement	Procurement planning								
	Procurement procedures								
	Procurement templates and documents								

Source: Based on data from April and Zrinski 2021

Notes: Countries in red (nascent) do not meet the standard and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; countries in blue (established) meet the standard entirely. The gray cells show that there are not enough data available to make a rating. The standards for each indicator can be found in Appendix B.

Legal and institutional foundations

Effective DRM—before, during, and after a disaster—depends on clear public financial management rules and institutional arrangements. The legal and regulatory framework should clearly specify: what authorities are granted to the central finance agency following the declaration of an emergency; what instruments are available for interim budget processes during disaster response; when these budgetary steps should be activated; and who is responsible for them. Legislation should also define the conditions in which postdisaster rules apply and for how long. Institutional arrangements include rules and processes for planning, mobilizing, appropriating, and executing financial resources to support disaster risk reduction, response, and recovery (April and Zrinski 2021).

Caribbean countries' legal and regulatory frameworks do not clearly specify what authorities are granted to the central finance agency in times of disaster. While Belize, Grenada, Guyana, Jamaica, and St. Lucia have specified some provisions in their legal and regulatory frameworks, other countries have a limited or unclear definition of interim budget processes during disaster response. Similarly, only moderate institutional frameworks are in place for executing the financing of disaster response and recovery operations. Most countries have only recently started integrating disaster preparedness and business continuity planning into key PFM processes and training staff to prepare for and respond to postdisaster financing needs. The COVID-19 pandemic and related collapse of the tourism sector and sharp drop in revenues that make it difficult for governments to meet agreed financing obligations have spurred the need to strengthen institutional PFM arrangements to improve disaster preparation and response (April and Zrinski 2021).

Budgeting and planning

Effective planning and budgeting processes support the timely, efficient, and responsible use of funds for ex ante DRM activities and ex post response and recovery activities. They allow countries to proactively address their risks while ensuring funding mechanisms are available to address the impacts of disaster events. Planning and budgeting for disaster risks can reduce exposure to disasters, improve resilience, and rationalize the allocation of funds. Transparency and fairness are critical to maintaining citizens' trust (April and Zrinski 2021).

Planning and budgeting for reduced disaster risks is the strongest area of public financial management in the Caribbean. However, countries' performance varies considerably. Jamaica has the most advanced financial planning system for disaster response and recovery, preparing and making provisions for likely expenditures. Dominica, Grenada, Jamaica, and St. Vincent and the Grenadines ensure adequate budget flexibility for disaster response and recovery, with clear procedures that allow central finance agencies to supplement and/or reallocate appropriations across and within budgetary units in response to a disaster (April and Zrinski 2021).

While budgeting and planning for reduced disaster risk is relatively strong, few countries integrate social inclusiveness in the allocation of resources for disaster risk reduction, response, and recovery. No Caribbean government has a comprehensive system or set of processes in place to identify the separate needs of men, women, young, elderly, and other vulnerable populations and allocate resources to address their needs in response to disasters. Jamaica has some strategies in place for children, but not for other vulnerable groups. This undermines a government's accountability to its citizens and jeopardizes the opportunity to respond to disaster in a way that meets its citizens' needs—for example, by providing disabled access to shelters or ensuring separate toilets for men and women in shelters (April and Zrinski 2021).

Budget execution and control

To hold stakeholders accountable for the way they use public resources and exercise authority in disaster response, governments must segregate duties and other controls when authorizing expenditures, transaction processing, custody, and recording functions. It should also be possible to track and verify all financial postdisaster relief and recovery transactions ex post, and to internally and independently review and scrutinize all disaster-related expenditures, frequently enough to ensure compliance with legislation and regulations (April and Zrinski 2021).

Country performance varies considerably. Grenada, Jamaica, and St. Vincent and the Grenadines have clear segregation of duties and controls in place. Postdisaster-related expenditures are not systematically tracked across the region, although Jamaica has a system to track COVID-19-related expenditure (April and Zrinski 2021).

The region underperforms globally in external oversight and scrutiny of public finances, with audits generally not adhering to international auditing standards and often delayed. Auditing of disaster-related expenditure is not common, although the Jamaican Audit or General's Department has conducted audits of COVID-19-related expenditure. The legislature in all countries except Jamaica has limited scrutiny of implementing budget policies targeted at disaster management, as presented in audit reports, further undermining government accountability to the electorate for budget allocation decisions. The region would benefit from further investing in the resilience of information systems and records to ensure that PFM information systems and digital records, including registries and financial transactions, can withstand the impacts of a catastrophic event, focusing on critical aspects of business continuity planning for central finance and line agencies (April and Zrinski 2021).

Public procurement

Timely disaster response often requires the procurement of goods and services through expedited procedures. Accountability, transparency, and overall value for money considering quality, cost, and time of delivery, are all vital. Disaster-resilient and responsive procurement is based on adequate planning, so that when disasters hit, agencies have information on adequate suppliers and can use transparent expenditure procedures that are in place before disasters (April and Zrinski 2021).

Procurement planning for emergencies and emergency procurement procedures are relatively weak in the region. Agencies responsible for procurement do not systematically undertake market research or prepare procurement plans, sourcing strategies, or other initiatives to optimize purchases for disaster relief, response, and recovery. Additionally, except for Jamaica, procuring entities with disaster relief and response responsibilities do not have standard operating procedures, handbooks, or other manuals that instruct how to conduct procurement in postdisaster situations; as a result, procurement responses to disasters are ad hoc, high-value, and less transparent (April and Zrinski 2021).

Public investment and management

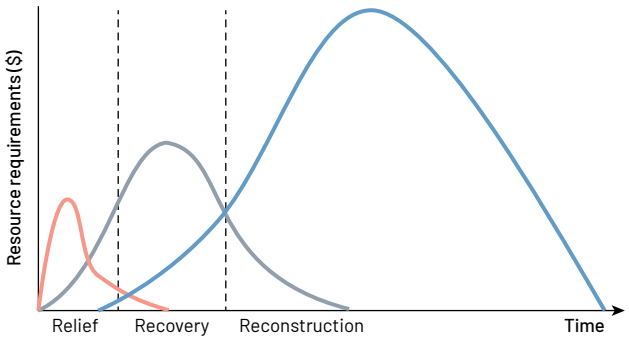
As discussed in *chapter 9*, governments need to manage their assets through public asset management systems. But in the Caribbean, integration of disaster resilience in public asset and public investment management systems is not mainstreamed. Despite their high vulnerability to natural hazards, no country has a systematic approach to disaster and climate risk-informed investment project identification, appraisal, and selection. Public assets are not systematically tracked and are financially underprotected, making it difficult to quickly carry out accurate postdisaster needs assessments or to replace destroyed assets (April and Zrinski 2021).

Implementing a cost-effective financial protection strategy

A financial protection strategy aims to meet government expenses in the wake of a disaster, triggered by public contingent liabilities. Two dimensions—resources and time—come into play when elaborating a financial protection strategy. In the aftermath of a disaster, financial resources are required in a timely manner for three main phases: relief (0–3 months), recovery (3–6 months), and reconstruction (6 months to several years) (*figure 12.2*).[9]

FIGURE 12.2 >>

Illustrative liquidity needs in the aftermath of a disaster



Source: Justiniano et al. 2021

Composing a financial protection strategy involves adopting different disaster risk financing instruments and cost-effectively combining them according to country risk profile. *Table 12.4* presents different key elements of a disaster risk financing strategy and uses a traffic light approach to show the extent to which the countries for which data were available have adopted them as part of their overall financial protection strategy. The three maturity levels are defined in *table 12.5.*

TABLE 12.4 >>

Disaster risk financing strategy components in Caribbean countries

Indicator name	Antigua and Barbuda	Bahamas, The	Barbados	Belize	Dominica	Dominican Republic	Grenada	Guyana	Haiti	Jamaica	Sint Maarten	St. Lucia	St. Vincent and the Grenadines
National disaster risk financing strategy													
Disaster risk financing assessment													
Alternative risk transfer instruments													
Ex post financial assistance													
State contingent debt instruments													
Traditional insurance													
Parametric insurance													
Contingent credit													
Budget													
Reserve fund													

Source: Based on data from Justiniano et al. 2021

Notes: Countries in red (nascent) do not meet the standard (table 12.5) and include areas that are only starting to or do not address the standard at all; countries in yellow (emerging) partly meet the standard and have progressed beyond the initiation point but have not reached the final point; countries in blue (established) meet the standard entirely. The gray cells show that not enough data are available to make a rating.

TABLE 12.5 >>

Defining terms: nascent, emerging, and established disaster risk financing strategies

Nascent	Emerging	Established
» **Reserve fund** has no recurrent capitalization	» **Reserve fund** has recurrent capitalization	» **Reserve fund** has adequate recurrent capitalization and disbursement rules
» There are no or vague guidelines on **emergency budget reallocation**	» Guidelines on **emergency budget reallocation** are clear but minimally used	» There is consistent loss-informed and minimal strategic use of **budget reallocation**
» **Contingent credit** arrangements are depleted or nonexistent	» **Contingent credit** is in place, but levels are low	» **Contingent credit** is in place and levels are sufficient
» **Parametric insurance** is in place, but coverage is low and includes few perils	» There is significant **parametric insurance** coverage for several perils	» **Parametric insurance** coverage is significant and optimized with respect to retention capacities, covering, and several perils are covered
» **Traditional insurance** has low market penetration, and few products are available	» **Traditional insurance** has average market penetration and some products are available	» **Traditional insurance** has significant market penetration and multiple products are available
» There are no **contingent debt instruments**	» **Contingent debt instruments** are in place, but parameters are not strategically applied	» **Contingent debt instruments** are in place and part of the national disaster risk financing strategy
» There are few arrangements for **ex post financial assistance**	» There are several arrangements for **ex post financial assistance**	» There are several regional arrangements for **ex post financial assistance** and there is active contribution to regional arrangements
» **Alternative financial products** are underdeveloped	» **Alternative financial products** are operational but have limited geographical extent	» **Alternative financial products** are operational and have a large geographical extent

Note: Alternative financial products is a broad category that could capture another type of alternative risk transfer instrument like a bond, or sector-specific instruments that complement adaptive social protection or agriculture, for example.

Macroprudential policies and financial development

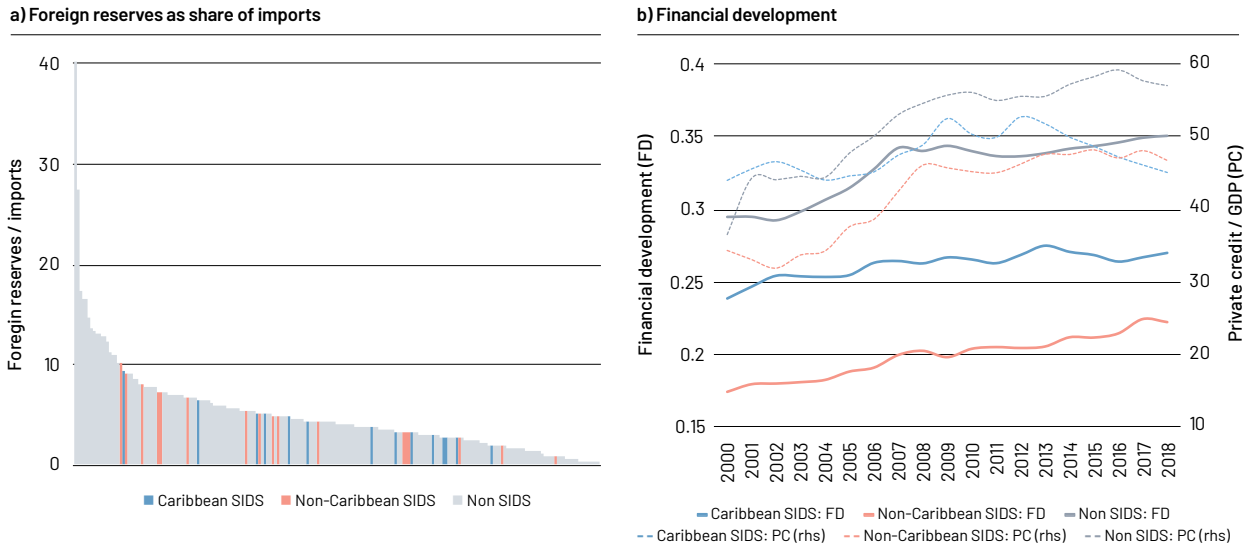
Macroprudential policy is considered one of the main macro-level tools for mitigating financial volatility. Well-designed policy can prevent excessive risk-taking in the private sector, leaving a cushion for external shocks, especially those that directly and indirectly affect financial sectors. Such a policy generally includes capital or liquidity requirements or credit growth limits for financial institutions. The positive impact of macroprudential policies on lowering volatility is evident, while that with economic growth is debatable and conditional on various economic characteristics. Benefits come from macroprudential policies limiting the occurrence of crisis and mitigating the negative impacts from large volatilities especially from financial markets. However, if poorly designed, macroprudential policies may compromise the market's ability to freely allocate financial resources, reducing efficiency and eventually hampering economic growth.

From a macroeconomic perspective, it is important to consider the financing cushions a country accumulates to prepare for external shocks, often proxied by international reserves. International reserves capture the degree of liquidity constraints at country level. Having enough reserves to face external shocks implies that liquid resources are immediately available to make payments immediately after the shock. This is especially important for developing countries with less financial market access. Even under a flexible exchange rate regime, even drastic changes in the exchange rate itself are unlikely to resolve external shocks on their own. Accumulated international reserves serve as proof of the ability to remain liquid and maintain international creditworthiness. But most Caribbean countries have lower levels of foreign reserves than other countries, including non-Caribbean SIDS (*figure 12.3a*).

The effectiveness of macroeconomic financing cushions is affected by factors such as institutional quality, financial market development, and financing cushions under such policies. Institutional quality is mostly related to public governance (*chapter 8*), while a highly developed financial market mitigates the impacts from external shocks by diversifying risks and improving access to finance after a shock. The IMF's Financial Development Index[10] measures the depth, access, and efficiency of financial institutions and financial markets. Data from this index shows that, despite ranking higher than other SIDS, financial development in the Caribbean lags global averages and has not improved in recent years (*figure 12.3b*). As a double-edged sword, financial markets could also fuel risks through financial leverages and arbitrages.

FIGURE 12.3 >>

Foreign reserves and financial development in the Caribbean



Source: Based on data from IMF Financial Development Indicators[10] and World Bank, World Development Indicators[6]

Note: Panel b: The dotted lines show private credit as a percentage of total domestic credit, another empirical proxy for financial development.

The financial sector's resilience depends on its shock-absorbing capacity, which increases when the sector is well capitalized and liquid. It is thus important to consider the health and soundness of the financial sector as a precondition for resilience. *Table 12.6* displays key financial soundness indicators for Caribbean countries. Importantly, these data are from 2019, so do not account for the impact of the COVID-19 pandemic on the financial sector. The results paint a mixed picture of the health of the region's financial sector on the eve of the pandemic. While most were well capitalized and had regulatory capital to risk-weighted asset ratios of more than 15 percent, asset quality was often already weak. The nonperforming loan (NPL) ratio exceeded 8 percent for five of the 13 countries for which data are available, standing as high as 24 percent of total loans in Anguilla and St. Kitts and Nevis. This high NPL level is not new in the Caribbean; NPLs often originate from past crises and are unresolved or written off due to shortcomings in the regulatory and oversight framework or deficiencies in the region's insolvency frameworks. In many countries, the risks from high NPL levels are amplified by low provisions. With banks in Anguilla and St. Kitts and Nevis building provisions for less than 20 percent of NPL stock, realizing losses on those loans would directly affect their income and capital.

TABLE 12.6 >>

Financial soundness of Caribbean countries (pre-COVID-19 pandemic)

	Solvency			Liquidity	
	Regulatory capital to risk-weighted assets (%)	NPL to total loans (%)	Provisions to NPLs (%)	Liquid asset to total assets (%)	Liquid assets to short-term liabilities (%)
Anguilla	8.6	25.8	18.2	48.3	57.3
Antigua and Barbuda	39.4	5.3	55.3	46.4	52.0
Barbados	14.6	6.9	58.0	19.3	
Belize	22.8	5.1	71.9		
Dominica		12.2	84.7	46.2	53.2
Grenada	11.9	2.2	85.0	43.5	47.7
Guyana	30.7	11.6	35.3	35.3	
Jamaica	14.8	3.1		22.4	
Montserrat		5.5	114.5	71.3	82.7
St. Kitts and Nevis	20.2	24.0	23.2	55.7	62.2
St. Lucia	25.6	8.2	62.2	40.4	43.2
St. Vincent and the Grenadines	22.2	6.4	64.7	41.4	45.5
Trinidad and Tobago	21.2	2.9	61.5	21.8	27.1
Thresholds (%)	*13–15*	*7–4*	*50–80*	*18–25*	*25–50*

Sources: Based on data from central banks; IMF International Financial Statistics;[11] IMF Financial Soundness Indicators[12]

Notes: Data as of end 2019. Scores in blue (established) represent low risk; those in yellow (emerging), medium risk; and those in red (nascent), high risk. Thresholds provide the range for which the indicator is classified as medium risk (emerging). The gray cells show that not enough data are available to make a rating.

Although the liquidity of Caribbean banks was encouraging in 2019, the economic impact of the pandemic is extremely likely to have put severe pressure on the region's financial sector. Central banks have adopted a set of countermeasures—including credit moratoria and relaxing loan classification and provisioning rules—but it will be some time before this has a visible impact on their balance sheets. It is broadly expected, however, that financial soundness indicators will deteriorate. This means that the sector's shock-absorbing capacity will decrease further and its ability to withstand climate-related shocks is lower than it was before the pandemic.

Elevated exposure to climate-related shocks and the financial sectors' depleted shock-absorbing capacity mean that Caribbean governments must pay attention to financial safety nets and crisis management frameworks. While proper safety nets can reduce the probability of a financial crisis by increasing trust in the system and thus reducing, for example, the likelihood of savers rushing to withdraw their money from banks in response to a shock, they also play an important role in minimizing the economic costs of a financial crisis.

The deposit insurance system, which aims to protect small and unsophisticated savers in the event of a banking crisis by guaranteeing a certain share of their savings, is an important part of the financial sector safety net. Deposit insurance systems are usually funded through regular contributions from member financial institutions—usually all the banks in a market—to a fund that compensates and repays depositors. This shifts the financial burden of protecting depositors away from governments to the banks. In the absence of such system, governments usually have to assume the cost and bail out the banks.

Despite these benefits, deposit insurance systems are not universally in place in the Caribbean. The first was established in the regional financial center, Trinidad and Tobago in 1986, followed by Jamaica and the Bahamas in the late 1990s. Barbados followed in the first decade of the new millennium, and Guyana and Belize recently established deposit insurance systems. An ECCU deposit insurance system is under consideration to become operational in 2021, but other Caribbean countries lack a formalized deposit insurance.

Deposit insurance systems often receive only a moderate amount of seed capital, so the volume of funds grows over time through the accumulation of, and investment income from, annual contributions from banks (premia). So it is not surprising that, while deposit insurance funds in Trinidad and Tobago and Jamaica are well capitalized at $500 million and $160 million, respectively, the funds of the newly established deposit insurance systems in Belize and Guyana are small and might not yet be able to repay all borrowers in case of a banking crisis without the need of emergency financing (*table 12.7*).

TABLE 12.7 >>

Deposit insurance systems in Caribbean countries

	Establishment and legal foundations	Fund size ($)	Annual premiums	Member institutions	Coverage ($)
Trinidad and Tobago	1986 CB Act	500 million	0.2%	24	17,900
Jamaica	Deposit Insurance Act of 1998	166.3 million	0.15%	11	4,275
Bahamas, The	Protection of Depositors Act 1999 and the Protection of Depositors Bye Laws 1999	58 million	0.0005%	11	50,000
Barbados	Deposit Insurance Act 2006 (fund established on June 8, 2007)	53 million	0.05%	11	12,500
Guyana	Section 5 of the Deposit Insurance Act 2018	3.6 million. Aims for a target size of 5% of the total industry's value of insured deposits within 10 years of its establishment	Initial contribution 0.5%	8	9,585
Belize	Passed by Parliament in December 2019 and signed into law in January 2020	A minimum fund coverage ratio of 4% within 10 years; with minimum target size set by the Board thereafter	0.10%	Fund members (domestic banks and credit unions)	9,980
ECCU	Draft legislation currently developed; planned to start in 2021				

Source: Based on data from the Central Bank of Trinidad and Tobago
Note: All premium rates are annual except Guyana.

It is also important to have efficient resolution regimes that ensure failed financial institutions are resolved in a least-cost way, imposing losses on creditors rather than the general public while also preserving financial stability (*box 12.3*). Given the interconnectedness of financial sectors and banks operating across multiple jurisdictions in the Caribbean, regional coordination and information sharing among supervisors and resolution entities are paramount. To facilitate this coordination, supervisors in the region are working within the Caribbean Group of Banking Supervisors on developing a regional financial crisis management plan. They also cooperate in the insurance sector through regional and bilateral MOUs on coordination and data exchange under the aegis of the Caribbean Association of Insurance Supervisors.

BOX 12.3 >>

Resilience of payment systems

Continuity of payment systems is a key component of overall financial sector resilience in the aftermath of a disaster, allowing firms, individuals, governments, and other economic agents to transfer money daily without having to use cash (Morales Resendiz 2018). Operational disruptions from natural disasters that threaten payment and settlement system include:

- Electricity, mobile network, and internet network disruptions from natural disasters directly impacting the operation of payment systems and banks and nonbank payment service providers' connections to these systems; if one or more of the systemically important participants in a payment system is disrupted, other participants could also be impacted
- Unavailability or limited availability of systemically important payment systems (SIPS) for extended periods (from as little as one hour) impacting broader financial stability due to linkages with functioning of money and capital markets and liquidity in the system
- Staff being physically cut off from operations centers, disrupting normal operations on system components, such as hardware, software, network, and participant interfaces
- Potential relaxation of risk management measures in the absence of resources increasing cyber risks, which impacts customer confidence and poses further challenges for authorities and relevant stakeholders
- Unavailability of retail payment systems impairing the payment services offered to individuals and firms, such as interbank credit transfers, card payments online and at point of sale, mobile money transfers between different operators, and so on, with knock-on effects on commerce and industry, the disbursement of social protection program-related payments, and the sending and receiving of remittances

In developing countries, where payments are often still made in cash, many people use agents—such as mobile money agents and those servicing government-to-person payment programs or providing cashback services to cardholders—to access cash, due to their proximity and other features. Cash availability is therefore easily disrupted where ATM operations are impacted or bank and agent branches are not fully operational.

The resilience of payments systems is also crucial for the quick and efficient distribution of government assistance programs in the aftermath of a disaster. This has been evident during the COVID-19 pandemic, where countries with modern and resilient payment systems have been more successful in supporting citizens during the crisis.

Endnotes

1. Although average social protection spending in the Caribbean is higher than the Latin American average, the effectiveness of safety nets, social insurance, labor market policies, and other social services is hampered by a lack of poverty data, insufficient coverage in the large informal sector, infrequent surveys, and ineffective and inefficient identification, delivery, and monitoring of services. For more details, see Beazley and Williams (2021).
2. "Leaning against the wind" refers to a monetary policy that is somewhat tighter—that is, a higher policy interest rate—than what is consistent with flexible inflation targeting without taking any effects on financial stability into account (Svensson 2017).
3. A classic example is the "financial accelerator" mechanism (Bernanke and Gertler 1989; Mishkin 2009), where a shock to the real economy or financial sector results in significant uncertainties to asset valuation, especially when information is opaque and financial frictions are high. Devaluation of assets during downturns will further depress lending activities and generate downward pressure on the real economy, increase uncertainties and initiate a vicious cycle. A well-developed financial sector with a modern collateral regime would mitigate asymmetric information problems.
4. In quite a few cases, public bodies perform quasifiscal activities—or public functions on the government's behalf—like regulatory functions and service delivery at subsidized tariffs (for example, for public transport).
5. https://www.imf.org/external/datamapper/FiscalRules/map/map.htm.
6. https://databank.worldbank.org/source/world-development-indicators.
7. Widely used instruments include: World Bank's Catastrophe-Deferred Drawdown Option (CAT DDO); the IDB's contingent credit line and facility; the Asian Development Bank's contingent credit line and contingent grants; national or regional contingency funds; and parametric insurance schemes to transfer risks, such as the Caribbean Catastrophe Risk Insurance Facility, Pacific Catastrophe Risk Assessment and Financing Initiative, African Risk Capacity, and Southeast Asia Disaster Risk Insurance Facility.
8. PFM is an umbrella term for a variety of loosely related processes for managing government finances', including estimating macroeconomic and fiscal prospects, allocating public money, and reporting financial results (Cangiano, Curristine and Lazare 2013). A good PFM system should "ensure that the policies of governments are implemented as intended and achieve their objectives" (PEFA 2016).
9. Timelines are indicative for illustrative purposes. They vary for each natural disaster, and are theoretically more suited for rapid onset disasters, like hurricanes, floods, or earthquakes, than slow onset disasters like droughts.
10. https://data.imf.org/?sk=f8032e80-b36c-43b1-ac26-493c5b1cd33b.
11. https://data.imf.org/?sk=4c514d48-b6ba-49ed-8ab9-52b0c1a0179b.
12. https://data.imf.org/?sk=51B096FA-2CD2-40C2-8D09-0699CC1764DA.

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3

Chapter 13 >>
Recommendation 1: Increase government efficiency

Chapter 14 >>
Recommendation 2: Empower households and the private sector

Chapter 15 >>
Recommendation 3: Reduce future physical risk

I.3

INTRODUCTION TO PART 3 >>

A way forward: three recommendations for building resilience to a new generation of shocks

Caribbean countries have a long history of dealing with large natural, financial, and biological shocks. As shown in Part 1, these shocks affect different sectors through different channels and have both short- and long-term detrimental effects on Caribbean societies.

Despite being highly exposed to shocks, these countries have learned to adapt, building buffering mechanisms to bounce back when hit by a shock. *Part 2* presented a comprehensive framework to help countries piece together these mostly scattered sectoral efforts into a comprehensive strategy for building resilience to a new generation of shocks in the region.

Together, the risk diagnostic (Part 1) and the TLS assessment (Part 2) yield two main findings.

Finding 1: Caribbean countries have built resilience levels that have allowed them to support economic development despite large recurring damages and losses from multiple hazards and shocks. Businesses in the region have invested in disaster preparedness, staff training, and backup infrastructure, such as water tanks and electric generators. Remittances from abroad have blunted postdisaster drops in consumption. In many cases, governments have prepared adeptly for extreme events, benefiting from regional collaboration mechanisms to monitor and forecast hurricanes and organize a coordinated response when the impact exceeds individual countries' response capacity.

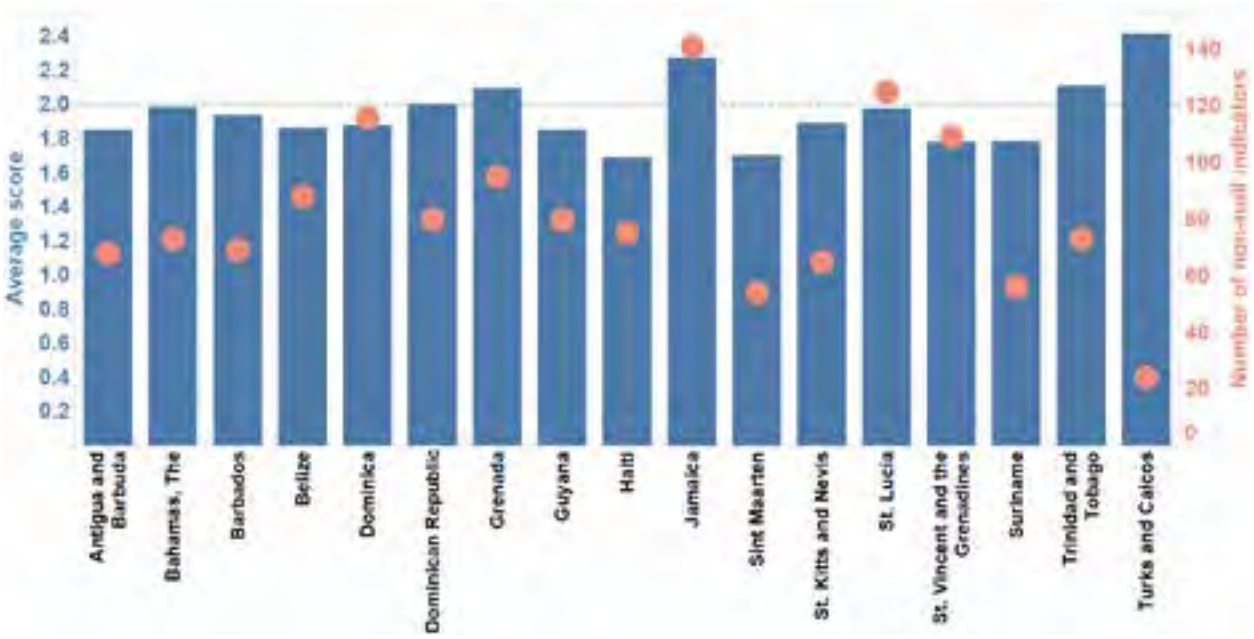
But resilience strategies have partly relied on external aid and informal mechanisms that do not systematically protect the poor and most vulnerable groups and do not always prevent the loss of human capital. As a result, despite these efforts, some people have been left behind.

Finding 2: Caribbean countries are vulnerable to new or intensifying challenges posed by socioeconomic trends, climate change, environmental degradation, and an uncertain future for the tourism and agriculture sectors. So, strategies that have worked in the past will not be enough to face future challenges. Climate change threatens to intensify natural hazards and brings new sources of volatility through impacts on health, agriculture yields, and coastal landscapes. The post-COVID-19 world brings more uncertainty on prospects for tourism. Many countries have also depleted their fiscal space and coping capacity while dealing with past crises.

These new challenges call for more consistent approaches to resilience that build on stronger institutions, robust analytics, and more transparent prioritization.

FIGURE I3.1 >>

Average TLS score per country, if all indicators are given equal weight



Sources: Based on data from background notes prepared for this report[1]

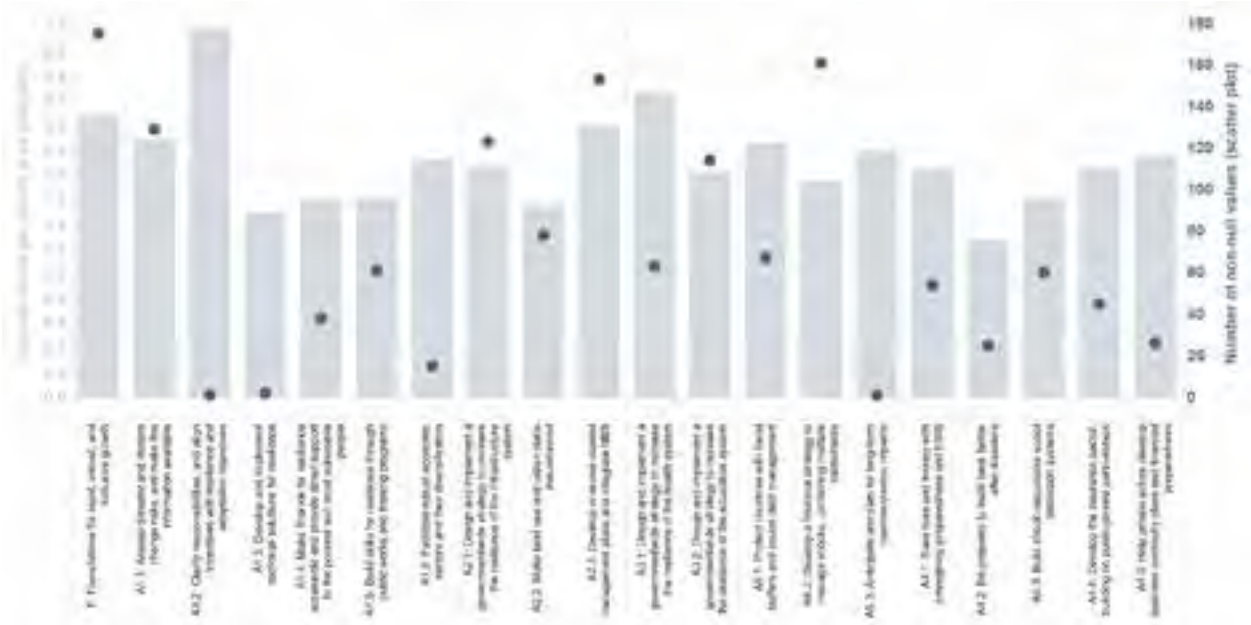
Note: Scores are based on 1 = nascent (the country includes areas that are only starting to or do not address the standard at all); 2 = emerging (the country partly meets the standard and has progressed beyond the initiation point but has not reached the final point); ; 3 = established (the country meets the standard entirely). Due to lack of data, many countries are missing scores for different indicators. As a result, the TLS assessment is incomplete, and the results presented here can change when indicator scores are completed.

Looking at overall TLS results across countries and priority areas, all countries have strengths and weaknesses in different aspects of resilience (see *Appendix B* for detailed individual country TLS results). Assuming the same weight for all indicators and giving indicators a value between 1 (nascent) and 3 (established), *figure I3.1* shows that total average scores are between 1.7 (for Haiti) and 2.2 (for Turks and Caicos, with the caveat that very few indicators are available for this country). *Figure I3.2* shows that the following areas require improvement across all countries:

- Make finance for resilience and direct support accessible to the poorest and most vulnerable people (TLS action 1.4)
- Develop skills for resilience through public works and training programs (TLS action 1.5)
- Make building codes and urban plans risk-informed (TLS action 2.2)
- Be prepared to build back better (TLS action 4.2)
- Build shock-responsive social protection systems (TLS action 4.3).

FIGURE I3.2 >>

Average score per TLS action, if all indicators and countries are given equal weight



Sources: Based on data from background notes prepared for this report[1]

Note: Scores are based on 1 = nascent (the country includes areas that are only starting to or do not address the standard at all); 2 = emerging (the country partly meets the standard and has progressed beyond the initiation point but has not reached the final point); ; 3 = established (the country meets the standard entirely). Due to lack of data, many countries are missing scores for different indicators. As a result, the TLS assessment is incomplete, and the results presented here can change when indicator scores are completed.

Combining the TLS assessment with sectoral priorities and recommendations identified in each of the background papers prepared for this report,[1] Caribbean governments should focus on three main areas to boost resilience and better prepare for future shocks and stresses:

Recommendation 1: Increase government efficiency by improving investment management and infrastructure maintenance, clarifying procurement rules, allocating budgets transparently, ensuring fiscal rules are robust, and layering risk financing strategies (*chapter 13*).

Recommendation 2: Empower households and the private sector by increasing both the coverage and adequacy of social protection, strengthening worker skills for resilience, improving access to finance, and facilitating access to risk information (***chapter 14***).

Recommendation 3: Reduce future physical risk by investing in critical infrastructure, better enforcing building codes and standards, systematically considering emerging and changing risks, and planning to build back better after shocks (***chapter 15***).

Together, these recommendations address the major regional gaps in building resilience, and focus on the region's most common priorities. Combining this with the individual TLS assessments in ***Appendix B***, countries can identify their own information gaps and lagging priority areas, set targets, and prioritize interventions by tailoring their strategies to their own needs, thus building resilience against a new generation of shocks in the Caribbean and ensuring a prosperous future for their communities.

Endnotes

1. Beazley and Williams 2021; Bellony and Powers 2021; Benavidez 2021; Giardino et al. 2021; Harnam and Khan 2021; Johnson, Caroca Fernandez and Restrepo Cadavid 2021; Li 2021; Makara 2021; Masetti 2021; Medina, Kullmann and Felter 2021; Miyamoto International 2021; Schweikert et al. 2021.

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TABLE I3.1 >>

Recommended actions for building resilience to a new generation of shocks in the Caribbean

Recommended action	Priority	Lead role (indicative)	TLS action
Recommendation 1: Increase government efficiency			
Invest in digitalization for key government services	Medium- to long-term	All key ministries, particularly Ministries of Education, Health, Social Affairs/Interior	A3.1, A3.2, A4.3
Improve postdisaster spending processes	Short- to medium-term	Ministry of Finance	A5.2, A3.1, A4.3
Reduce budget variability and fiscal risks by improving public asset management	Medium-term	Ministry of Finance, in coordination with Infrastructure	A5.2
Build fiscal resilience	Medium- to long-term	Ministry of Finance	A5.1, A5.2
Improve debt management	Medium-term	Ministry of Finance	A5.1
Assess direct and indirect liabilities and improve the transparency of budget allocation for emergency social protection and health expenditures	Short-term	Ministry of Finance, in coordination with Ministries of Health, Social Affairs/Interior	A3.1, A4.3
Roll out the development of disaster risk financing (DRF) strategies that cover the entire spectrum of risk—from small, frequent events to rare, extreme events	Short- to medium-term	Ministry of Finance	A5.2
Regional coordination, and skills and resource sharing	Medium-term	Ministries of Health, Social Affairs/Interior, Education	A1.5, A3.1, A3.2
Recommendation 2: Empower households and the private sector			
Help firms and households plan ahead by making good quality risk data publicly available in a format that can be used and analyzed and reflects the (uncertain) future impacts of climate change	Short-term	Ministry of Economy	A1.1
Help households diversify their income and bounce back after disasters by building a social protection system that has high coverage, comprehensively addresses risks, and provides adequate benefits	Short-term	Ministry of Social Affairs/ Interior	A3.3
Help firms (including MSMEs) and households invest in resilience and rebuild after disasters by developing the financial and insurance sectors, including by regulating risk disclosure and strengthening financial sector safety nets	Short- to medium-term	Ministry of Economy	A4.3
Support farmers and fisherfolk with access to data, technological solutions, and finance	Short- to medium-term	Ministry of Economy or Agriculture	A1.1, A1.3, A1.4
Invest in digital infrastructure and build digital skills to strengthen businesses and increase human capital	Medium- to long-term	Ministries of Planning or Infrastructure and Education	A1.5, A3.2
Improve continuity of learning during and after shocks	Short-term	Ministry of Education	A3.2
Reduce economic vulnerability through diversification	Medium-term	Ministry of Economy	A1.6
Recommendation 3: Reduce future physical risk			
Develop and implement risk-informed building codes that are relevant to the local context and ensure informal builders are equipped to build resiliently	Short-term	Ministry of Planning or Infrastructure	A2.2
Develop risk-informed coastal and land use plans that consider future climate change impacts	Short-term	Ministry of Environment or Planning	A2.2, A2.3
Take advantage of natural capital	Short-term	Ministry of Environment or Planning	A2.3
Identify and strengthen critical infrastructure assets, including schools and health centers	Short-term	Ministry of Infrastructure	A2.1, A3.1, A3.2
Develop water resources management strategies	Short-term	Ministry of Planning, Environment, Infrastructure, or Economy	A1.2, A2.1
Be prepared to build back better, possibly in different places	Short- to medium-term	Ministries of Planning, Infrastructure	A2.1, A4.2

Note: For each recommended action, the table identifies the corresponding TLS action(s), allowing governments to link the proposed recommendations back to the TLS assessment in Appendix B. The appropriate ministry in charge of leading each recommendation might differ country to country.

13

CHAPTER 13 >>

Recommendation 1: Increase government efficiency

TABLE 13.1 >>

Recommended actions for increasing government efficiency in Caribbean countries

Recommended action	Priority	Lead role (indicative)	TLS action
Invest in digitalization for key government services	Medium- to long-term	All key ministries, particularly Ministries of Education, Health, Social Affairs/Interior	A3.1, A3.2, A4.3
Improve postdisaster spending processes	Short- to medium-term	Ministry of Finance	A5.2, A3.1, A4.3
Reduce budget variability and fiscal risks by improving public asset management	Medium-term	Ministry of Finance, in coordination with Infrastructure	A5.2
Build fiscal resilience	Medium- to long-term	Ministry of Finance	A5.1, A5.2
Improve debt management	Medium-term	Ministry of Finance	A5.1
Assess direct and indirect liabilities and improve the transparency of budget allocation for emergency social protection and health expenditures	Short-term	Ministry of Finance, in coordination with Ministries of Health, Social Affairs/Interior	A3.1, A4.3
Roll out the development of DRF strategies that cover the entire spectrum of risk—from small, frequent events to rare, extreme events	Short- to medium-term	Ministry of Finance	A5.2
Regional coordination, and skills and resource sharing	Medium-term	Ministries of Health, Social Affairs/Interior, Education	A1.5, A3.1, A3.2

Note: For each recommended action, the table identifies the corresponding TLS action(s), allowing governments to link the proposed recommendations back to the TLS assessment in Appendix B. The appropriate ministry in charge of leading each recommendation might differ country to country.

Governments have many responsibilities for building resilience, from investing in more robust infrastructure systems to organizing disaster response and supporting firms and households after shocks. Given their limited capacity and public budgets, governments need to focus managing public budgets and delivering services in a more efficient and transparent way. This chapter outlines eight actions governments can take to increase their efficiency (*table 13.1*).

Invest in digitalization for key government services

Digital development is a key building block for publicly sharing risk information, enabling interoperable and interagency information systems—between disaster management agencies, health authorities, and education authorities—that are crucial for responding effectively to shocks and for more efficient and transparent government services. For example, digitalization would improve land management through electronic cadastral systems and an efficient land registration process and social protection, by allowing countries to move away from rudimentary Excel- or paper-based registries (Beazley and Williams 2021; Bellony and Powers 2021; Harnam and Khan 2021; Johnson, Caroca Fernandez and Restrepo Cadavid 2021).

High-quality data and information are also the basis for adequate public management and policy making. However, certain aspects of data quality and information collection in the Caribbean region are relatively weak. For example, household surveys to monitor poverty are only conducted every 10 years—and sometimes less frequently. And although most countries have conducted a household budget and living conditions survey recently, data and analyses from these surveys are only available for the mid-2000s. The exception to this is St. Lucia. Outdated data and analysis of poverty prevalence, the root causes of poverty, or distributional aspects prevent countries from identifying their poor and vulnerable populations, and adequately targeting poverty reduction policies. Macroeconomic and fiscal data are either not publicly available or not timely enough to adequately inform the public and investors, impeding the design of targeted policies to alleviate poverty and promote growth. Key opportunities lie in improved data collection, analysis, and timely and transparent disclosure of public data to inform international investors and enhance public accountability. As small economies, Caribbean countries have limited capacity to process high-quality data. With available data scattered across different departments and ministries, this leaves policy making uncoordinated and inefficient. Digitalizing national data and integrating regional data management and support can help overcome this disadvantage.

In the health sector, disease reporting during shocks has often been untimely or incomplete, reflecting gaps in Caribbean countries' national health surveillance systems. A strong system produces timely death, injury, and illness data during disease outbreaks or disasters to guide immediate and long-term actions, including the allocation of limited public health resources. A well-functioning system has many components including clinician reporting, laboratory diagnostics, information technologies, epidemiological capacities, and information dissemination mechanisms (Groseclose and Buckeridge 2017). While maintaining existing surveillance capacities, countries should monitor and regularly evaluate their surveillance system to identify opportunities and needs for strengthening.

To ensure continuity of learning during and after shocks, governments need to monitor and evaluate the quality and effectiveness of distance learning and use these data to address the needs of students from diverse socioeconomic, ethnic, and geographical circumstances. This includes improving teaching and learning and informing policy; incorporating remediation strategies and accelerating learning where needed to minimize learning loss; supporting learners, teachers, and caregivers through complementary services; reviewing, planning, and building on lessons learnt to develop new strategies for multimodality distance learning; and

including all educational levels. Education Management Information Systems (EMIS) allow governments to evaluate, monitor and improve quality of education, during normal times as well as during and after shocks. Key opportunities to strengthen quality and continuity of learning include establishing such systems in the many Caribbean countries that do not have them, updating them where they exist but are out of date, and linking them with other government administrative databases where they not yet connected.

For social protection, establishing a system for nationwide unique IDs and digital registries is the first step towards interoperability and integration. Countries would then need to develop protocols and mechanisms for sharing and protecting data within and between the social protection and DRM sectors, to ensure program designs and operations are more risk-informed and enhance coordination. They would also need to establish mechanisms for frequent updates, to ensure that the data are current, relevant, and of good quality. As no country in the region has such a mechanism (Beazley and Williams 2021), continued leadership by regional organizations like CARICOM and OECS can facilitate the process at national levels. Risk-informed SPISs, including beneficiary and social registries, can provide key data for shock preparedness and responses, such as household characteristics and locations. The more integrated and interoperable Social Protection Information Systems (SPIS) are with data from disaster risk information systems and other sectors, the better the quality of data and the more informed and data-driven policy decisions can be. Strengthening institutional policy, coordination, and capacity to deliver adaptive social protection nationwide is of utmost importance. This includes staffing, skills, financial resources, and contingency staffing arrangements for scaled-up services in post-shock contexts.

Improve postdisaster spending processes

Fiscal responses to disasters in the Caribbean are not always strategic or efficient, while emergency finance procedures are often undocumented, ad hoc, coincidental, and sometimes inefficient. Despite the frequency of natural disasters in the Caribbean, national authorities provide little guidance on how to manage public finances, procurement, and investments to swiftly respond to—or rebuild after—disasters. A critical step for governments to respond faster and more transparently is to improve policies and procedures for postdisaster budget execution, which would facilitate postdisaster expenditures tracking and create a feedback loop to ensure decision making in future is risk-informed. And while some emergency supply needs depend on the shock—for example, disease-specific medicines during an outbreak—others are more predictable, such as personal protection equipment during a health crisis or construction materials after a natural disaster. But even procurement mechanisms for some of these supplies with greater demand predictability in emergencies seems to be ad hoc, with many Caribbean countries relying on donations of medical equipment and pharmaceuticals.

By strengthening procurement planning for emergencies and emergency procurement procedures, countries can improve both speed and transparency. Market research, preparing procurement plans and sourcing strategies, and other initiatives to optimize purchases for disaster relief, response and recovery are therefore key inputs. For predictable items, preparation can include establishing pre-positioned contracts and standby arrangements allowing for draft contracts to be tendered and signed, with implementation triggered when an emergency occurs.

Since most governments do not systematically assess and manage public assets, it is difficult to quickly carry out accurate postdisaster needs assessments. And since those assets are also often financially underprotected, repairs and replacements are usually slow. Asset management systems for public items remain at an embryonic stage in the Caribbean, establishing them would facilitate contingent liability assessments and allow governments to tailor their DRF instruments.

Reduce budget variability and fiscal risks by improving public asset management

Examining the efficiency of public expenditure is a key policy consideration. World Bank public expenditure reviews generally evaluate multiple dimensions of public spending, including effectiveness, equity, efficiency, and fiscal sustainability. For example, the Guyana Public Expenditure Review focuses on efforts to improve the efficiency, equity, and effectiveness of the country's public spending on education.

Increasing the transparency and accountability of state-owned enterprises is another avenue of improvement. For example, transport authorities and water utilities need asset management systems and preemptive maintenance budgets. But, while most Caribbean countries have some type of asset registry, they have yet to expand this to a comprehensive inventory of all assets that covers both their condition and the strategic, financial, and technical aspects of infrastructure management. Most countries make reactive decisions, based on experience, rather than ex ante decisions that are driven by data. Without appropriate succession planning and business continuity practices, such decisions are susceptible to staff turnover. State-owned water utilities could largely improve their efficiency by reducing their high nonrevenue water levels—that is, water lost through pipes in bad condition. In the Caribbean, 24–63 percent of potable water never reaches the customer after leaving the point of production (Medina, Kullmann and Felter 2021).

Build fiscal resilience

In response to external shocks, fiscal policy is the most important instrument for Caribbean governments. However, the fiscal fragilities they have accumulated over the past decades have left the region with limited fiscal space and unable to respond to volatilities. This is further aggravated by inefficiencies in public governance. Over the past decades, the region has operated significantly procyclical fiscal policies, accumulating high public debt. In the current environment, fiscal policy not only fails to accumulate enough fiscal cushion to mitigate external shocks; it also amplifies external shocks to the overall economy via fiscal spending. To rebuild and strengthen fiscal resilience, countries can establish fiscal responsibility frameworks to discipline fiscal policies and build credibility in normal times, thereby ensuring financing cushions in the event of an external shock.

Adopting and strengthening the design and effectiveness of appropriate fiscal rules should be a priority for all Caribbean governments. Countries have made significant progress in adopting fiscal rules with the required enforcement, escape clauses, and oversight. The benefits of following the rules are also prominent—for example, after implementing the 2015 Fiscal Responsibility Law, Grenada saw its debt-to-GDP ratio reduced by 48 percentage points to less than 60 percent of GDP in 2019. Other countries adopting rules-based fiscal responsibility frameworks include The Bahamas, which adopted the Fiscal Responsibility Act in 2018; St. Vincent and the Grenadines, which approved the Fiscal Responsibility Resolution in 2019; and St. Lucia and Belize, which are both preparing to adopt fiscal rules.

Improve debt management

The lack of robust medium-term debt strategies has led to weak debt portfolio construction and a high concentration of external debt, increasing the exposure of several countries' debt to external shocks.

Shocks emanating from contingent liabilities, such as SOEs, also contribute to debt accumulation, highlighting the need for more effective debt transparency and management.

Several Caribbean countries have started reforms in reducing fiscal vulnerabilities supported under the *Sustainable Development Financing Policy's* performance and policy actions.[1] This policy aims to incentivize countries to move towards transparent, sustainable financing and to promote coordination between the World Bank's International Development Association and other creditors in support of recipient countries' efforts. Guyana, Grenada, Dominica, St. Lucia, and St. Vincent and the Grenadines are all under the framework and have committed to reforms that include enhancing debt transparency by publishing reports, strengthening debt management policies, and implementing a rules-based fiscal responsibility framework. Such actions are expected to reduce fiscal vulnerabilities and enable more policy space to achieve sustainable development goals.

Assess direct and indirect liabilities and improve the transparency of budget allocation for emergency social protection and health expenditures

Many Caribbean governments have started assessing direct contingent liabilities for disaster risk financing (DRF) strategy design. To complement these assessments, governments should also evaluate indirect liabilities from reduced fiscal revenues and increased expenditure for ASP and health emergency services due to a shock. Most countries do not have such ex ante quantification of indirect contingent liabilities. But these are fundamental for establishing adequate financing mechanisms to manage the financial risk of the entire frequency and severity spectrum and for linking with adaptive social protection (ASP) and health emergency financing mechanisms to ensure an effective and sustainable response to shocks. While most Caribbean countries are party to risk financing arrangements—notably through the CCRIF SPC—they lack strategies for comprehensive DRF and a systematic link to ASP and health emergency financing.

Roll out the development of DRF strategies that cover the entire spectrum of risk—from small, frequent events to rare, extreme events

The region has been actively building layers of DRF with support from international organizations, including the World Bank. Most countries are also part of the CCRIF SPC.[2] But a more comprehensive DRF approach is crucial to adequately cover the spectrum of frequencies and severity of shocks. At a minimum, this should include:

- A reserve fund capitalized roughly to the level of a country's average annual losses from prominent hazards to provide a source of immediate liquidity for severe events or to easily address more frequent events
- Access to some kind of contingent credit from a development partner for moderate to severe events
- Risk transfer mechanisms to cover sovereign risk and provide immediate (ideally parametric) budget support and more tailored indemnity products to cover specific risks, for more severe events

Insurable public assets and privately owned assets providing critical public services should also be covered with indemnity, hybrid, or parametric products. And, depending on the specific country's priorities, sector-specific risk transfer products and scalable social protection products can also be included.

Such a layering approach needs to be tailored to each country's specific situation using disaster risk profiles that provide an understanding of direct liabilities from infrastructure and indirect liabilities from reduced fiscal revenues and increased adaptive social protection and health emergency service expenditure. This risk information must be up to date, so recent hazard data, loss and damage databases for all magnitude of events, and an inventory of geolocated public assets are critical to help governments assess risk and validate models. To be able to tailor risk financing instruments in the case of a health crisis, governments also need to analyze contingent financing needs, based on assessments of health system needs during previous shocks and regular risk assessments.

A government-approved policy should form the basis of implementing such an approach, and as this requires the involvement of multiple sectors, a cross-government dialogue on all matters is crucial, through a DRF working group with champions from each sector. Agriculture, tourism, and housing sectors are essential for food security and economic growth in the region and deserve special consideration during the current piloting of nascent innovative insurance products. It is therefore worth having a separate DRF strategy for each sector under the national strategy. Countries should also pay special attention to cash transfer programs for widespread social support after shocks, as having an efficient, scalable social protection program in place allows them to budget in advance.

St. Lucia's National Strategy for Disaster Risk Financing (2018) is a well-established legal and institutional framework for managing disaster and climate risks that strengthens the government's ability to assess, reduce, and manage fiscal risks from natural disasters. This is a model worth replicating across countries to enable governments to adequately budget and prepare for the financial impact of disasters and ensure immediate liquidity without jeopardizing medium- to long-term development goals.

Regional coordination, and skills and resource sharing

The Caribbean has a long history of coordination and collaboration, and many mechanisms in place. However, shocks—particularly the frequent ones—put those mechanisms to the test and point to opportunities for further strengthening.

The size of each individual country constrains their capacity to prepare and respond to disasters. If it is well sequenced and includes proper risk management safeguards, advancing regional collaboration and integration can catalyze capacity and resources for better policy responses. Organizations like CARICOM and OECS have initiated several reforms that have contributed to regional competitiveness as a whole. Various arrangements have been established to further strengthen risk pooling, with economic integration as a substitute for diversification. Going forward, areas with great potential include fiscal and financial integration with a central oversight committee; a central contingency fund for major external shocks; and more coordinated strategies to attract foreign direct investment and tourism to avoid a "race to the bottom" and high fiscal costs.

Pooling regional resources through enhanced collaboration can offer economies of scale for building code enforcement that cannot be otherwise achieved. A CARICOM platform for collaboration could offer greater opportunities for industry practitioners to network and share relevant experiences, lessons learned, and best practices, and to obtain training. This could function as a regional center for excellence that is jointly operated by regional agencies with a stake in enhancing resilient construction through building regulation. Regional organizations like CDEMA, CROSQ, CDB, and OECS are already prioritizing this agenda. An ongoing regional initiative, supported by the World Bank and the EU, would coalesce all of

these critical partners around the strengthening building regulation agenda in CARICOM member states. Such a regional platform could centralize processes and maximize talent across the region by:

- Centrally developing and regularly updating a regional model building code
- Offering capacity building and training for locally calibrating model code provisions to specific hazard maps
- Providing training, educational, and certification opportunities for building sector practitioners to maintain and improve their knowledge base to support greater building code compliance
- Ensuring adequate guidance—such as building code companions, guides, checklists, and so on—exists to support the implementation of a common regional building code
- Serving as a knowledge and advisory hub where local implementers can learn about best practices in the region and globally and obtain advisory support for resolving building regulation challenges
- Serving as a hub for research and development on all matters relating to the enhancement of building code compliance in the region—for example, generating, collecting, analyzing, synthesizing, and disseminating data

In the health sector, the unpredictable nature of shocks—especially the introduction of novel diseases—presents many challenges for health professionals. In responding to emergencies, clinicians and public health workers have to adapt to rapidly evolving situations and may have to perform different roles, adjust their work schedules, rapidly learn new information and/or procedures, work outside typical settings, compromise routine service provision, and make rapid policy decisions. More broadly, it is necessary to have national and regional mechanisms for adapting human resources to meet situation-specific health needs, such as a regional agreement for countries to support each other by moving health professionals (surge capacity) to any country in need after a disaster.

In the education sector, the COVID-19 pandemic provides a platform to comprehensively review educational progress with a view to reform. With COVID-19, regional collaboration in education has been limited, except for OECS projects for their member states. However, countries have much to gain by sharing best practices and innovative approaches across borders. The time is apt for regional economies to address the learning crisis exacerbated by recurrent shocks to education systems and determine ways to improve and accelerate education. A detailed assessment of education systems will provide crucial information on learning outcomes, existing challenges, lessons learnt, and stocktaking on progress on the SDGs, ensuring countries are better equipped to develop strategies to minimize learning loss, improve education quality, equity, equality, and reorient teaching and learning to prepare students for the future of work.

Endnotes

1. https://ida.worldbank.org/debt/sustainable-development-finance-policy.
2. For detailed information on payouts from the CCRIF SPC, see: https://www.ccrif.org/about-us.

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14

CHAPTER 14 >>

Recommendation 2: Empower households and the private sector

TABLE 14.1 >>

Recommended actions for empowering households and the private sector in Caribbean countries

Recommended action	Priority	Lead role (indicative)	TLS action
Help firms and households plan ahead by making good quality risk data publicly available in a format that can be used and analyzed and reflects the (uncertain) future impacts of climate change	Short-term	Ministry of Economy	A1.1
Help households diversify their income and bounce back after disasters by building a social protection system that has high coverage, comprehensively addresses risks, and provides adequate benefits	Short-term	Ministry of Social Affairs/ Interior	A3.3
Help firms (including MSMEs) and households invest in resilience and rebuild after disasters by developing the financial and insurance sectors, including by regulating risk disclosure and strengthening financial sector safety nets	Short- to medium-term	Ministry of Economy	A4.3
Support farmers and fisherfolk with access to data, technological solutions, and finance	Short- to medium-term	Ministry of Economy or Agriculture	A1.1, A1.3, A1.4
Invest in digital infrastructure and build digital skills to strengthen businesses and increase human capital	Medium- to long-term	Ministries of Planning or Infrastructure and Education	A1.5, A3.2
Improve continuity of learning during and after shocks	Short-term	Ministry of Education	A3.2
Reduce economic vulnerability through diversification	Medium-term	Ministry of Economy	A1.6

Note: For each recommended action, the table identifies the corresponding TLS action(s), allowing governments to link the proposed recommendations back to the TLS assessment in Appendix B. The appropriate ministry in charge of leading each recommendation might differ country to country.

As well as improving the efficiency of government support for resilience, governments need to empower private actors (households and businesses) to help them diversify their income sources, make more resilient choices, and bounce back after disasters. This chapter outlines seven actions governments can take to empower households and the private sector (*table 14.1*).

Help firms and households plan ahead by making good quality risk data publicly available in a format that can be used and analyzed and reflects the (uncertain) future impacts of climate change

While all countries in the Caribbean have made significant progress in producing data needed for hazard and risk assessments and carrying out hazard and risk analytics—as reflected in their relatively high scores for TLS action A1.1 indicators (*Appendix B*)—few have up-to-date risk information in a geospatial data format, at the right scale, that considers the future impacts of climate change. Geospatial data require local technical staff and computer systems to produce timely analytics and information for specific projects or plans. However, most Caribbean countries have limited capacity for this.

Data must also be relevant for DRM, with hazard maps, exposure data sets, vulnerability information, and risk analytics made publicly available on websites or other public information platforms. While sensitive data, such as household surveys, can only be shared within government, the public availability of hazard and risk information is important even when urban and coastal planning are weak, as it can inform private actors' decision making about where and how to build. Even in countries where risk-informed planning is not applied or is only applied to a limited extent, risk maps can still shape development if they are publicly available. This also reinforces the need to educate practitioners and the public about risk analytics, and to clearly communicate uncertainty about future risk and the range of changes that climate change can bring—for example, to coastal flooding.

In the Caribbean, there are gaps in the foundational policy framework for data governance. Not all countries have passed freedom of information legislation into law—it is lacking, for example, in Barbados, St. Lucia, Grenada, Dominica, Suriname, and Haiti. Similarly, the existence of open data and data management policies is inconsistent, while the lack of legislation for cybersecurity creates a propensity to restrict all access to all data in the name of security.

Help households diversify their income and bounce back after disasters by building a social protection system that has high coverage, comprehensively addresses risks, and provides adequate benefits

The fastest available response to poor households in post-shock contexts is often through vertical expansion of existing social protection benefits. So, if countries' foundational social protection programs—particularly their flagship cash transfer program—have limited coverage, it can be difficult to scale them up quickly and effectively to help the poor cope with emergencies or shocks.

High coverage can be achieved by combining different programs that address different risks across a lifecycle approach. This includes cash transfer programs and social pensions to smooth household and elderly people's consumption; school feeding programs to improve food security, nutrition outcomes, and school attendance; active labor market programs to improve employability and increase earnings

among working aged people; and social insurance to protect against certain risks, such as unemployment, disability, and old age. Expanding coverage also includes the complementary development and growth of private microinsurance for small businesses and households, which would reduce the potential burden on the safety net in a post-shock environment. While Caribbean countries offer a range of these benefits, program coverage is often too limited to translate into broad coverage. Countries could therefore benefit from a more thorough assessment of how the program mix could help improve coverage while also addressing various risks across the lifecycle.

Central to effective coverage expansion is improving targeting systems for foundational social protection programs, particularly to ensure that those who are most in need can be identified and enrolled. These targeting systems should be optimally informed by updated household survey data. But the lack of such data in several Caribbean countries constrains their ability to effectively identify the poor and tailor social protection provision.

Ensuring that benefits provided are adequate to help programs meet their objectives, and by extension, foster meaningful resilience, is also important, primarily to ensure that benefits for the flagship poverty-targeted safety net are enough to smooth consumption in beneficiary households. It is also important to recognize that countries face difficult trade-offs between expanding coverage and increasing benefits. Programs with small coverage that provide adequate benefits and include deliberate measures to facilitate economic inclusion and poverty reduction could help pave the way for new rounds of beneficiaries through graduation.

There is limited provision of complementary measures to support beneficiary households of foundational social protection programs in the Caribbean, and deliberate links to building resilience are even more limited. Social protection programs can have significant positive impacts on household resilience, not only by delivering cash or in-kind transfers, but also through effective family accompaniment and case management strategies, which can help facilitate changes in household coping strategies, and complementary measures to link households to resilience-strengthening interventions. Such efforts have been uneven in the region, with the Dominican Republic leading through multipronged approaches to address economic inclusion, housing vulnerability, and employability. Jamaica's experiences with its case management provision and Steps-to-Work program offers a positive example for foundational social protection implementers. Other small-scale efforts—such as Belize's BOOST Plus and Job Readiness Component—also offer useful lessons to inform a scale-up of activities. Conversely, deliberate links to address climate resilience have been weak. For example, public works programs are absent from many countries' social protection landscape or do not fully integrate DRM or social protection objectives.

Caribbean countries could scale up the provision of family accompaniment and case management to existing social protection beneficiaries. Such services, which are either not supported or small-scale, largely due to capacity constraints, provide an opportunity to better support beneficiaries during program participation; respond more effectively to familial crises; help families identify and meet their goals; and better assess whether programs are meeting their objectives.

Finally, it is important to develop complementary interventions to enhance resilience among social protection beneficiaries, as such measures—including ensuring that social protection programs are risk-informed and risk-responsive—are largely absent in several Caribbean countries. For example, countries could integrate hazard vulnerability into program responses for poor households by including beneficiary education on risk reduction strategies into cash transfer programs; referring beneficiaries to complementary programs and benefits; and supporting more deliberate financial inclusion strategies for beneficiaries. Public works projects could promote climate adaptation or contribute to postdisaster recovery, reconstruction, and livelihood restoration, while skills training programs could promote

livelihood diversification and other adaptation strategies. Supporting such interventions requires effective referral mechanisms, coordination arrangements, trained staff, and sound monitoring mechanisms to evaluate outcomes and adjust measures as needed. These programs also often require cross-sector coordination—with DRM, agriculture, banking, and so on—and joint implementation.

Help firms (including MSMEs) and households invest in resilience and rebuild after disasters by developing the financial and insurance sectors, including by regulating risk disclosure and strengthening financial sector safety nets

Financial development plays a key role in promoting competitiveness and diversification. It also helps countries better manage the impact of trade volatility, especially in the case of small, open economies like those in the Caribbean. In the face of external shocks, a less developed financial market is not only unable to give firms timely and needed liquidity; its high vulnerability and significant systemic risk exposure also amplifies the shocks. Strengthening financial regulation and improving financial access for MSMEs are the two key reforms for leveraging financial markets and helping offset external shocks.

Increased insurance penetration and a wider range of instruments would also allow the private sector to better hedge against the economic and financial costs of a natural disaster. Increasing insurance uptake requires both demand- and supply-side initiatives. On the demand side, authorities need to better understand the reasons behind a reluctance to insure and consider public information and financial education campaigns to increase understanding about the benefits and functions of insurance. On the supply side, they should consider assessing the market structure and possible impediments to product development.

Improved insurance coverage also requires stronger supervision and competition mechanisms. Strengthening supervisory functions would improve the collection, management, and analysis of insurance-industry data as well as the ability to undertake risk-based regulation. Addressing information asymmetry and other market failures should also facilitate the development of the insurance industry, enabling it to provide a wider range of instruments on more favorable terms. Robust and standardized information on insurance coverage and incurred claims would allow the authorities to strengthen oversight of the market in key areas such as pricing, reserve definitions, capital requirements, and reinsurance. By encouraging private sector actors and families take their own steps to prepare financially for disaster events or other relevant contingencies, these steps would help to reduce the government's role as insurer of last resort of the whole economy. Government-led initiatives—such as the Caribbean Ocean and Aquaculture Sustainability Facility project, which provides parametric insurance coverage to fishers in Grenada and St. Lucia against adverse weather and tropical cyclones—can also boost insurance coverage.

Establishing credit registries or bureaus could help address the lack of credit information, a key gap for developing the financial sector. The private sector could set these up with the appropriate legal framework, or central banks could offer them as a public good. Such registries would help mitigate information asymmetries and enhance access to credit for underserved segments, such as MSMEs. Improving the secured transaction and moveable collateral framework would also improve access to credit, thus facilitating liquidity—a much-needed service for postpandemic recovery. Governments should also consider promoting access to credit for upfront investments in private sector resilience building.

For example, St. Lucia has advanced the Secured Transaction Act and Insolvency Act, which will promote credit access for MSMEs by enabling movable collateral and will encourage investors by addressing distressed loans and minimizing losses. These reforms will serve as an example for other countries to undertake similar steps in the region. The passage of the Banking Act in the eight OECS member states also provides a framework for improved supervision and resolution. As well as benchmarking the Caribbean to international sound practice, such financial sector reforms will help build crisis preparedness and resilience.

The health of the region's large financial sector is a key factor for private sector resilience in the Caribbean. In fact, one of the crises with the strongest impact on regional GDP over the last two decades was caused not by a natural disaster but by the failure of regional financial conglomerate CL Financial in 2009. The COVID-19 pandemic also presents a massive challenge to the region's financial sector, and it is therefore paramount to ensure that financial sector regulation and supervision are aligned with international good practice and that they are proactively used to safeguard financial stability. This applies not only to the banking sector but also credit unions, investment funds, and other parts of the financial sector that receive less scrutiny. Given the interconnectedness of the Caribbean's financial sector, resilience can only be achieved through close cooperation and timely information sharing across jurisdictions.

Financial sector supervisors should also focus on building resilience to climate and environmental risks. This includes direct physical risks from natural disasters and transition risks from the global transition towards a low-carbon economy that could affect the value of financial assets, especially in countries like Guyana or Trinidad and Tobago that have a large hydrocarbon sector. As initial steps, it might be useful to perform in-depth environmental risk assessments of the impact of climate and environmental risks on financial institutions to improve information collection and risk metric monitoring, and to build internal capacity on the topic. Supervisors should also increase climate stress capacity, particularly to assess the potential impact of catastrophic weather-related events that lend themselves well for these more forward-looking assessment tools. To model such events, regulators could make use of existing in-country natural catastrophe modeling capacity, if available. Informed by such assessments, authorities might consider explicit climate and environmental risk management, governance, and disclosure guidelines for financial institutions. To get more information and share experiences, central banks and supervisors could also consider joining the NGFS.[1]

While crisis prevention is crucial for financial sector resilience, authorities should also establish measures to mitigate the costs of a crisis, if prevention fails. They should strengthen and expand financial sector safety nets in the region to protect the most vulnerable, such as unsophisticated savers, while avoiding moral hazard and large fiscal liabilities. Given the small size of many countries and the relatively high fixed costs of running a deposit insurance system, regional approaches should be preferred where possible—for example, within the ECCU.

The continuity of payment systems in the aftermath of a natural disaster is crucial for financial stability and the recovery of the real economy. Financial authorities must therefore identify critical payment systems infrastructure to ensure normal operation. The criteria for this should be based on relevance of services and the access points they provide to the public and vulnerable groups, and on interdependencies between systems and payment systems providers. Risk management frameworks and business continuity plans can help avoid disruptions to crucial payment system infrastructure. It is also important to evaluate the specific needs of critical payment service providers in terms of access to sources of liquidity and financial assets. Finally, crisis decision-making and communication protocols are essential and authorities should put governance arrangements in place to ensure responsibilities are clearly assigned and timely decisions can be taken.

Support farmers and fisherfolk with access to data, technological solutions, and finance

Solutions for adaptation must be based on local, historic climate knowledge, with local farmers and fisherfolk inputting and participating in their creation and implementation. Farmers and fisherfolk also need to expand their knowledge and access climate-adaptive and risk management tools and strategies. To create an enabling environment, governments should:

- Make financing available and accessible
- Ensure the necessary materials and equipment are available in local markets
- Provide advisory services to deliver technical guidance
- Create policy and regulatory environments that incentivize farmers and fisherfolk to invest in climate-adaptive tools and strategies
- Consider management reform and offshore mariculture as solutions for improving resilience in the fisheries sector

In a worsening climate with longer periods of drought, water management strategies are also vital for farmers' production success. A water management framework consists of three crucial components: access and availability, storage, and distribution. Climate adaptation policy needs to grant maximum flexibility to farmers so they can modify their water use as necessary to reduce their vulnerability from "double exposure" to climate and economic change (Gamble, Curtis and Popke 2017). Adopting best practice for water extraction, production, and distribution is also key for enhancing the resilience of freshwater resources (CIAT 2018).

Invest in digital infrastructure and build digital skills to strengthen businesses and increase human capital

Digitalization can increase the efficiency of key economic sectors like tourism by opening new ways for customer acquisition, improving online brand visibility, expanding international reach, and improving the quality of service delivery and client satisfaction (Masetti 2021). Strong internet connection can attract "digital nomads"—remote workers, academics, or freelancers who are not geographically bound to their workplace and want to work from a Caribbean country for up to 18 months—either from the diaspora or other countries. While these newcomers would not be taxed in the short term, they can be a source of innovation and potentially future fiscal revenues if they decide to stay.

Access to innovative, low-cost digital financial services—transaction accounts, savings, credit, insurance, remittances, and so on—could also help vulnerable households save and MSMEs and farmers invest in their businesses, smoothing consumption over time and mitigating the impact of climate and other shocks to their livelihoods. Modernized payment system regulation and infrastructure would also support the efficient transmission of social cash transfer funds to vulnerable households throughout the Caribbean (Masetti 2021).

Digitalization also plays an important role in access to education and health services. When social distancing measures imposed during the COVID-19 pandemic forced many schools to close and switch to remote learning, disparity in access to technology led to inequitable access to education. In the Caribbean, one in every 10 households with school-aged children—mostly low-income households—lacks access to the tools and equipment they need to enable remote learning (Bellony and Powers 2021).

Digital development will require upgrades to physical ICT infrastructure and legal and regulatory reforms in the telecommunications sector to increase the scope and reduce the costs of connectivity under clearly defined rules and responsibilities. Alongside these reforms, governments must help businesses adopt technology and empower individuals with digital skills. Eastern Caribbean countries continue to lag significantly across most of the digital economy foundations, compared to their peers at similar levels of socioeconomic development. COVID-19 has further underlined these digital deficits, exposing the region's lack of preparedness to move government operations, education, communications, and commerce online.

Creating redundancy in infrastructure networks, ensuring backup power infrastructure is in place, and putting legislation in place for cybersecurity will create resilient digital systems (Sandhu and Raja 2019). But in the Caribbean, cybersecurity legislation and policies are often nonexistent. The ITU's 2018 Global Cybersecurity Index rates all countries in the region except Cuba, Jamaica, and the Dominican Republic in the lowest tier of commitment to cybersecurity due to a lack of legislation, policies, and trained personnel (ITU 2019).

Improve continuity of learning during and after shocks

Education quality is a fundamental element in reducing achievement gaps arising from inequities. At the onset of COVID-19, the immediate consideration in delivering distance education was access to instruction; there was less focus on quality of education. As countries take stock of the initial effectiveness of remote learning, it is important to fill the gaps in teaching and learning.

To arrest declines in achievement gaps and recoup losses in learning, special programs are needed to get children at risk of dropping out back into schools and to give them the pedagogical and social safety nets and the socioemotional support they need to accelerate their learning. In the future, digitalizing government and linking social protection systems to EMISs to trigger adequate responses, will cushion the impacts of natural disaster and health shocks on low-income households. Parents and caregivers play an important role in supporting education continuity and recent evidence shows that well-educated parents are better poised to protect children from learning loss after disasters (Andrabi, Daniels and Das 2020). Giving educational tools to children from disadvantaged households without addressing their parents' educational shortcomings where these exist is counterproductive. As policy makers plan to address the challenges of education quality and equity, it is important to enhance the skills of parents, especially mothers, given their roles in supporting the continuity of learning.

Reduce economic vulnerability through diversification

For small economies, diversification means finding a balance between expanding to more industries and achieving economies of scale in individual industries. The inherent vulnerability of the Caribbean tourism and commodity sectors to external shocks requires a shift to other, more resilient sectors. But given the small size of countries' economies, diversifying into multiple sectors limits the resources available for each sector. So exploring other routes of diversification is vital, including focusing on enhancing sector competitiveness and viewing diversification on a regional—rather than a single economy—level.

Digitalization could pave the way for an economic diversification and transition toward a knowledge-based economy that is less dependent on natural resources and in-person transactions for economic growth and employment. In the Caribbean, digitalization can also enable business models that connect

local workers with global employment opportunities through online working platforms, allowing the region's educated workforce to find employment outside small domestic markets unaffected by regional shocks, without causing a "brain-drain".

Upgrading and exploring new opportunities within existing sectors is another option. In the Caribbean, this means the tourism and commodity sectors. Caribbean countries are endowed with rich ocean and commodity resources, which are depletable and vulnerable to external shocks; however, when used efficiently and sustainably, tourism and commodity exports can bring in profits, advanced technology, higher management experiences, and foreign investment. COVID-19 has clearly shown the tourism sector vulnerabilities, but also has opened avenues for building sustainable tourism strategies, and so, enhancing resilience to demand-side shocks. Costa Rica, Kenya and Jordan's sustainable development strategies can be used as examples on how to do this. For countries that are rich in natural resources, one option is extending production, both upstream and downstream along the value chain, centered around resources. This encourages a greater variety of products, bringing higher margins and income that is more resilient toward price shocks.

A final option is exploring renewable energies, which complement traditional natural resources and provide sustainable and economic solutions for meeting domestic energy gaps.

Endnotes

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15

CHAPTER 15 >>

Recommendation 3: Reduce future physical risk

TABLE 15.1 >>

Recommended actions for reducing future physical risk in Caribbean countries

Recommended action	Priority	Lead role (indicative)	TLS action
Develop and implement risk-informed building codes that are relevant to the local context and ensure informal builders are equipped to build resiliently	Short-term	Ministry of Planning or Infrastructure	A2.2
Develop risk-informed coastal and land use plans that consider future climate change impacts	Short-term	Ministry of Environment or Planning	A2.2, A2.3
Take advantage of natural capital	Short-term	Ministry of Environment or Planning	A2.3
Identify and strengthen critical infrastructure assets, including schools and health centers	Short-term	Ministry of Infrastructure	A2.1, A3.1, A3.2
Develop water resources management strategies	Short-term	Ministry of Planning, Environment, Infrastructure, or Economy	A1.2, A2.1
Be prepared to build back better, possibly in different places	Short- to medium-term	Ministries of Planning, Infrastructure	A2.1, A4.2

Note: For each recommended action, the table identifies the corresponding TLS action(s), allowing governments to link the proposed recommendations back to the TLS assessment in Appendix B. The appropriate ministry in charge of leading each recommendation might differ country to country.

Aging infrastructure stocks are a constraint to future growth and resilience in the Caribbean. The absence of land use plans also makes planning for sea level rise and changes in flood extents extremely challenging. Although countries need to be pragmatic, given the high costs of infrastructure investments, there are many opportunities for reducing physical risk at reasonable costs. This chapter outlines six actions governments can take to reduce physical risks in the face of future intensifying shocks (*table 15.1*).

Develop and implement risk-informed building codes that are relevant to the local context and ensure informal builders are equipped to build resiliently

Limiting the creation of new risks by tailoring building design and construction to the local hazard context is among the most cost-efficient approaches to managing disaster risk. While the Caribbean region is already quite advanced in developing and promoting resilient building codes and standards, a number of aspects need strengthening.

Building codes are at the heart of the building regulatory regime. They translate societal values around public health, safety, accessibility, and energy efficiency into technical requirements that serve as minimum physical standards for building design, construction, maintenance, and renovation. They communicate the acceptable level of risk and provide a common understanding for building professionals, owners, and regulators. Building codes must be locally appropriate and match locally available materials and production capacities. When codes are transposed from higher-income settings, they often reference technical standards for a limited range of construction materials and methods, and rarely address locally prevalent non-engineered construction. If they do not offer an adequate range or "stratification" of technical standards to respond to different levels of sophistication and reality in construction, building codes will relegate indigenous or vernacular construction practices to the vulnerabilities of the informal sector. The same applies to requirements for professional qualifications and licenses. If a training curriculum does not include knowledge of locally relevant vernacular construction, it may cause professionals to be unfairly wary of non-engineered structures, widening the gap between the formal and informal building sectors.

Another important dimension of locally relevant building codes in the Caribbean is the extent to which they include up-to-date hazard information in terms of the frequency and severity of expected events. In the Caribbean, hazard maps typically exist for a range of common hazard types, providing helpful information on areas that are prone to flooding or storm surge. However, these maps are often outdated and of low resolution, limiting analysis that uses geographic information systems and ultimately the translation of this information into risk management measures. To overcome this challenge, building requirements that reference specific hazard maps must become the basis for design, construction, inspection, and building code compliance.

Building standards must be adapted to local circumstances and uniformly applied across the sector to ensure all buildings comply with the local code. But to be effective, they must also consider how the poorest can afford to build, thus addressing the high levels of informal building in the Caribbean. It is advisable for national building legislation to provide guidance or make provision for national and local government management of informal sector builders. Jamaica is already doing this through its Building Act 2017, which establishes provisions for regulating a new category of "previously unregistered and unregulated (informal) builders". The Act gives building practitioners the opportunity to be formally registered and receive a license to construct residential and small commercial buildings. As most such buildings have not

previously been subject to regulatory review or inspection, this provision extends the benefits of building standards to the informal building sector.

Risk-informed land use and building code implementation and enforcement are typically the weakest parts of the building regulatory system due to a lack of allocated human and financial resources. Since many Caribbean countries are small and lack an abundance of financial and human resources, pooling regional resources can offer economies of scale that countries would otherwise not achieve. For example, enhanced regional collaboration through a centralized platform could offer greater opportunities for building industry practitioners to network, share relevant experiences, lessons learned and best practices, and access training that would enable them to bring their expertise where it is needed in the region. Alternatively, technological solutions—such as online building permit approval processes—can increase efficiency and enhance coordination among relevant agencies, enabling physical planning departments to focus their limited human resources on ensuring building codes are adequately implemented and enforced.

Develop risk-informed coastal and land use plans that consider future climate change impacts

Many Caribbean countries do not effectively use urban planning to strategically manage development to increase resilience. Although most have policies and documents that recognize the importance of urban planning and integrating disaster risk into planning, regulations and institutional frameworks continue to lag, and there are not enough human capital and skills to support the planning process. So, even when plans are in place, many countries lack the resources to implement them (Johnson, Caroca Fernandez and Restrepo Cadavid 2021).

Countries that have drafted new land use planning laws and policies should prioritize ratifying these to make them binding documents with a national government budget behind them. Countries should also review and update obsolete, out-dated, or colonial planning laws, if they still exist, and revise overlapping or unclear legislation to ensure clear responsibility for planning and environmental concerns. An important priority is also to institutionalise the meaningful participation of citizens and interest groups in planning by stipulating participation in laws or policies (Johnson, Caroca Fernandez and Restrepo Cadavid 2021).

Land use plans need to consider future climate change impacts and the resources required for protecting coastal areas from sea level rise. A high-level assessment of coastal protection infrastructure investment needs shows that some countries, such as Dominica, Guyana, and Suriname could have significant investment needs for coastal protection, driven by maintenance costs as much as new investments (*table 15.2*; Nicholls et al. 2019). In the absence of appropriate funding and asset management systems for adequately maintaining coastal protection infrastructure, governments should consider alternative strategies, including natural barriers and managed relocation. Making relocation a strategic option that leaves people, communities, and the environment better off poses significant challenges for coordinating scientific inputs and government support. Research is needed to identify vulnerable population groups and how to build communities' capacity to successfully navigate relocation. Incorporating local needs, knowledge, and preferences into planning processes is also crucial. Given the highly uncertain tradeoffs and consequences of managed relocation, governments should work with scientists to explore the actions, policies, and support that will make people better off across many plausible futures.

BOX 15.1 >>

Examples of adaptation options for St. Lucia

With its combination of steep coasts and low-lying beaches and towns, St. Lucia is representative of the different types of coastline typology present in the Caribbean. Important connecting transport hubs, such as the George F L Charles Airport, Dennery and Vieux Fort ports, and built-up areas like Anse le Raye and Laborie are already significantly exposed to floods, and this is only expected to increase with future sea level rise (***figure B15.1.1***). Sea level rise is also likely to have a considerable impact on the island's sandy beaches, which account for 25 percent of the coastline. According to estimates presented in ***chapter 2***, the expected average retreat of sandy beaches induced by sea level rise with no adaptation ranges from 50 meters under RCP 4.5 to 80 meters under RCP 8.5, resulting in a total land loss of 1.5–2.3 square kilometers.

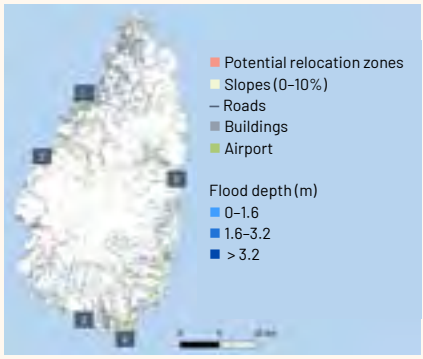
Safe areas for future development

Hazard maps—when available at local level—can be used as a planning tool to identify safe areas for development. ***Figure B15.1.1*** identifies safe areas by overlaying the 100-year return period flood extent in 2100 under the RCP 8.5 sea level rise scenario with the building footprint, road infrastructure, and terrain slope. The green dashed areas are relatively close to the urban hazardous zone (about 1.5 kilometers), so households at risk do not have to relocate far; these areas also have enough space to increase current urbanization, are close to existing road infrastructure, and have slopes smaller than 10 percent.[a] These areas could be suitable for potential future development or relocation from areas that are subject to flooding. Areas at, or close to airports are not marked as suitable for relocation since nuisance, safety, and future airport development have to be considered. Buildings and assets in locations with flood depths of 0.5 meter or more (dark blue) should be prioritized in possible retreat initiatives, followed by those in locations with flood depths of under 0.5 meter (light blue).

FIGURE B15.1.1 >>

Identifying areas that are potentially suitable for future development in St. Lucia

a) Location of areas



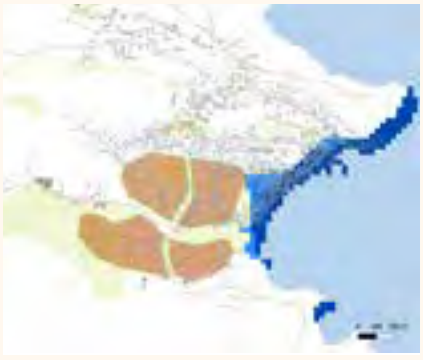
b) George F L Charles Airport region

c) Anse La Raye

d) Laborie

e) Vieux-Fort, Hewanorra International Airport

f) Dennery



Source: Giardino et al. 2021

Note: Areas in pink are potentially suitable for future development or relocations away from possible flood plains (in blue). Flooding is shown for sea level rise estimates by 2100 under RCP8.5.

The regions identified in the maps do not consider current detailed information on land use, ownership of land, and/or susceptibility to other types of natural hazard, such as erosion, riverine flooding, landslide, or earthquake. All these factors are important for identifying suitable relocation areas and should be part of a more detailed future planning study.

Adaptation strategies

In general, there are three options for adapting to coastal hazards and sea level rise (*figure B15.1.2*):

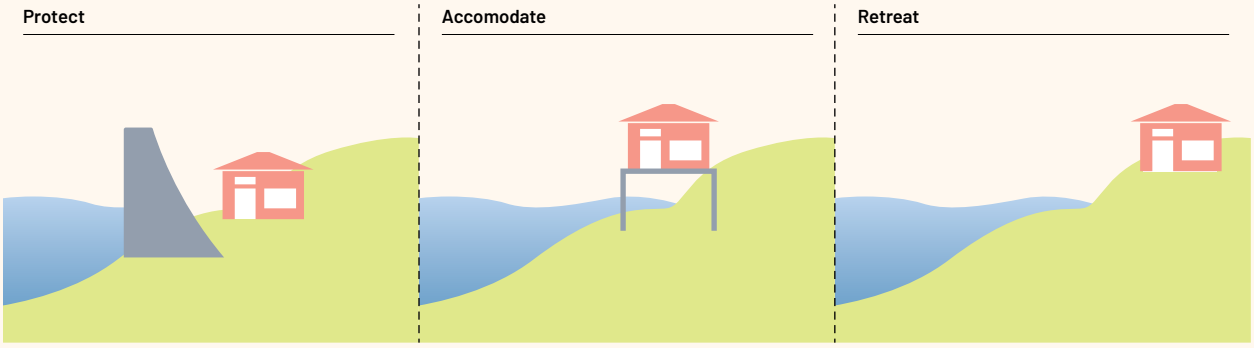
1. **Protect or advance:** defend vulnerable areas by building green and gray infrastructure
2. **Accommodate:** continue to occupy vulnerable areas but accept a greater degree of risk by changing land use and improving preparedness
3. **(Planned) retreat:** abandon structures in developed but exposed areas, resettling inhabitants and setting new developments back from the shore (Giardino et al. 2021; IPCC 1990)

In St. Lucia, the authorities should explore the (planned) retreat option for houses and (some of) the economic activities in low-lying areas close to the coastline. This will also imply adapting the island's road network to increase accessibility for more inland areas. For larger infrastructures—such as the airport and ports—it is more costly to retreat so viable strategies will be to protect—for example, with seawalls—or accommodate by increasing the height of the runway. In Anse La Raye, Laborie, and Dennery, which are fronted by sandy beaches, exploring coastal protection strategies, such as sand nourishments or hybrid solutions combining green and gray infrastructure, is an option. Sand nourishments are a nature-based type of solution, with the advantage of being flexible, easily adaptable to compensate for a faster or lower sea level rise rates and preserving the touristic attractiveness of beaches. When exploring coastal protection strategies, it is important to minimize the impact on the island's coastal ecosystems, including coral reef and mangroves, and make use of them as NBSs if possible.

Uncertainties in the rate and magnitude of sea level rise complicate coastal adaptation decision making (Haasnoot et al. 2020). Therefore, it is important to consider the feasibility of different adaptation strategies under different scenarios. For extreme sea level rise conditions of several meters, most accommodating or protecting options may no longer be feasible, necessitating setback zones and relocation zones to be explored for larger portions of the coastal towns (Giardino et al. 2021).

FIGURE B15.1.2 >>

Identifying areas that are potentially suitable for future development in St. Lucia



Source: Adapted from IPCC 1990

[a] Slopes between 6 and 9 percent are the maximum values indicated for wheelchair accessibility and comfortable pedestrian walking (Vernon, Tennant and Garmony 2013). These values are low enough to reduce both landslide risk and the required earthworks to level up a region for construction.

TABLE 15.2 >>

Caribbean countries' coastal protection capital and maintenance investment needs (2020–2050) under RCP 4.5

	Total coastal protection investment costs ($, millions)		Total coastal protection maintenance costs ($, millions)		Total cost per year (% of 2019 GDP)	
	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound
Antigua and Barbuda	53	138	94	256	0.3	0.8
Bahamas, The	1,828	1,711	2,275	4,779	1.0	1.6
Belize	194	508	244	660	0.8	2.1
Dominica	112	291	210	568	1.8	4.9
Dominican Republic	225	554	409	1,095	0.0	0.1
Guyana	5,095	10,869	2,431	5,178	4.8	10.3
Jamaica	128	280	256	561	0.1	0.2
St. Martin	59	153	103	282	0.4	1.0
St. Vincent and the Grenadines	18	47	33	90	0.2	0.6
Suriname	1,505	4,009	817	2,180	2.1	5.6
Turks and Caicos Islands	48	122	121	330	0.5	1.3
Total region	9,266	18,682	6,992	15,980	0.4	0.9

Source: Nicholls et al. 2018

Notes: Costs are presented for an adaptation strategy based on a cost-benefit analysis. Other scenarios are available in Nicholls et al. (2018).

In general, countries will need to simulate additional (and more extreme) sea level rise scenarios than those available today, to provide a broader range of possible impacts. Sea level rise modeling frameworks should also include other erosion processes (for example, from storms), the impacts of hurricane events (including rainfall and winds), and more accurate flood protection levels (for example, accounting for differences between countries and between urbanized and non-urbanized areas). Validating flood risk modeling results using local data from different countries after a flood event could provide useful insight on estimated flood risk, while a socioeconomic development assessment could make use of more realistic local data that account for urbanization trends in combination with future flood hazards.

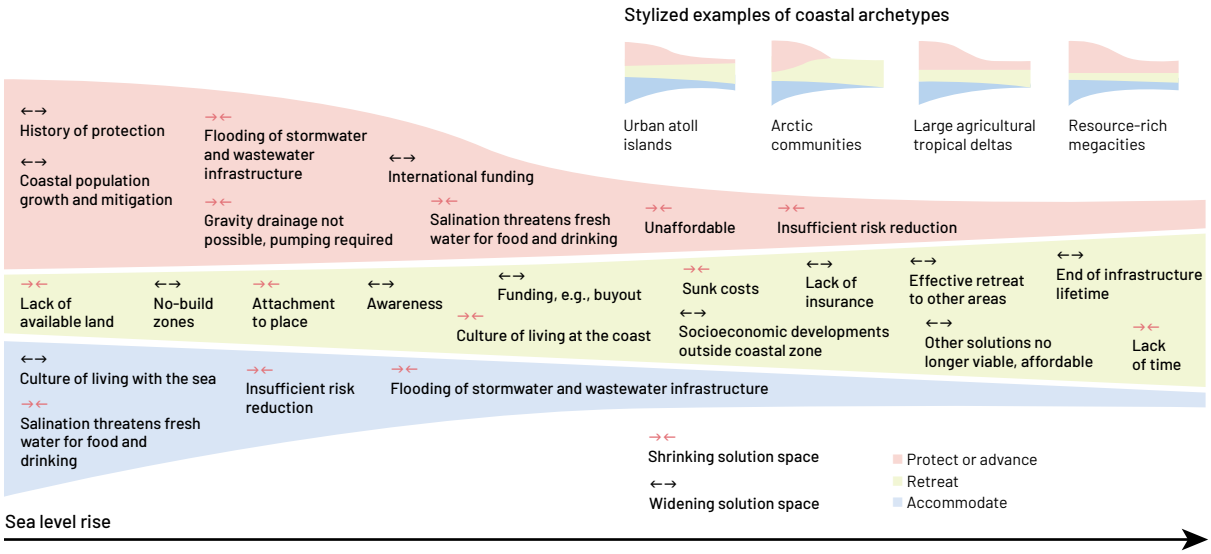
To start prioritizing possible adaptation options, it is important to jointly discuss hazard modeling results with different local stakeholders. Prioritization should consider a country's existing plans and priorities, possible physical, financial, and institutional limitations that could preclude the implementation of some of the options, and future socioeconomic developments. Such a process could provide the basis for setting up a multisectoral investment plan. To test different solutions, further improvement of local models and local data use (particularly DTM) are recommended to compare the costs and benefits of different options.

Dynamic adaptive policy pathway planning is a practical approach for exploring different adaptation pathways and to break solutions—which usually have to be planned far ahead—into manageable steps over time, align them with social and maintenance goals, and implement them, depending on how the future unfolds (Haasnoot, Lawrence and Magnan 2021). A first step in pathway planning is to assess hazards, vulnerabilities, and uncertainties, and identify adaptation options. Next, by sequencing options, starting with low-regret and preparatory actions that can or need to be taken in the near term, pathways can be designed while simultaneously testing their sensitivity to a range of sea level rise increments. Close monitoring enables the identification of early warning signals on approaching thresholds and windows of opportunity for preemptive action (Haasnoot, Lawrence and Magnan 2021). ***Figure 15.1*** shows some

adaptation to sea level rise thresholds and opportunities for urban atoll islands, starting with an initial narrowing of solution space as a whole, followed by a change in ratio between the three adaptation strategies, with retreat becoming more dominant.

FIGURE 15.1 >>

The changing solution space for urban island atolls under different adaptation strategies



Source: Haasnoot, Lawrence and Magnan 2021

Notes: The colored areas show how the solution space to protect or advance, accommodate, and retreat changes as sea levels rise. Depending on the coastal archetype, different solutions apply. This figure shows possible solutions for an urban atoll island, showcasing solutions for Caribbean islands.

As the solution space shrinks and the option to retreat becomes more important, Caribbean countries should start thinking about long-term dynamic planning and treating retreat as a serious adaptation option. Managed retreat takes decadal lead time to plan and implement equitably, as it involves a sequence of actions across pathways, including community engagement, vulnerability assessment, land use planning, active retreat, compensation, and repurposing (Haasnoot, Lawrence and Magnan 2021). Retreat is not easy but enables governments to anticipate long-term change at the coast in an orderly way, minimizing undesirable outcomes such as stress on people and agencies as well as inequitable outcomes. To determine when to start active retreat, countries can assess when retreat is required—for example, when other strategies become increasingly limited (towards the right side of the solution space in ***figure 15.1***)—or when retreat becomes more beneficial than other strategies. Haasnoot, Lawrence and Magnan (2021) recommend that, for retreat to be considered as a serious option and implemented where necessary, the following enablers are required:

- Improved understanding of how sea level rise is a changing risk over time and how it will affect communities differently
- Improved understanding of staging managed retreat
- Developing regulations and policies grounded in anticipatory planning
- Developing analytical methods such as mapping the solution space
- Identifying when retreat will be needed
- Enhancing the role of political leadership in building community trust for managed retreat

Take advantage of natural capital

Natural barriers are often cost-efficient, no-regret solutions for coastal protection that have many co-benefits, from becoming tourism attractions to providing habitats for animals that are critical for the fisheries sector. Investing in coastal wetlands can stabilize coastlines by trapping sediment with their root systems and reducing wave height and velocity with their dense vegetation. For example, salt marshes, coral reefs, seagrass beds, and mangroves can reduce non-storm wave heights by an average of 72, 70, 36, and 31 percent, respectively; coral and oyster reef systems can control coastal erosion by reducing wave velocity; and seagrass can help stabilize sediment and regulate water currents that contribute to coastal erosion. A paper prepared for this report finds that the presence of mangrove helps mitigate hurricane damage, avoiding 6–40 percent of total economic damage (Miranda et al. 2021). Restoring coastal wetlands can be two to five times cheaper than building submerged breakwaters to deal with wave heights of up to half a meter.

As well as being critical assets for tourism, sandy beaches and dunes can prevent waves and storm surge from reaching inland areas. Where sandy beaches are being eroded by sea level rise, they can be enhanced through artificial sand nourishment. However, sound environmental frameworks are necessary to ensure that dredging sand does not create environmental issues in other places.

TABLE 15.3 >>

Estimated beach nourishment costs in Caribbean countries, assuming no additional adaptation action

	Total beach nourishment cost (2020–2050, $ millions)		Total cost per year (% of 2019 GDP)	
	Lower bound	Upper bound	Lower bound	Upper bound
Antigua and Barbuda	111.2	556	0.22	1.12
Bahamas, The	4,158	20,790	1.02	5.10
Barbados	23.6	118	0.02	0.08
Belize	396	1,980	0.70	3.51
Dominican Republic	0	0	0	0
Dominica	256	1,280	1.47	7.33
Grenada	20.4	102	0.06	0.28
Guyana	164.4	822	0.11	0.53
Haiti	230.8	1,154	0.05	0.27
Jamaica	119.6	598	0.02	0.12
Sint Maarten	32	160	0.09	0.45
St. Kitts and Nevis	25.2	126	0.08	0.40
St. Lucia	26	130	0.04	0.20
St. Vincent and the Grenadines	19.2	96	0.08	0.39
Suriname	20.8	104	0.02	0.09
Trinidad and Tobago	127.2	636	0.02	0.09
Turks and Caicos	301.6	1,508	0.84	4.20
Total region	**6,032**	**30,160**	**0.11**	**0.55**

Source: Based on data from Giardino et al. 2021

Note: The lower-bound cost is based on $10 per cubic meter, while the upper-bound is based on $50 per cubic meter. Most of the cost is due to the need to dredge and transport the sand and thus depends on distance to the dredging site. The countries in blue are the third with the lowest costs, those in red are the third with the highest costs; those in yellow are the middle third.

Table 15.3 presents high-level estimates of the potential cost of beach nourishment in the Caribbean, assuming linear erosion between 2020 and 2050 and using current beach nourishment costs. It also compares annual beach nourishment costs to countries' 2019 GDP. These estimates show that beach nourishment can be an affordable solution to erosion in many countries. But in The Bahamas, Belize, Dominica, and Turks and Caicos, the costs are high, and countries will need to develop strategies for selecting the beaches they want to protect or complementing sand nourishment with other measures that reduce erosion—such as submerged breakwaters or vegetation on the beach—assuming there is no existing infrastructure. Where sand nourishment is too expensive, countries might need to organize managed retreat away from the coast to allow vegetation to protect the dunes and the beach.

Noting that understanding the institutional and policy environment that creates enabling conditions for NBS is key to their successful implementation, further enhancements for creating an enabling environment to integrate NBS into DRM and other development strategies include:

- Incorporating sustainable landscape vision into strategies and policies. Land use planning can help create a shared vision of the multiple goals of sustainable landscapes and help embed that vision into relevant jurisdictional strategies.

- Creating incentives for local actors to participate in NBS. This can include aligning public incentives with local or privately led NBS efforts, establishing national payment for ecosystem service programs or land acquisition programs for NBS.

- Authorizing and enabling NBS and allowing for regulatory flexibility. Governments can signal that individuals and firms can use NBS to comply with environmental requirements of building codes, water safety regulations, and environmental impact mitigation plans, and to achieve climate mitigation and adaptation objectives, and air quality and public health targets.

- Mainstreaming NBS into decision making. Integrating NBS into planning often involves guidance or policy—for example, providing criteria for infrastructure projects to include NBS—or adopting building codes or zoning laws that require a portion of space to be dedicated to green elements.

- Supporting NBS monitoring, research, and innovation through government-sponsored research and data collection programs.

- Facilitating cross-sector, interagency coordination to operationalize NBS. Governments can grant legal authority to DRM agencies to implement cross-sector NBS projects and link NBS to existing policy objectives such as climate mitigation, adaptation, infrastructure, and water security.

- Creating financing mechanisms to unlock investment in NBS. Governments can earmark public funds for explicit use in NBS or set policy that generates funds from other sources.

Another key to successful NBS implementation is ensuring the necessary funding is rerouted or unlocked to support these projects. Financing mechanisms and opportunities that can help provide the necessary funding required to fully achieve the NBS investment potential include:

- International public finance opportunities. Taking advantage of the financing provided by international environmental and climate funds—such as the Global Environmental Facility and the Green Climate Fund—can unlock a remarkable amount of financing for NBS.

» Domestic public finance opportunities. This includes using existing or defining new local and national taxes, fees, and charges to earmark funding for NBS and environmental projects, and structuring and defining municipal bonds for green or NBS projects.

» Defining new financing models to make NBS bankable and appeal to commercial interests. Examples include structuring and defining green bonds; insurance payments for risk reduction, such as Global Ecosystem Resilience Facility catastrophe bonds for supporting coastal Caribbean communities; pay-for-success models, where loan disbursements are made against results, such as environmental impact bonds or conservation impact bonds; and debt-for-nature swaps, especially for countries with large debts and threatened natural ecosystems.

Identify and strengthen critical infrastructure assets, including schools and health centers

Most countries would probably aspire to very low-risk infrastructure systems. Indeed, given their small size, this may seem achievable for most Caribbean countries. However, the severity and frequency of extreme events, the degree of uncertainty around the intensity and complexity of future events, and the financial and implementation capacity limitations these countries face advise a strategic approach based on prioritization instead. *Table 15.4* presents an estimation of the costs of retrofitting existing exposed infrastructure. Although it does not cover all assets, these calculations suggest that costs are relatively limited in most Caribbean countries and could be spread over several years. For example, Belize, Guyana, Haiti, the Dominican Republic, and Trinidad and Tobago spent on average 1.95 percent of GDP on infrastructure between 2008 and 2019. Belize spends the most, with an average of 4.2 percent, and Haiti the least, at 0.39 percent (Infralatam 2021). There are, however, several caveats. First, these estimates assume that infrastructure is well maintained, while many of the assets could be in bad condition. If this is the case, retrofitting would become reconstruction, which costs two to three times more. Second, the estimates assume that authorities know which assets are exposed to hazards and can prioritize investments based on exposure. Third, although retrofitting would reduce vulnerability by 30 to 80 percent depending on the assets, it would not offer much protection against high-intensity events like Category 5 hurricanes, so there is still a need for preparedness (Miyamoto International 2021).

Increasing the resilience of infrastructure systems at an acceptable cost begins by identifying its most critical parts that are also exposed and vulnerable. Criticality analyses can help identify which parts of a networked system play particularly important roles for the functioning of the whole system, making it possible to prioritize the interventions that will give the largest benefits. Since criticality analyses include the functional aspects of systems, they can also help inform preparedness and response activities for the assets identified as critical but where interventions to increase resilience have yet to take place. In this way, the focus shifts from an asset-based to a resilience-based perspective, which goes beyond the robustness of a system to address flexibility and adaptability (Fisher and Gamper 2017). Given budget constraints in the Caribbean, using criticality analyses can help prioritize across sectors.

TABLE 15.4 >>

Costs of retrofitting existing infrastructure assets exposed to hazards in Caribbean countries

	Low retrofit cost (% of 2019 GDP)	High retrofit cost (% of 2019 GDP)	Roads	Bridges	Power plants	Hospitals	Airports	Water treatment plants
Antigua and Barbuda	1.4	3.9	✓	✓	✓	✓		
Bahamas, The	4	9.5	✓	✓	✓	✓	✓	
Barbados	0.3	1.1	✓	✓	✓	✓		
Belize	4.6	21.2	✓	✓	✓	✓	✓	
Dominica	3	14	✓	✓	✓	✓	✓	
Dominican Republic	2	5.2	✓	✓	✓	✓	✓	✓
Grenada	0.3	1	✓	✓	✓	✓		✓
Haiti	1.2	3.7	✓	✓	✓	✓	✓	
Jamaica	1.5	6	✓	✓	✓	✓		✓
St. Kitts and Nevis	0.4	1.2	✓	✓	✓	✓		
St. Lucia	0	0.4	✓	✓		✓		
St. Vincent and the Grenadines	1.3	2.4	✓	✓	✓	✓		
Suriname	15.9	27.1	✓	✓	✓	✓	✓	
Trinidad and Tobago	2.8	4.9	✓	✓	✓	✓		

Source: Based on data from Miyamoto International 2021; Schweikert et al. 2021

Notes: Only the assets for which publicly available localization data are available are considered. The improvement considered would reduce vulnerability by 30–80 percent, depending on the asset and the hazard. Calculations assume that assets are in good condition; however, if assets need to be rebuilt rather than improved, costs will double or triple.

When identifying critical facilities in the education sector, it is necessary to reflect on the role of learning spaces in the community. Schools function as social spaces for communities and, in times of disaster, as emergency shelters. If housing infrastructure is significantly damaged or destroyed, the return of schools to educational use is often delayed. Recent experiences in the Dominican Republic have proved that school facilities are central to community well-being. The country is using school facilities to implement public policies to overcome health, nutrition, and recreational challenges at community level. Developing operational guidelines for different school uses—including as emergency shelters—is essential to the resilience of the education system.

After identifying critical infrastructure assets and systems, governments need to redefine acceptable and intolerable risk levels, which infrastructure sectors can then use to design their own regulations and measures, ensuring consistency across systems. For health facilities, they can use PAHO's Smart Hospital Initiative[1] and the *WHO Guidance for Climate Resilient and Environmentally Sustainable Health Care Facilities* (WHO 2020) to guide and support national infrastructure improvements.

Develop water resources management strategies

Utilities need to reimagine the paradigm of water management to handle today's complexities and uncertainties, bearing in mind their interconnections and anticipating the range of unpredictable events and changes, which can range from natural and anthropogenic disasters to demographic shifts, pandemics, land use changes, and other shocks. Paltán et al. (2020) recommend that water utilities and national governments must evaluate investments, not only in terms of the traditional analysis of coverage, access, and financial indicators, but also under the lens of resilience, considering how they should build infrastructure to respond to extreme, unusual, unforeseen, and unpredictable events. Their salient findings are that:

- Utilities in the Caribbean should increase access to piped water
- Collection and treatment of wastewater are severely lacking
- Utilities need to establish reliable income streams to cover costs and invest in their systems
- Data management and recordkeeping are deficient—yet indispensable for assessing performance
- Countries should have clear baselines on performance and establish multiyear targets for increasing quality of service and operating efficiency and agree on sources of funding to cover the associated costs
- Countries should seek to increase SOEs transparency and accountability

Be prepared to build back better, possibly in different places

It can take many years for Caribbean countries to recover from a disaster, and the process is often interrupted by yet another impact. When Hurricane Maria struck Dominica in 2017, the commerce and microbusiness sector was only beginning to regain its strength after Tropical Storm Erika in 2015, and housing reconstruction had not been finalized. An efficient recovery can reduce the impact not only of future disasters but also of the disaster that caused the damage in the first place, by helping the economy bounce back more quickly. However, the often high level of urgency to reconstruct usually leaves little time and human resources are stretched. To be truly able to build back better, governments need to prepare for a faster, stronger recovery and reconstruction.

Faster recovery refers to speedier reestablishment of connectivity and access to services, which shortens impacts on well-being. To achieve this, materials, machinery, replacements, and people need to be pre-positioned before an event so they can efficiently access and address issues. Many countries in the region already use this practice but can strengthen it further through risk analytics and by prioritizing critical infrastructure. Faster recovery also requires quick procurement of goods and services while ensuring accountability, transparency, and overall value for money, considering quality, cost, and delivery time. Apart from Jamaica, emergency procurement planning and procedures are relatively weak in the region. Strengthening disaster-resilient and responsive procurement through market research, and by preparing procurement plans and developing sourcing strategies is critical for speeding up recovery in the region so that, when a disaster occurs, agencies already have information on adequate suppliers and can use pre-established transparent expenditure procedures. According to Hallegatte, Rentschler and Walsh (2018), faster recovery could lower average well-being losses by 46 percent in Belize and St. Lucia, 50 percent in Trinidad and Tobago, and 54 percent in Dominica.

Reconstruction that does not consider risk-informed land use plans and follows outdated building codes—or fails to enforce building codes—will miss the opportunity to increase resilience with a forward-looking perspective that takes climate change effects into account. Preparing for recovery requires obtaining the

necessary political commitment for developing recovery policies and programs that strengthen public and private sector institutional and technical capacities to ensure individual builders, carpenters, contractors, and building officials at all levels of government have the capacity for design, construction, and quality assurance required for postdisaster situations. According to Hallegatte, Rentschler and Walsh (2018), stronger reconstruction would reduce overall well-being losses due to natural disasters by more than 40 percent in Antigua and Barbuda, Dominica, and Trinidad and Tobago.

While political commitment may be limited before a disaster, extreme events often open a window of opportunity to pass previously prepared legislation, enact specific guidelines, or enable the use of supporting information. Housing is one of the fields where preparation is particularly critical, especially if resettlement is involved. Without land use plans, it is impossible to relocate people quickly to safe areas. Besides, with sea level rise, current resettlement approaches are likely to be inadequate. Making resettlement a viable option requires much higher coordination between stakeholders and continuous planning processes. Given the uncertainty around future climate impacts, key issues are how to best incorporate local needs, knowledge, and preferences into planning processes, and ensuring choices are flexible.

Endnotes

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Appendix A

ANTIGUA AND BARBUDA

- Surface area (sq. km): **440**
- GDP per cap ($): **17,110**
- Total population: **97,100**

*Summary of risk drivers for Antigua and Barbuda. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

Urban built-up area	*7.8%*
Roads	*4.3%*
Agricultural land	*16.5%*
Airports and ports	*0%*
Facilities *(power plants, waste water treatment, health)*	*0%*

VULNERABILITY

PEOPLE

Poverty rate	*18.3%*
Inequality (Gini index)	

MACROECONOMY

Lack of diversification	
Trade deficit	*8.3%*
Debt	*90.1%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

Volatility of per capita GDP growth	
Annual average well-being losses	*23%*
Average annual asset losses, earthquake	*0.49%*
Average annual asset losses, hurricane	*3.81%*
Average annual asset losses, tsunami	*0.001%*
Average annual asset losses, flood	*0%*
Annual average asset losses, total	*4.30%*

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	*0.28%*
Shoreline retreat	*0.03%*
Hotels experiencing beach loss	*55.1%*
Landmass loss	*0.63%*
Annual extreme heat days increase	*26*
Agricultural yield loss	*18%*

BAHAMAS, THE

- Surface area (sq. km): **13,880**
- GDP per cap ($): **34,860**
- Total population: **389,500**

*Summary of risk drivers for The Bahamas. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

- Urban built-up area — *14.7%*
- Roads — *4.9%*
- Agricultural land — *20.0%*
- Airports and ports — *6.6%*
- Facilities *(power plants, waste water treatment, health)* — *5.3%*

VULNERABILITY

PEOPLE

- Poverty rate — *12.8%*
- Inequality (Gini index)

MACROECONOMY

- Lack of diversification
- Trade deficit — *10.0%*
- Debt — *55.5%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

- Volatility of per capita GDP growth
- Annual average well-being losses
- Average annual asset losses, earthquake — *0%*
- Average annual asset losses, hurricane — *4.79%*
- Average annual asset losses, tsunami — *0%*
- Average annual asset losses, flood — *0%*
- Annual average asset losses, total — *4.79%*

CLIMATE CHANGE IMPACTS IN 2050

- People exposed to coastal flooding — *0.46%*
- Shoreline retreat — *0%*
- Hotels experiencing beach loss — *17.9%*
- Landmass loss — *0.75%*
- Annual extreme heat days increase — *107*
- Agricultural yield loss — *18%*

BARBADOS

- Surface area (sq. km): **430**
- GDP per cap ($): **18,150**
- Total population: **287,000**

*Summary of risk drivers for Barbados. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

- *No data/Unknown*
- *Low*
- *Medium*
- *High*

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

- Urban built-up area: *4.6%*
- Roads: *2.5%*
- Agricultural land: *10.5%*
- Airports and ports: *0%*
- Facilities *(power plants, waste water treatment, health)*: *0%*

VULNERABILITY

PEOPLE

- Poverty rate: *17.2%*
- Inequality (Gini index)

MACROECONOMY

- Lack of diversification
- Trade deficit: *4.0%*
- Debt: *145.4%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

- Volatility of per capita GDP growth
- Annual average well-being losses
- Average annual asset losses, earthquake: *0.16%*
- Average annual asset losses, hurricane: *0.58%*
- Average annual asset losses, tsunami: *0%*
- Average annual asset losses, flood: *0%*
- Annual average asset losses, total: *0.74%*

CLIMATE CHANGE IMPACTS IN 2050

- People exposed to coastal flooding: *0.01%*
- Shoreline retreat: *0%*
- Hotels experiencing beach loss: *0.4%*
- Landmass loss: *0.14%*
- Annual extreme heat days increase: *32*
- Agricultural yield loss: *18%*

BELIZE

- Surface area (sq. km): **22,970**
- GDP per cap ($): **4,820**
- Total population: **390,400**

*Summary of risk drivers for Belize. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

- Urban built-up area — *9.1%*
- Roads — *14.4%*
- Agricultural land — *27.3%*
- Airports and ports — *8.0%*
- Facilities *(power plants, waste water treatment, health)* — *6.3%*

VULNERABILITY

PEOPLE

- Poverty rate — *41.3%*
- Inequality (Gini index) — *53.3*

MACROECONOMY

- Lack of diversification
- Trade deficit — *8.6%*
- Debt — *96.3%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

- Volatility of per capita GDP growth
- Annual average well-being losses
- Average annual asset losses, earthquake — *0.05%*
- Average annual asset losses, hurricane — *0.73%*
- Average annual asset losses, tsunami — *0%*
- Average annual asset losses, flood — *0.61%*
- Annual average asset losses, total — *1.39%*

CLIMATE CHANGE IMPACTS IN 2050

- People exposed to coastal flooding — *0.26%*
- Shoreline retreat — *0%*
- Hotels experiencing beach loss
- Landmass loss — *0.04%*
- Annual extreme heat days increase — *85*
- Agricultural yield loss — *61%*

DOMINICA

- Surface area (sq. km): **750**
- GDP per cap ($): **8,110**
- Total population: **71,800**

*Summary of risk drivers for Dominica. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

- *No data/Unknown*
- *Low*
- *Medium*
- *High*

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

Urban built-up area	*15.2%*
Roads	*7.3%*
Agricultural land	*8.2%*
Airports and ports	*25.0%*
Facilities *(power plants, waste water treatment, health)*	*16.7%*

VULNERABILITY

PEOPLE

Poverty rate	*28.8%*
Inequality (Gini index)	

MACROECONOMY

Lack of diversification	
Trade deficit	*20.5%*
Debt	*75.6%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

Volatility of per capita GDP growth	
Annual average well-being losses	*6.7%*

Average annual asset losses, earthquake	*0.64%*
Average annual asset losses, hurricane	*2.73%*
Average annual asset losses, tsunami	*0%*

Average annual asset losses, flood	*0%*
Annual average asset losses, total	*3.38%*

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	*1.51%*
Shoreline retreat	*0.05%*

Hotels experiencing beach loss	*0%*
Landmass loss	*0%*

Annual extreme heat days increase	*36*
Agricultural yield loss	*18%*

DOMINICAN REPUBLIC

- Surface area (sq. km): **48,670**
- GDP per cap ($): **8,280**
- Total population: **10,739,000**

*Summary of risk drivers for the Dominican Republic. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

- *No data/Unknown*
- *Low*
- *Medium*
- *High*

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

Urban built-up area	*13.6%*
Roads	*10.7%*
Agricultural land	*19.5%*
Airports and ports	*12.5%*
Facilities *(power plants, waste water treatment, health)*	*8.0%*

VULNERABILITY

PEOPLE

Poverty rate	*20.9%*
Inequality (Gini index)	*41.9*

MACROECONOMY

Lack of diversification	
Trade deficit	*0.9%*
Debt	*48.6%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

Volatility of per capita GDP growth	
Annual average well-being losses	*1.6%*
Average annual asset losses, earthquake	*0.18%*
Average annual asset losses, hurricane	*0.27%*
Average annual asset losses, tsunami	*0%*
Average annual asset losses, flood	*0.04%*
Annual average asset losses, total	*0.49%*

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	*0.06%*
Shoreline retreat	*0%*
Hotels experiencing beach loss	*16.8%*
Landmass loss	*0%*
Annual extreme heat days increase	*122*
Agricultural yield loss	*16%*

GRENADA

- Surface area (sq. km): **340**
- GDP per cap ($): **10,810**
- Total population: **112,000**

*Summary of risk drivers for Grenada. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

Urban built-up area	*10.1%*
Roads	*4.7%*
Agricultural land	*10.8%*
Airports and ports	*0%*
Facilities *(power plants, waste water treatment, health)*	*0%*

VULNERABILITY

PEOPLE

Poverty rate	*37.7%*
Inequality (Gini index)	

MACROECONOMY

Lack of diversification	
Trade deficit	*13.8%*
Debt	*72.0%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

Volatility of per capita GDP growth	
Annual average well-being losses	
Average annual asset losses, earthquake	*0.19%*
Average annual asset losses, hurricane	*0.46%*
Average annual asset losses, tsunami	*0%*
Average annual asset losses, flood	*0%*
Annual average asset losses, total	*0.65%*

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	*0.21%*
Shoreline retreat	*0.16%*
Hotels experiencing beach loss	*0%*
Landmass loss	*0.15%*
Annual extreme heat days increase	*4*
Agricultural yield loss	*18%*

GUYANA

- Surface area (sq. km): **214,970**
- GDP per cap ($): **6,610**
- Total population: **782,800**

*Summary of risk drivers for Guyana. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

Flood, river	
Flood, urban	
Flood, coastal	
Hurricane	
Landslide	
Earthquake	
Tsunami	
Wildfire	
Volcano	
Extreme heat	
Water scarcity	

ASSET EXPOSURE

Urban built-up area	*37.2%*
Roads	*0.1%*
Agricultural land	*24.6%*
Airports and ports	*0%*
Facilities *(power plants, waste water treatment, health)*	*0%*

VULNERABILITY

PEOPLE

Poverty rate	
Inequality (Gini index)	*45.1*

MACROECONOMY

Lack of diversification	
Trade deficit	*10.9%*
Debt	*51.7%*

ECONOMIC SECTORS

Road network vulnerability	
Economic structure vulnerability	
Financial vulnerability index	

RISK

Volatility of per capita GDP growth	
Annual average well-being losses	*1.8%*
Average annual asset losses, earthquake	*0.001%*
Average annual asset losses, hurricane	*0%*
Average annual asset losses, tsunami	*0%*
Average annual asset losses, flood	*0.42%*
Annual average asset losses, total	*0.42%*

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	*2.32%*
Shoreline retreat	*0.07%*
Hotels experiencing beach loss	
Landmass loss	*0%*
Annual extreme heat days increase	*142*
Agricultural yield loss	*11%*

HAITI

- Surface area (sq. km): **27,750**
- GDP per cap ($): **1,270**
- Total population: **11,263,100**

*Summary of risk drivers for Haiti. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

Urban built-up area	*23.3%*
Roads	*11.0%*
Agricultural land	*13.3%*
Airports and ports	*8.3%*
Facilities *(power plants, waste water treatment, health)*	*8.8%*

VULNERABILITY

PEOPLE

Poverty rate	*58.5%*
Inequality (Gini index)	*41.1*

MACROECONOMY

Lack of diversification	
Trade deficit	*3.9%*
Debt	*39.3%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

Volatility of per capita GDP growth	
Annual average well-being losses	*12.1%*
Average annual asset losses, earthquake	*0.42%*
Average annual asset losses, hurricane	*0.18%*
Average annual asset losses, tsunami	*0%*
Average annual asset losses, flood	*0.10%*
Annual average asset losses, total	*0.70%*

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	*0.06%*
Shoreline retreat	*0%*
Hotels experiencing beach loss	*0%*
Landmass loss	*0%*
Annual extreme heat days increase	*154*
Agricultural yield loss	*12%*

JAMAICA

- Surface area (sq. km): **10,990**
- GDP per cap ($): **5,580**
- Total population: **2,948,300**

*Summary of risk drivers for Jamaica. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

- Urban built-up area — *11.3%*
- Roads — *12.1%*
- Agricultural land — *16.2%*
- Airports and ports — *0%*
- Facilities *(power plants, waste water treatment, health)* — *20.0%*

VULNERABILITY

PEOPLE

- Poverty rate — *12.6%*
- Inequality (Gini index) — *45.5*

MACROECONOMY

- Lack of diversification
- Trade deficit — *1.5%*
- Debt — *104.7%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

- Volatility of per capita GDP growth
- Annual average well-being losses — *2.4%*
- Average annual asset losses, earthquake — *0.07%*
- Average annual asset losses, hurricane — *0.57%*
- Average annual asset losses, tsunami — *0%*
- Average annual asset losses, flood — *0.01%*
- Annual average asset losses, total — *0.65%*

CLIMATE CHANGE IMPACTS IN 2050

- People exposed to coastal flooding — *0.3%*
- Shoreline retreat — *0.02%*
- Hotels experiencing beach loss — *27.5%*
- Landmass loss — *0%*
- Annual extreme heat days increase — *154*
- Agricultural yield loss — *19%*

SINT MAARTEN

- Surface area (sq. km): **34**
- GDP per cap ($): **29,160**
- Total population: **40,700**

*Summary of risk drivers for Sint Maarten. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

- Urban built-up area — *0.4%*
- Roads
- Agricultural land — *0%*
- Airports and ports
- Facilities *(power plants, waste water treatment, health)*

VULNERABILITY

PEOPLE

- Poverty rate
- Inequality (Gini index)

MACROECONOMY

- Lack of diversification
- Trade deficit
- Debt

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

- Volatility of per capita GDP growth
- Annual average well-being losses
- Average annual asset losses, earthquake
- Average annual asset losses, hurricane
- Average annual asset losses, tsunami
- Average annual asset losses, flood
- Annual average asset losses, total

CLIMATE CHANGE IMPACTS IN 2050

- People exposed to coastal flooding — *0.49%*
- Shoreline retreat — *0.14%*
- Hotels experiencing beach loss — *8.7%*
- Landmass loss — *2.35%*
- Annual extreme heat days increase
- Agricultural yield loss — *18%*

ST. KITTS AND NEVIS

- Surface area (sq. km): **260**
- GDP per cap ($): **19,930**
- Total population: **52,800**

*Summary of risk drivers for St. Kitts and Nevis. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

- Urban built-up area: *0.3%*
- Roads: *1.7%*
- Agricultural land: *0.5%*
- Airports and ports: *0%*
- Facilities *(power plants, waste water treatment, health)*: *10.0%*

VULNERABILITY

PEOPLE

- Poverty rate: *21.8%*
- Inequality (Gini index)

MACROECONOMY

- Lack of diversification
- Trade deficit: *9.9%*
- Debt: *60.1%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

- Volatility of per capita GDP growth
- Annual average well-being losses
- Average annual asset losses, earthquake: *0.65%*
- Average annual asset losses, hurricane: *1.35%*
- Average annual asset losses, tsunami: *0%*
- Average annual asset losses, flood: *0%*
- Annual average asset losses, total: *2.00%*

CLIMATE CHANGE IMPACTS IN 2050

- People exposed to coastal flooding: *0.34%*
- Shoreline retreat: *0.06%*
- Hotels experiencing beach loss: *6.3%*
- Landmass loss: *0.24%*
- Annual extreme heat days increase: *35*
- Agricultural yield loss: *18%*

ST. LUCIA

- Surface area (sq. km): **620**
- GDP per cap ($): **11,610**
- Total population: **182,800**

*Summary of risk drivers for St. Lucia. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

Urban built-up area	*9.3%*
Roads	*7.8%*
Agricultural land	*9.6%*
Airports and ports	*0%*
Facilities *(power plants, waste water treatment, health)*	*14.3%*

VULNERABILITY

PEOPLE

Poverty rate	*25.0%*
Inequality (Gini index)	*51.2*

MACROECONOMY

Lack of diversification	
Trade deficit	*1.8%*
Debt	*60.9%*

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

Volatility of per capita GDP growth	
Annual average well-being losses	*2.8%*
Average annual asset losses, earthquake	*0.15%*
Average annual asset losses, hurricane	*1.24%*
Average annual asset losses, tsunami	*0%*
Average annual asset losses, flood	*0%*
Annual average asset losses, total	*1.39%*

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	*0.14%*
Shoreline retreat	*0.08%*
Hotels experiencing beach loss	*28.9%*
Landmass loss	*0.10%*
Annual extreme heat days increase	*27*
Agricultural yield loss	*18%*

ST. VINCENT AND THE GRENADINES

- Surface area (sq. km): **390**
- GDP per cap ($): **7,460**
- Total population: **110,600**

*Summary of risk drivers for St. Vincent and the Grenadines. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

Urban built-up area	17.2%
Roads	3.7%
Agricultural land	8.1%
Airports and ports	0%
Facilities *(power plants, waste water treatment, health)*	11.1%

VULNERABILITY

PEOPLE

Poverty rate	30.2%
Inequality (Gini index)	

MACROECONOMY

Lack of diversification	
Trade deficit	12.5%
Debt	77.6%

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

Volatility of per capita GDP growth	
Annual average well-being losses	2.2%

Average annual asset losses, earthquake	0.11%
Average annual asset losses, hurricane	0.82%
Average annual asset losses, tsunami	0%

Average annual asset losses, flood	0%
Annual average asset losses, total	0.93%

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	0.07%
Shoreline retreat	0.04%

Hotels experiencing beach loss	0.7%
Landmass loss	0.12%

Annual extreme heat days increase	19
Agricultural yield loss	18%

SURINAME

- Surface area (sq. km): **163,820**
- GDP per cap ($): **6,360**
- Total population: **581,400**

*Summary of risk drivers for Suriname. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

Flood, river	High
Flood, urban	High
Flood, coastal	High
Hurricane	Low
Landslide	Low
Earthquake	Low
Tsunami	Medium
Wildfire	High
Volcano	
Extreme heat	Medium
Water scarcity	Low

ASSET EXPOSURE

Urban built-up area	34.6%
Roads	
Agricultural land	26.4%
Airports and ports	21.4%
Facilities (power plants, waste water treatment, health)	23.1%

VULNERABILITY

PEOPLE

Poverty rate	
Inequality (Gini index)	57.9

MACROECONOMY

Lack of diversification	
Trade deficit	2.1%
Debt	74.3%

ECONOMIC SECTORS

Road network vulnerability	
Economic structure vulnerability	
Financial vulnerability index	

RISK

Volatility of per capita GDP growth	High
Annual average well-being losses	
Average annual asset losses, earthquake	0%
Average annual asset losses, hurricane	0%
Average annual asset losses, tsunami	0%
Average annual asset losses, flood	0.55%
Annual average asset losses, total	0.55%

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	1.72%
Shoreline retreat	0.64%
Hotels experiencing beach loss	
Landmass loss	0%
Annual extreme heat days increase	
Agricultural yield loss	11%

TRINIDAD AND TOBAGO

- Surface area (sq. km): **5,130**
- GDP per cap ($): **17,400**
- Total population: **1,395,000**

*Summary of risk drivers for Trinidad and Tobago. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

Urban built-up area	19.5%
Roads	11.0%
Agricultural land	22.5%
Airports and ports	15.4%
Facilities *(power plants, waste water treatment, health)*	11.0%

VULNERABILITY

PEOPLE

Poverty rate	17.1%
Inequality (Gini index)	40.3

MACROECONOMY

Lack of diversification	
Trade deficit	-3.2%
Debt	40.6%

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

Volatility of per capita GDP growth	
Annual average well-being losses	2.0%
Average annual asset losses, earthquake	0.87%
Average annual asset losses, hurricane	0.03%
Average annual asset losses, tsunami	0%
Average annual asset losses, flood	0.001%
Annual average asset losses, total	0.90%

CLIMATE CHANGE IMPACTS IN 2050

People exposed to coastal flooding	0.03%
Shoreline retreat	0.06%
Hotels experiencing beach loss	66.8%
Landmass loss	0.06%
Annual extreme heat days increase	22
Agricultural yield loss	18%

TURKS AND CAICOS

- Surface area (sq. km): **950**
- GDP per cap ($): **31,350**
- Total population: **38,200**

*Summary of risk drivers for Turks and Caicos. The ratings (low/medium/high) are all relative to other countries in the Caribbean, except for probability of natural shocks, which is from ThinkHazard.org. See **Annex A** for more details on data sources and methods.*

No data/Unknown
Low
Medium
High

PROBABILITY OF NATURAL SHOCKS

- Flood, river
- Flood, urban
- Flood, coastal
- Hurricane
- Landslide
- Earthquake
- Tsunami
- Wildfire
- Volcano
- Extreme heat
- Water scarcity

ASSET EXPOSURE

- Urban built-up area
- Roads — *0%*
- Agricultural land
- Airports and ports — *0%*
- Facilities *(power plants, waste water treatment, health)* — *0%*

VULNERABILITY

PEOPLE

- Poverty rate
- Inequality (Gini index)

MACROECONOMY

- Lack of diversification
- Trade deficit
- Debt

ECONOMIC SECTORS

- Road network vulnerability
- Economic structure vulnerability
- Financial vulnerability index

RISK

- Volatility of per capita GDP growth
- Annual average well-being losses
- Average annual asset losses, earthquake — *0.01%*
- Average annual asset losses, hurricane — *1.96%*
- Average annual asset losses, tsunami — *0.001%*
- Average annual asset losses, flood — *0%*
- Annual average asset losses, total — *1.97%*

CLIMATE CHANGE IMPACTS IN 2050

- People exposed to coastal flooding — *0.08%*
- Shoreline retreat — *0%*
- Hotels experiencing beach loss — *2.6%*
- Landmass loss — *0.79%*
- Annual extreme heat days increase
- Agricultural yield loss — *18%*

ANNEX A

Indicator	Low	Medium	High	Notes	Source
PROBABILITY OF NATURAL SHOCKS					
Flood, river	Return period: 1,000 years, flood depth: 0.5m	Return period: 50 years, flood depth: 0.5m	Return period: 10 years, flood depth: 0.5m	(i) For probabilistic data, the probability of occurrence is classified as *high* if the hazard exceeds at any location in the ADM-2 (second order administrative division) unit the damaging intensity threshold presented under *high*; the same for *medium* and *low* for their respective thresholds. This implies that aggregation at the national level, as has been done for purposes of this report, in the most extreme cases can result in classifying the entire country as *high* when just one ADM-2 unit classified as *high*. For more detail on ADM-1 or ADM-2, visit https://thinkhazard.org/en/. (ii) While ThinkHazard! distinguishes between *low* and *very low*, for the purposes of this report, both are aggregated under *low*. (iii) For hurricanes, the categorization is based on the probability of a Category 4–5 storm passing within 30km of each country. The 30km buffer is used to also consider passing storms which do not make landfall, but the actual radii of damaging winds varies. Storm tracks are based on the synthetic 10,000 year event set of the STORM Dataset (Bloemendaal et al. 2020).	ThinkHazard!
Flood, urban	Return period: 1,000 years, flood depth: 0.5m	Return period: 50 years, flood depth: 0.5m	Return period: 10 years, flood depth: 0.5m		ThinkHazard!
Flood, coastal	Return period: 100 years, flood depth: 0.5m	Return period: 50 years, flood depth: 0.5m	Return period: 10 years, flood depth: 2m		ThinkHazard!
Hurricane	Return period: 1,000 years, Category 4–5	Return period: 100 years, Category 4–5	Return period: 50 years, Category 4–5		Authors' calculations
Landslide	Annual frequency: <3.2 landslides/km^2/year	Annual frequency: 3.2–7.5 landslides/km^2/year	Annual frequency: >7.5 landslides/km^2/year		ThinkHazard!
Earthquake	Return period: 1,000–2,500 years, Peak ground acceleration (PGA): 0.1g	Return period: 475–500 years, PGA: 0.1g	Return period: 100–250 years, PGA: 0.2g		ThinkHazard!
Tsunami	Return period: 2,500 years, coastal maximum amplitude: 0.5m	Return period: 500 years, coastal maximum amplitude: 1m	Return period: 100 years, coastal maximum amplitude: 2m		ThinkHazard!
Wildfire	Return period: 30 years, Canadian wildfire index: >15WFI	Return period: 10 years, Canadian wildfire index: >20WFI	Return period: 2 years, Canadian wildfire index: >30WFI		ThinkHazard!
Volcano	Volcanic explosivity index: <3 or last known eruption date in more ancient times or not known	Volcanic explosivity index: 3–5 or last known eruption date <10,000 years ago	Volcanic explosivity index: >5 or last known eruption date <2,000 years ago		ThinkHazard!
Extreme heat	Return period: 100 years, daily maximum temperature: <28°C	Return period: 20 years, daily maximum temperature: 28–32°C	Return period: 5 years, daily maximum temperature: >32°C		ThinkHazard!
Water scarcity	≤1,700 m^3/capita/year	≤1,000 m^3/capita/year	≤500 m^3/capita/year		AQUASTAT
ASSET EXPOSURE					
Urban built-up area	Bottom third	Middle third	Top third	Share of urban areas exposed to river, urban, and coastal flooding, >15cm flood depths, return period: 100 years.	Authors' calculations
Roads	Bottom third	Middle third	Top third	Share of primary, secondary and tertiary roads exposed to river, coastal, and urban flooding, return period: 50 years.	Schweikert et al. 2021
Agriculture land	Bottom third	Middle third	Top third	Share of agricultural land exposed to river, urban, and coastal flooding, >15cm flood depths, return period: 100 years.	Authors' calculations
Facilities (power plants, waste water treatment and health facilities)	Bottom third	Middle third	Top third	Share of power plants, health and waste water treatment facilities exposed to river, coastal, and urban flooding, return period: 50 years.	Schweikert et al. 2021
Airports and ports	Bottom third	Middle third	Top third	Share of airports and ports exposed to river, coastal, and urban flooding, return period: 50 years.	Schweikert et al. 2021
VULNERABILITY					
Poverty rate	Bottom third	Middle third	Top third	Share of population that is poor, latest year available.	Country Poverty Assessment Reports and Living Conditions Surveys 2005–2018
Inequality (Gini index)	Bottom third	Middle third	Top third	The Gini index is a measure of statistical dispersion representing the income or wealth inequality in a country.	World Development Indicators
Lack of diversification	Bottom third	Middle third	Top third	Sum of agriculture, mining and tourism as percentage of total exports, average of 2016–2018. The higher the share, the less diversified.	Li 2021
Trade deficit	Bottom third	Middle third	Top third	Imports minus exports, average of 2016–2018.	Li 2021
Debt	Bottom third	Middle third	Top third	Debt as share of GDP, average of 2016–2018.	Li 2021
Road network vulnerability	Bottom third	Middle third	Top third	Average consumer losses from single link disruptions (due to longer routes or isolation of routes).	Koks et al. forthcoming
Economic structure vulnerability	Bottom third	Middle third	Top third	Vulnerability of a country's economic structure to storms, drawing on historic correlations between storms and economic activity.	Massetti 2021
Financial vulnerability	Bottom third	Middle third	Top third	Exposure of banks' loan portfolios to physical risks stemming from natural disasters.	Massetti 2021
RISK					
Volatility of per capita GDP growth	Bottom third	Middle third	Top third	Standard deviation of real GDP per capita growth 2009–2018.	Li 2021
Average annual well-being losses	Bottom third	Middle third	Top third	Total average annual wellbeing losses from floods, cyclones, earthquakes, and tsunamis in $PPP as % of GDP.	Hallegatte et al. 2016
Average annual asset losses, earthquake	Bottom third	Middle third	Top third	Total average annual losses from earthquakes as % of GDP.	UNISDR 2015
Average annual asset losses, hurricane	Bottom third	Middle third	Top third	Total average annual losses from hurricanes as % of GDP.	UNISDR 2015
Average annual asset losses, tsunami	Bottom third	Middle third	Top third	Total average annual losses from tsunamis as % of GDP.	UNISDR 2015
Average annual asset losses, flood	Bottom third	Middle third	Top third	Total average annual losses from floods as % of GDP.	UNISDR 2015
Average annual asset losses, total	Bottom third	Middle third	Top third	Total average annual losses from floods, cyclones, earthquakes, and tsunamis as % of GDP.	UNISDR 2015
CLIMATE CHANGE IMPACTS IN 2050					
People exposed to coastal flooding	Bottom third	Middle third	Top third	Projected share of population annually exposed to floods in 2050 under an RCP 4.5 scenario, based on 2010 population figures.	Deltares 2021
Shoreline retreat	Bottom third	Middle third	Top third	Projected shoreline retreat in 2050 as a result of sea level rise under an RCP 4.5 scenario as % of total sandy coastline.	Deltares 2021
Land mass loss	Bottom third	Middle third	Top third	Projected land mass loss in 2050 due to sea level rise under an RCP 4.5 scenario as % of total land mass.	Deltares 2021
Agricultual yield loss	Bottom third	Middle third	Top third	Difference in agricultural yield in 2050 relative to 2010 between projected values accounting for climate change (IPSL model) and assuming no climate change. Values for Antigua and Barbuda, The Bahamas, Barbados, Dominica, Grenada, Sint Maarten, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, and Turks and Caicos are average values for 'Other Caribbean countries', which also include Aruba, Anguilla, Bonaire, British Virgin Islands, Cayman Islands, Guadeloupe, Montserrat, Netherlands Antilles, Puerto Rico, St. Barthelemy, and U.S. Virgin Islands. The estimates for Guyana and Suriname are joint estimates for the group of countries 'Guyanas', which, also include French Guiana.	IFPRI
Extreme heat days (pessimistic scenario)	Bottom third	Middle third	Top third	Annual increase in the number of extreme heat days (>35°C) for the 90th percentiles of all models (RCP 4.5) between 2040–2059.	World Bank Climate Change Knowledge Portal
Hotels experiencing beach loss	Bottom third	Middle third	Top third	Coastal hotels located within 1 kilometer (Euclidean distance) from the beach experiencing beach loss by 2050 under RCP 4.5.	Campbell, Spencer and Strobl 2021

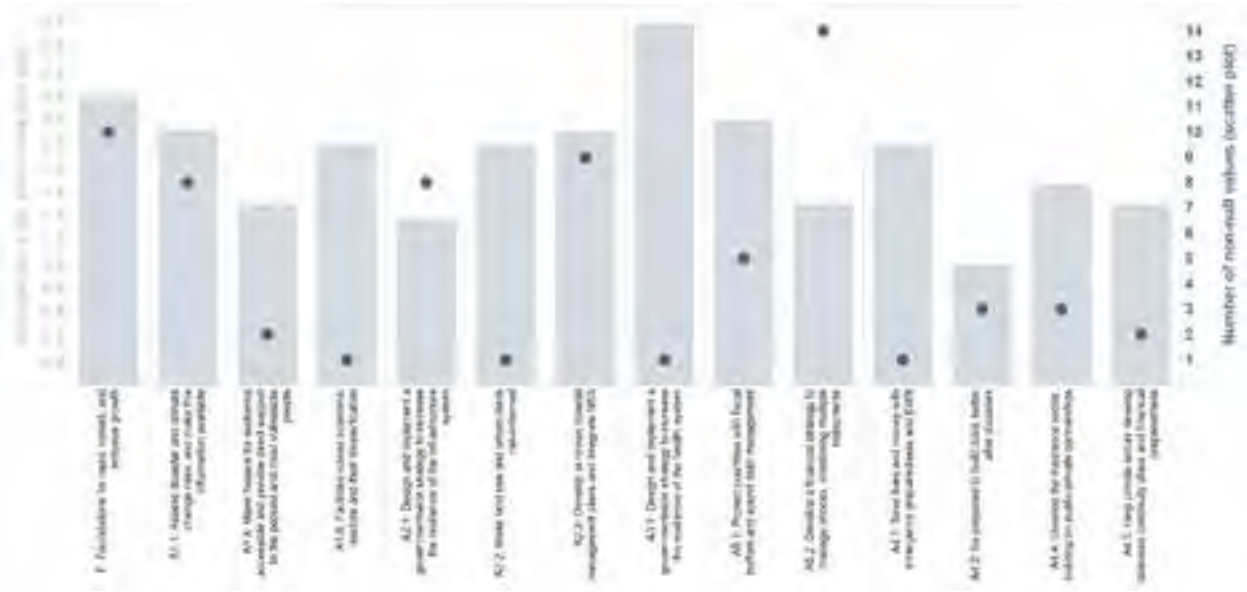
Note: To assign a category (*high/medium/low*), a relative scoring has been applied. This means that for each indicator, each country is scored relative to their peers in the region, assigning *low* to those in the bottom third, *medium* to those in the middle third, and *high* to those in the top third. For the indicators belonging to assets exposure and those related to average annual asset losses, the scoring exercise is done among countries within this group of indicators.

Appendix B

ANTIGUA AND BARBUDA

●○○	Nascent
●●○	Emerging
●●●	Established
○○○	No data/unknown

The indicators presented in the traffic light system (TLS) below form a non-exhaustive list to measure cross-sectoral progress towards resilience. It follows the framework of *The Adaptation Principles* but was adapted to the Caribbean context. Detailed descriptions of the indicators, sources, and criteria for rating are available in Annex B. The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. Due to lack of data, many countries are missing scores for different indicators. The TLS is intended to serve as a starting point for discussion, and the indicators and ratings can be modified based on additional country-level information.



Notes: Scores are based on 1 = nascent (the country includes areas that are only starting to or do not address the standard at all); 2 = emerging (the country partly meets the standard and has progressed beyond the initiation point but has not reached the final point); 3 = established (the country meets the standard entirely). All indicators are given equal weight and only those actions with available data are included in this summary graph.

FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●●○	Governance
●○○	GDP per capita growth
●●○	Poverty rate
○○○	Targeting of main social safety nets
○○○	Coverage of main social safety nets
●●○	Access to universal health coverage
●●●	Access to primary education
●●●	Access to secondary education
●●●	Access to basic water services
●●●	Access to basic sanitation services
●●●	Access to energy
○○○	Access to financial services
●●○	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available	
●●●	Hydromet data completeness
●●●	Hydromet data availability
●●●	High-resolution DTM data existance, coverage
●●○	Public availability of high-resolution DTM data
●○○	Local-scale hazard map availability (1:10.000 or larger)
●○○	National-scale hazard map availability (covering entire country)
●○○	National system exists for capturing past and current, small- and large-scale events
○○○	Community awareness of hazard and vulnerability levels
●●●	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives
Residual risk target level
Dedicated water resources management agencies
A1.3. Develop and implement technical solutions for resilience
Research and development for resilience
Climate-smart practices used in agriculture
Resilience tariff
A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people
Ease of getting credit for firms
Protecting minority investors
Access to finance for the poorest 40%
Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs
Complementary social protection measures for resilience
Inclusion and application of climate change and disaster risk reduction in education curriculum
Number of qualified planners
Presence of planning education
Professional planning association
Technical capability to incorporate disaster risk into planning
Human capital development for resilience
A1.6. Facilitate robust economic sectors and their diversification
Business environment
State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system
Water reliability index
Power reliability index
Transport infrastructure inventory
Water and sanitation infrastructure inventory
Asset management system
Adequate maintenance budget
Nonrevenue water levels
Resilient infrastructure agency
Long-term resilient infrastructure plan
National climate adaptation plan
Public asset management
Public investment management
Share of renewable energy-powered power plants
A2.2. Make land use and urban plans risk-informed
Planning regulations and institutional framework
Land administration

Building and construction regulatory system
Building regulation and implementation
Governance and politics in urban planning
Financing for planning
Financing for implementation
Use of disaster risk information in planning
A2.3. Develop or revise coastal management plans and integrate NBS
Integrated coastal zone management plan
Updated environmental laws
Climate change law/policy
Long-term strategy/sustainable development plan
Civil society organizations in climate change/resilience
Coastal zone management agency
Governmental agency responsible for climate change/resilience
Enforcement of environmental policies
Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system
Hospital facility safety
Health service provision
Emergency education for health workers
Adequate number of doctors, nurses, and midwives
Adequate number of CR-FELTP trained workers
Health information system
Health sector surveillance system

Health risk communication
Research capacity
Stockpile of medicines and medical and laboratory medicines
National health emergency framework
Decentralized decision making
Membership of relevant organizations
Emergency funding arrangements with external bodies
Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system
Enabling environment for school safety
Availability of and alignment with plans and guidelines to enable a safe learning environment
Monitoring and evaluation framework for safe schools
Education facility maintenance plan
Operational standards for alternative use of schools
Education continuity plans
Remote learning content
Monitoring and evaluation of effectiveness of distance education
Resources to enable remote learning
Comprehensive, integrated education management information system
Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems
EP&R legislation
Disaster management information system for EP&R
Emergency operations centers
Urban firefighting equipment and capabilities
Formal EP&R training program
Impact-based forecasting
Communication and dissemination of warnings
Community disaster response plans
Early warning system feedback mechanisms
A4.2. Be prepared to build back better after disasters
Resilient recovery and reconstruction plans
Procurement planning
Procurement procedures
Procurement templates and documents
A4.3. Build shock-responsive social protection systems
Postdisaster household assessment collection and usage
Postdisaster benefit delivery
Interoperable social protection and DRM information systems
ASP operational processes
Disaster risk finance mechanism for ASP
ASP human resource capacity
ASP coordination
ASP policy structures
A4.4. Develop the insurance sector, building on public-private partnerships
Insurance penetration
Deposit insurance system
Resilience/adaptation insurance
A4.5. Help private actors develop business continuity plans and financial preparedness
Firms in tourism industry with business continuity plans
Firms in tourism industry with disaster insurance coverage

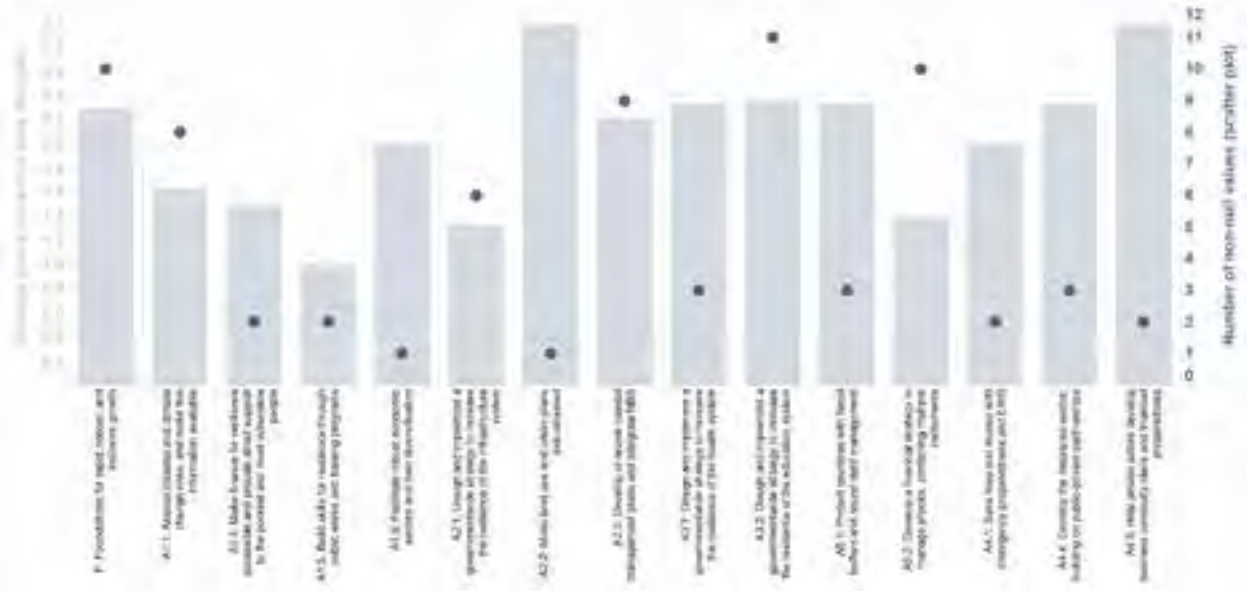
★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management
External debt
Fiscal balance
Fiscal rule
Monetary policy independence
Financial solvency risk
Liquidity risk
A5.2. Develop a financial strategy to manage shocks, combining multiple instruments
National DRF strategy
DRF assessment
Alternative risk transfer instruments
Ex post financial assistance
State contingent debt instruments
Traditional insurance
Parametric insurance
Contingent credit
Budget
Reserve fund
Resource planning
Budget appropriation
Gender-sensitive resource allocation
Expenditure controls
Expenditure tracking
Auditing practices
PFM rules and regulations
Institutional PFM arrangements
A5.3. Anticipate and plan for long-term macroeconomic impacts
Sector-level adaptation plans
Long-term plan to diversify tax revenues
Tax revenues originating from high-vulnerability sectors
Debt sustainability or financial sector assessment program considers climate and disaster impacts
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems
Specific disaster and climate risk requirements bank and large investor regulations
Climate and disaster risk stress tests for banks and large investors
Quantified estimates of their exposure to natural hazards by banks and large investors

BAHAMAS, THE

Nascent
Emerging
Established
No data/unknown

The indicators presented in the traffic light system (TLS) below form a non-exhaustive list to measure cross-sectoral progress towards resilience. It follows the framework of *The Adaptation Principles* but was adapted to the Caribbean context. Detailed descriptions of the indicators, sources, and criteria for rating are available in Annex B. The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. Due to lack of data, many countries are missing scores for different indicators. The TLS is intended to serve as a starting point for discussion, and the indicators and ratings can be modified based on additional country-level information.



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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

Governance
GDP per capita growth
Poverty rate
Targeting of main social safety nets

Coverage of main social safety nets
Access to universal health coverage
Access to primary education
Access to secondary education
Access to basic water services

Access to basic sanitation services
Access to energy
Access to financial services
Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available
Hydromet data completeness
Hydromet data availability
High-resolution DTM data existance, coverage
Public availability of high-resolution DTM data

Local-scale hazard map availability (1:10.000 or larger)
National-scale hazard map availability (covering entire country)
National system exists for capturing past and current, small- and large-scale events
Community awareness of hazard and vulnerability levels
Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives	
○○○	Residual risk target level
○○○	Dedicated water resources management agencies
A1.3. Develop and implement technical solutions for resilience	
○○○	Research and development for resilience
○○○	Climate-smart practices used in agriculture
○○○	Resilience tariff
A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people	
●○○	Ease of getting credit for firms
●●○	Protecting minority investors
○○○	Access to finance for the poorest 40%
○○○	Gender gap in access to finance
A1.5. Build skills for resilience through public works and training programs	
○○○	Complementary social protection measures for resilience
●○○	Inclusion and application of climate change and disaster risk reduction in education curriculum
○○○	Number of qualified planners
○○○	Presence of planning education
○○○	Professional planning association
○○○	Technical capability to incorporate disaster risk into planning
●○○	Human capital development for resilience
A1.6. Facilitate robust economic sectors and their diversification	
●●○	Business environment
○○○	State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system	
●●○	Water reliability index
●○○	Power reliability index
○○○	Transport infrastructure inventory
○○○	Water and sanitation infrastructure inventory
○○○	Asset management system
○○○	Adequate maintenance budget
●○○	Nonrevenue water levels
○○○	Resilient infrastructure agency
●○○	Long-term resilient infrastructure plan
●○○	National climate adaptation plan
○○○	Public asset management
○○○	Public investment management
●●○	Share of renewable energy-powered power plants
A2.2. Make land use and urban plans risk-informed	
○○○	Planning regulations and institutional framework
○○○	Land administration
○○○	Building and construction regulatory system
●●●	Building regulation and implementation
○○○	Governance and politics in urban planning
○○○	Financing for planning
○○○	Financing for implementation
○○○	Use of disaster risk information in planning
A2.3. Develop or revise coastal management plans and integrate NBS	
●●○	Integrated coastal zone management plan
●●○	Updated environmental laws
●●○	Climate change law/policy
●●○	Long-term strategy/sustainable development plan
●●●	Civil society organizations in climate change/resilience
●●○	Coastal zone management agency
●●●	Governmental agency responsible for climate change/resilience
●○○	Enforcement of environmental policies
●●●	Existence of environmental or climate change taxes or incentives

2 2 2 2 3 2 3 1 3

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system	
○○○	Hospital facility safety
●●○	Health service provision
○○○	Emergency education for health workers
○○○	Adequate number of doctors, nurses, and midwives
○○○	Adequate number of CR-FELTP trained workers
○○○	Health information system
○○○	Health sector surveillance system
●●○	Health risk communication
○○○	Research capacity
○○○	Stockpile of medicines and medical and laboratory medicines
●●●	National health emergency framework
○○○	Decentralized decision making
○○○	Membership of relevant organizations
○○○	Emergency funding arrangements with external bodies
○○○	Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system

- Enabling environment for school safety
- Availability of and alignment with plans and guidelines to enable a safe learning environment
- Monitoring and evaluation framework for safe schools
- Education facility maintenance plan
- Operational standards for alternative use of schools
- Education continuity plans
- Remote learning content
- Monitoring and evaluation of effectiveness of distance education
- Resources to enable remote learning
- Comprehensive, integrated education management information system
- Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems

- EP&R legislation
- Disaster management information system for EP&R
- Emergency operations centers
- Urban firefighting equipment and capabilities
- Formal EP&R training program
- Impact-based forecasting
- Communication and dissemination of warnings
- Community disaster response plans
- Early warning system feedback mechanisms

A4.2. Be prepared to build back better after disasters

- Resilient recovery and reconstruction plans
- Procurement planning
- Procurement procedures
- Procurement templates and documents

A4.3. Build shock-responsive social protection systems

- Postdisaster household assessment collection and usage
- Postdisaster benefit delivery
- Interoperable social protection and DRM information systems
- ASP operational processes
- Disaster risk finance mechanism for ASP
- ASP human resource capacity
- ASP coordination
- ASP policy structures

A4.4. Develop the insurance sector, building on public-private partnerships

- Insurance penetration
- Deposit insurance system
- Resilience/adaptation insurance

A4.5. Help private actors develop business continuity plans and financial preparedness

- Firms in tourism industry with business continuity plans
- Firms in tourism industry with disaster insurance coverage

★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management

- External debt
- Fiscal balance
- Fiscal rule
- Monetary policy independence
- Financial solvency risk
- Liquidity risk

A5.2. Develop a financial strategy to manage shocks, combining multiple instruments

- National DRF strategy
- DRF assessment
- Alternative risk transfer instruments
- Ex post financial assistance
- State contingent debt instruments
- Traditional insurance
- Parametric insurance
- Contingent credit
- Budget
- Reserve fund
- Resource planning
- Budget appropriation
- Gender-sensitive resource allocation
- Expenditure controls
- Expenditure tracking
- Auditing practices
- PFM rules and regulations
- Institutional PFM arrangements

A5.3. Anticipate and plan for long-term macroeconomic impacts

- Sector-level adaptation plans
- Long-term plan to diversify tax revenues
- Tax revenues originating from high-vulnerability sectors
- Debt sustainability or financial sector assessment program considers climate and disaster impacts

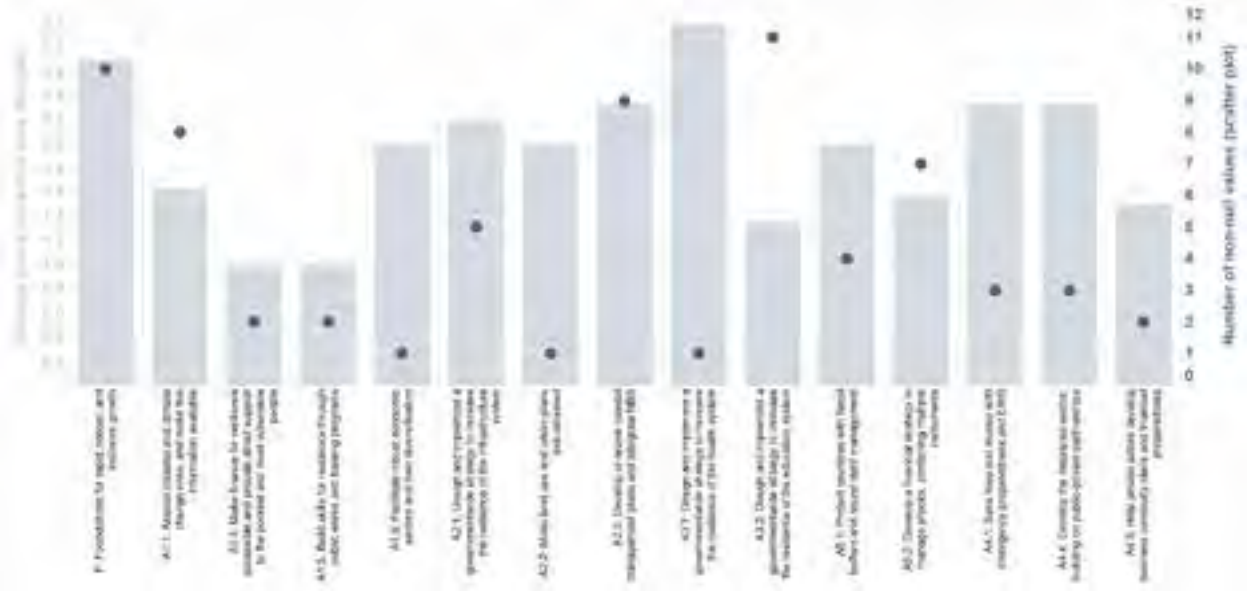
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems

- Specific disaster and climate risk requirements bank and large investor regulations
- Climate and disaster risk stress tests for banks and large investors
- Quantified estimates of their exposure to natural hazards by banks and large investors

BARBADOS

●○○	Nascent
●●	Emerging
●●●	Established
○○○	No data/unknown

The indicators presented in the traffic light system (TLS) below form a non-exhaustive list to measure cross-sectoral progress towards resilience. It follows the framework of *The Adaptation Principles* but was adapted to the Caribbean context. Detailed descriptions of the indicators, sources, and criteria for rating are available in Annex B. The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. Due to lack of data, many countries are missing scores for different indicators. The TLS is intended to serve as a starting point for discussion, and the indicators and ratings can be modified based on additional country-level information.



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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●●●	Governance
●○○	GDP per capita growth
●●●	Poverty rate
○○○	Targeting of main social safety nets

○○○	Coverage of main social safety nets
●●	Access to universal health coverage
●●●	Access to primary education
●●●	Access to secondary education
●●●	Access to basic water services

●●●	Access to basic sanitation services
●●●	Access to energy
○○○	Access to financial services
●●●	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available	
●●	Hydromet data completeness
●●●	Hydromet data availability
●●●	High-resolution DTM data existance, coverage
●○○	Public availability of high-resolution DTM data

●○○	Local-scale hazard map availability (1:10.000 or larger)
●○○	National-scale hazard map availability (covering entire country)
●○○	National system exists for capturing past and current, small- and large-scale events
○○○	Community awareness of hazard and vulnerability levels
●○○	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives
Residual risk target level
Dedicated water resources management agencies
A1.3. Develop and implement technical solutions for resilience
Research and development for resilience
Climate-smart practices used in agriculture
Resilience tariff
A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people
Ease of getting credit for firms
Protecting minority investors
Access to finance for the poorest 40%
Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs
Complementary social protection measures for resilience
Inclusion and application of climate change and disaster risk reduction in education curriculum
Number of qualified planners
Presence of planning education
Professional planning association
Technical capability to incorporate disaster risk into planning
Human capital development for resilience
A1.6. Facilitate robust economic sectors and their diversification
Business environment
State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system
Water reliability index
Power reliability index
Transport infrastructure inventory
Water and sanitation infrastructure inventory
Asset management system
Adequate maintenance budget
Nonrevenue water levels
Resilient infrastructure agency
Long-term resilient infrastructure plan
National climate adaptation plan
Public asset management
Public investment management
Share of renewable energy-powered power plants
A2.2. Make land use and urban plans risk-informed
Planning regulations and institutional framework
Land administration

Building and construction regulatory system
Building regulation and implementation
Governance and politics in urban planning
Financing for planning
Financing for implementation
Use of disaster risk information in planning
A2.3. Develop or revise coastal management plans and integrate NBS
Integrated coastal zone management plan
Updated environmental laws
Climate change law/policy
Long-term strategy/sustainable development plan
Civil society organizations in climate change/resilience
Coastal zone management agency
Governmental agency responsible for climate change/resilience
Enforcement of environmental policies
Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system
Hospital facility safety
Health service provision
Emergency education for health workers
Adequate number of doctors, nurses, and midwives
Adequate number of CR-FELTP trained workers
Health information system
Health sector surveillance system

Health risk communication
Research capacity
Stockpile of medicines and medical and laboratory medicines
National health emergency framework
Decentralized decision making
Membership of relevant organizations
Emergency funding arrangements with external bodies
Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system

- Enabling environment for school safety
- Availability of and alignment with plans and guidelines to enable a safe learning environment
- Monitoring and evaluation framework for safe schools
- Education facility maintenance plan
- Operational standards for alternative use of schools
- Education continuity plans
- Remote learning content
- Monitoring and evaluation of effectiveness of distance education
- Resources to enable remote learning
- Comprehensive, integrated education management information system
- Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems

- EP&R legislation
- Disaster management information system for EP&R
- Emergency operations centers
- Urban firefighting equipment and capabilities
- Formal EP&R training program
- Impact-based forecasting
- Communication and dissemination of warnings
- Community disaster response plans
- Early warning system feedback mechanisms

A4.2. Be prepared to build back better after disasters

- Resilient recovery and reconstruction plans
- Procurement planning
- Procurement procedures
- Procurement templates and documents

A4.3. Build shock-responsive social protection systems

- Postdisaster household assessment collection and usage
- Postdisaster benefit delivery
- Interoperable social protection and DRM information systems
- ASP operational processes
- Disaster risk finance mechanism for ASP
- ASP human resource capacity
- ASP coordination
- ASP policy structures

A4.4. Develop the insurance sector, building on public-private partnerships

- Insurance penetration
- Deposit insurance system
- Resilience/adaptation insurance

A4.5. Help private actors develop business continuity plans and financial preparedness

- Firms in tourism industry with business continuity plans
- Firms in tourism industry with disaster insurance coverage

★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management

- External debt
- Fiscal balance
- Fiscal rule
- Monetary policy independence
- Financial solvency risk
- Liquidity risk

A5.2. Develop a financial strategy to manage shocks, combining multiple instruments

- National DRF strategy
- DRF assessment
- Alternative risk transfer instruments
- Ex post financial assistance
- State contingent debt instruments
- Traditional insurance
- Parametric insurance
- Contingent credit
- Budget
- Reserve fund
- Resource planning
- Budget appropriation
- Gender-sensitive resource allocation
- Expenditure controls
- Expenditure tracking
- Auditing practices
- PFM rules and regulations
- Institutional PFM arrangements

A5.3. Anticipate and plan for long-term macroeconomic impacts

- Sector-level adaptation plans
- Long-term plan to diversify tax revenues
- Tax revenues originating from high-vulnerability sectors
- Debt sustainability or financial sector assessment program considers climate and disaster impacts

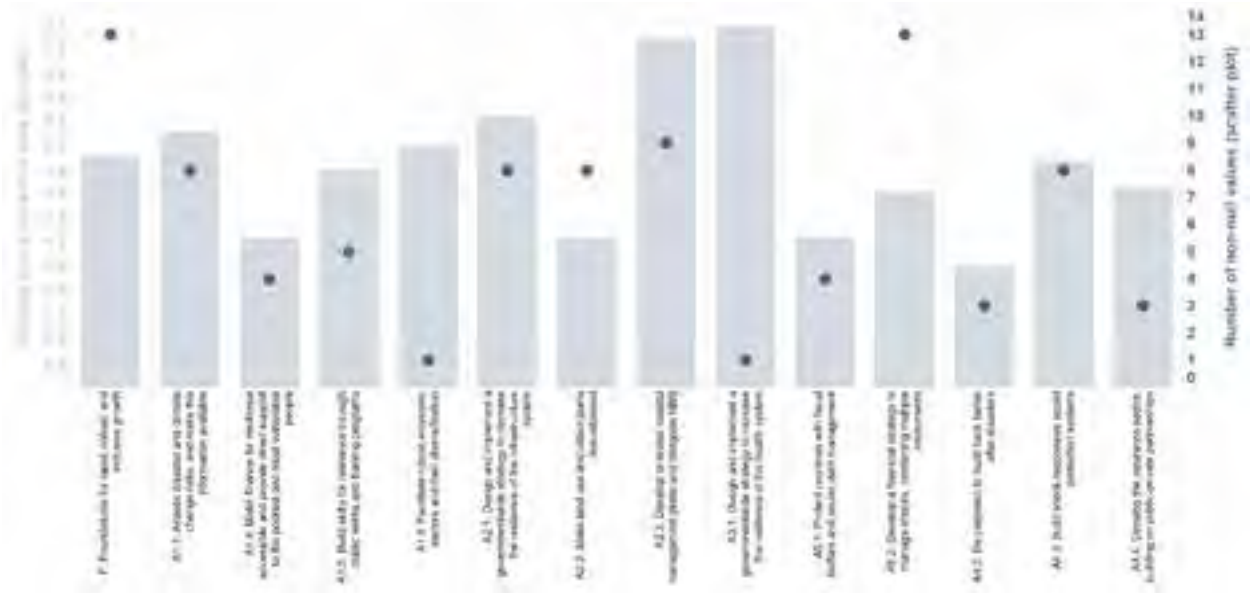
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems

- Specific disaster and climate risk requirements bank and large investor regulations
- Climate and disaster risk stress tests for banks and large investors
- Quantified estimates of their exposure to natural hazards by banks and large investors

BELIZE

●○○	Nascent
●●○	Emerging
●●●	Established
○○○	No data/unknown

The indicators presented in the traffic light system (TLS) below form a non-exhaustive list to measure cross-sectoral progress towards resilience. It follows the framework of *The Adaptation Principles* but was adapted to the Caribbean context. Detailed descriptions of the indicators, sources, and criteria for rating are available in Annex B. The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. Due to lack of data, many countries are missing scores for different indicators. The TLS is intended to serve as a starting point for discussion, and the indicators and ratings can be modified based on additional country-level information.



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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●○○	Governance
●●○	GDP per capita growth
●○○	Poverty rate
●●○	Targeting of main social safety nets
●○○	Coverage of main social safety nets
●●○	Access to universal health coverage
●●●	Access to primary education
●●○	Access to secondary education
●●●	Access to basic water services
●●●	Access to basic sanitation services
●●●	Access to energy
●○○	Access to financial services
●○○	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available	
●●●	Hydromet data completeness
●○○	Hydromet data availability
●●○	High-resolution DTM data existance, coverage
○○○	Public availability of high-resolution DTM data
●○○	Local-scale hazard map availability (1:10.000 or larger)
●●●	National-scale hazard map availability (covering entire country)
●○○	National system exists for capturing past and current, small- and large-scale events
●●●	Community awareness of hazard and vulnerability levels
●●●	Local-scale climate change scenarios

continued on next page

★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives

- Residual risk target level
- Dedicated water resources management agencies

A1.3. Develop and implement technical solutions for resilience

- Research and development for resilience
- Climate-smart practices used in agriculture
- Resilience tariff

A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people

- Ease of getting credit for firms
- Protecting minority investors
- Access to finance for the poorest 40%
- Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs

- Complementary social protection measures for resilience
- Inclusion and application of climate change and disaster risk reduction in education curriculum
- Number of qualified planners
- Presence of planning education
- Professional planning association
- Technical capability to incorporate disaster risk into planning
- Human capital development for resilience

A1.6. Facilitate robust economic sectors and their diversification

- Business environment
- State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system

- Water reliability index
- Power reliability index
- Transport infrastructure inventory
- Water and sanitation infrastructure inventory
- Asset management system
- Adequate maintenance budget
- Nonrevenue water levels
- Resilient infrastructure agency
- Long-term resilient infrastructure plan
- National climate adaptation plan
- Public asset management
- Public investment management
- Share of renewable energy-powered power plants

A2.2. Make land use and urban plans risk-informed

- Planning regulations and institutional framework
- Land administration
- Building and construction regulatory system
- Building regulation and implementation
- Governance and politics in urban planning
- Financing for planning
- Financing for implementation
- Use of disaster risk information in planning

A2.3. Develop or revise coastal management plans and integrate NBS

- Integrated coastal zone management plan
- Updated environmental laws
- Climate change law/policy
- Long-term strategy/sustainable development plan
- Civil society organizations in climate change/resilience
- Coastal zone management agency
- Governmental agency responsible for climate change/resilience
- Enforcement of environmental policies
- Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system

- Hospital facility safety
- Health service provision
- Emergency education for health workers
- Adequate number of doctors, nurses, and midwives
- Adequate number of CR-FELTP trained workers
- Health information system
- Health sector surveillance system
- Health risk communication
- Research capacity
- Stockpile of medicines and medical and laboratory medicines
- National health emergency framework
- Decentralized decision making
- Membership of relevant organizations
- Emergency funding arrangements with external bodies
- Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system
Enabling environment for school safety
Availability of and alignment with plans and guidelines to enable a safe learning environment
Monitoring and evaluation framework for safe schools
Education facility maintenance plan
Operational standards for alternative use of schools
Education continuity plans
Remote learning content
Monitoring and evaluation of effectiveness of distance education
Resources to enable remote learning
Comprehensive, integrated education management information system
Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems
EP&R legislation
Disaster management information system for EP&R
Emergency operations centers
Urban firefighting equipment and capabilities
Formal EP&R training program
Impact-based forecasting
Communication and dissemination of warnings
Community disaster response plans
Early warning system feedback mechanisms
A4.2. Be prepared to build back better after disasters
Resilient recovery and reconstruction plans
Procurement planning
Procurement procedures
Procurement templates and documents
A4.3. Build shock-responsive social protection systems
Postdisaster household assessment collection and usage
Postdisaster benefit delivery
Interoperable social protection and DRM information systems
ASP operational processes
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Firms in tourism industry with business continuity plans
Firms in tourism industry with disaster insurance coverage

★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management
External debt
Fiscal balance
Fiscal rule
Monetary policy independence
Financial solvency risk
Liquidity risk
A5.2. Develop a financial strategy to manage shocks, combining multiple instruments
National DRF strategy
DRF assessment
Alternative risk transfer instruments
Ex post financial assistance
State contingent debt instruments
Traditional insurance
Parametric insurance
Contingent credit
Budget
Reserve fund
Resource planning
Budget appropriation
Gender-sensitive resource allocation
Expenditure controls
Expenditure tracking
Auditing practices
PFM rules and regulations
Institutional PFM arrangements
A5.3. Anticipate and plan for long-term macroeconomic impacts
Sector-level adaptation plans
Long-term plan to diversify tax revenues
Tax revenues originating from high-vulnerability sectors
Debt sustainability or financial sector assessment program considers climate and disaster impacts
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems
Specific disaster and climate risk requirements bank and large investor regulations
Climate and disaster risk stress tests for banks and large investors
Quantified estimates of their exposure to natural hazards by banks and large investors

DOMINICA

●○○	Nascent
●●○	Emerging
●●●	Established
○○○	No data/unknown

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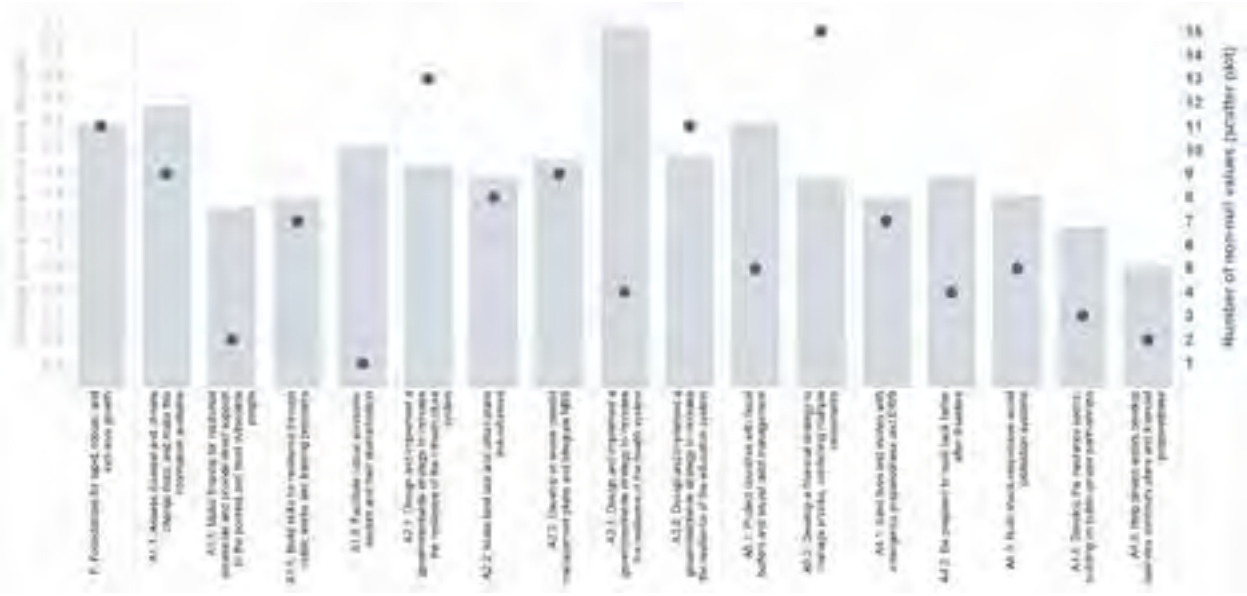

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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●●○	Governance
●○○	GDP per capita growth
●●○	Poverty rate
●○○	Targeting of main social safety nets
●●○	Coverage of main social safety nets
○○○	Access to universal health coverage
●●●	Access to primary education
●●●	Access to secondary education
●●○	Access to basic water services
●●●	Access to basic sanitation services
●●●	Access to energy
○○○	Access to financial services
●●○	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available	
●●○	Hydromet data completeness
●●○	Hydromet data availability
●●●	High-resolution DTM data existance, coverage
●●○	Public availability of high-resolution DTM data
●○○	Local-scale hazard map availability (1:10.000 or larger)
●●●	National-scale hazard map availability (covering entire country)
●●○	National system exists for capturing past and current, small- and large-scale events
●●●	Community awareness of hazard and vulnerability levels
●●●	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives

- Residual risk target level
- Dedicated water resources management agencies

A1.3. Develop and implement technical solutions for resilience

- Research and development for resilience
- Climate-smart practices used in agriculture
- Resilience tariff

A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people

- Ease of getting credit for firms
- Protecting minority investors
- Access to finance for the poorest 40%
- Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs

- Complementary social protection measures for resilience
- Inclusion and application of climate change and disaster risk reduction in education curriculum
- Number of qualified planners
- Presence of planning education
- Professional planning association
- Technical capability to incorporate disaster risk into planning
- Human capital development for resilience

A1.6. Facilitate robust economic sectors and their diversification

- Business environment
- State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system

- Water reliability index
- Power reliability index
- Transport infrastructure inventory
- Water and sanitation infrastructure inventory
- Asset management system
- Adequate maintenance budget
- Nonrevenue water levels
- Resilient infrastructure agency
- Long-term resilient infrastructure plan
- National climate adaptation plan
- Public asset management
- Public investment management
- Share of renewable energy-powered power plants

A2.2. Make land use and urban plans risk-informed

- Planning regulations and institutional framework
- Land administration
- Building and construction regulatory system
- Building regulation and implementation
- Governance and politics in urban planning
- Financing for planning
- Financing for implementation
- Use of disaster risk information in planning

A2.3. Develop or revise coastal management plans and integrate NBS

- Integrated coastal zone management plan
- Updated environmental laws
- Climate change law/policy
- Long-term strategy/sustainable development plan
- Civil society organizations in climate change/resilience
- Coastal zone management agency
- Governmental agency responsible for climate change/resilience
- Enforcement of environmental policies
- Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system

- Hospital facility safety
- Health service provision
- Emergency education for health workers
- Adequate number of doctors, nurses, and midwives
- Adequate number of CR-FELTP trained workers
- Health information system
- Health sector surveillance system
- Health risk communication
- Research capacity
- Stockpile of medicines and medical and laboratory medicines
- National health emergency framework
- Decentralized decision making
- Membership of relevant organizations
- Emergency funding arrangements with external bodies
- Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system

- Enabling environment for school safety
- Availability of and alignment with plans and guidelines to enable a safe learning environment
- Monitoring and evaluation framework for safe schools
- Education facility maintenance plan
- Operational standards for alternative use of schools
- Education continuity plans
- Remote learning content
- Monitoring and evaluation of effectiveness of distance education
- Resources to enable remote learning
- Comprehensive, integrated education management information system
- Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems

- EP&R legislation
- Disaster management information system for EP&R
- Emergency operations centers
- Urban firefighting equipment and capabilities
- Formal EP&R training program
- Impact-based forecasting
- Communication and dissemination of warnings
- Community disaster response plans
- Early warning system feedback mechanisms

A4.2. Be prepared to build back better after disasters

- Resilient recovery and reconstruction plans
- Procurement planning
- Procurement procedures
- Procurement templates and documents

A4.3. Build shock-responsive social protection systems

- Postdisaster household assessment collection and usage
- Postdisaster benefit delivery
- Interoperable social protection and DRM information systems
- ASP operational processes
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- ASP human resource capacity
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- Insurance penetration
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A4.5. Help private actors develop business continuity plans and financial preparedness

- Firms in tourism industry with business continuity plans
- Firms in tourism industry with disaster insurance coverage

★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management

- External debt
- Fiscal balance
- Fiscal rule
- Monetary policy independence
- Financial solvency risk
- Liquidity risk

A5.2. Develop a financial strategy to manage shocks, combining multiple instruments

- National DRF strategy
- DRF assessment
- Alternative risk transfer instruments
- Ex post financial assistance
- State contingent debt instruments
- Traditional insurance
- Parametric insurance
- Contingent credit
- Budget
- Reserve fund
- Resource planning
- Budget appropriation
- Gender-sensitive resource allocation
- Expenditure controls
- Expenditure tracking
- Auditing practices
- PFM rules and regulations
- Institutional PFM arrangements

A5.3. Anticipate and plan for long-term macroeconomic impacts

- Sector-level adaptation plans
- Long-term plan to diversify tax revenues
- Tax revenues originating from high-vulnerability sectors
- Debt sustainability or financial sector assessment program considers climate and disaster impacts

A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems

- Specific disaster and climate risk requirements bank and large investor regulations
- Climate and disaster risk stress tests for banks and large investors
- Quantified estimates of their exposure to natural hazards by banks and large investors

DOMINICAN REPUBLIC

●○○	Nascent
●●○	Emerging
●●●	Established
○○○	No data/unknown

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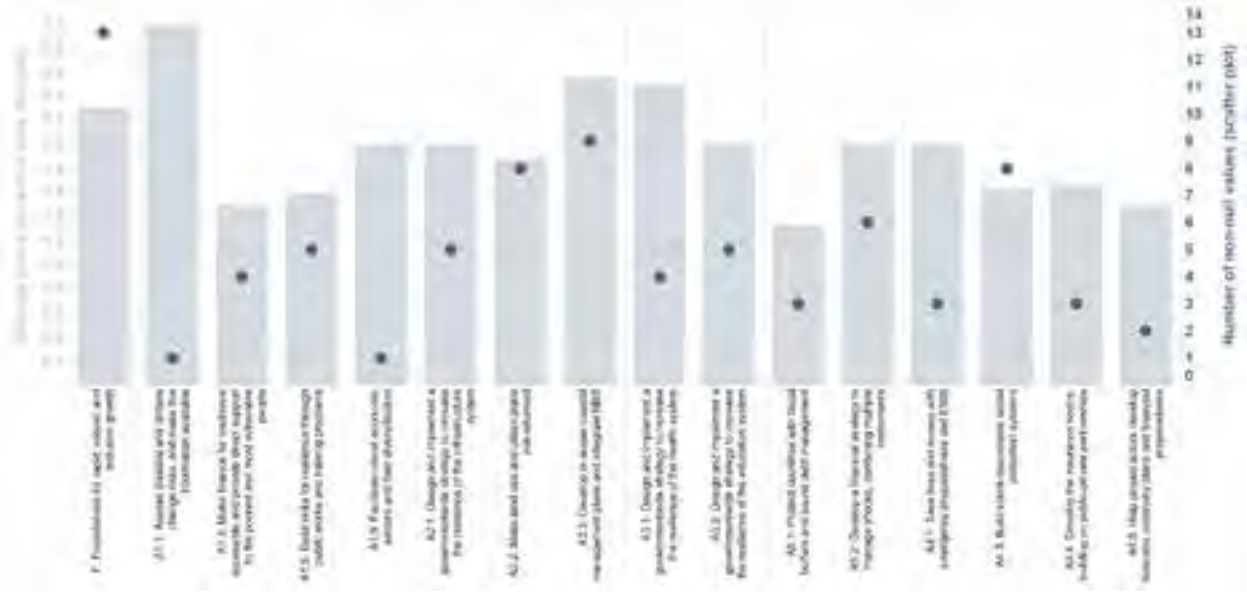

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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●○○	Governance
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FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

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○○○	National system exists for capturing past and current, small- and large-scale events
○○○	Community awareness of hazard and vulnerability levels
●●●	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives

- Residual risk target level
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A2.3. Develop or revise coastal management plans and integrate NBS

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- Membership of relevant organizations
- Emergency funding arrangements with external bodies
- Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system
Enabling environment for school safety
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Climate and disaster risk stress tests for banks and large investors
Quantified estimates of their exposure to natural hazards by banks and large investors

GRENADA

●○○	Nascent
●●○	Emerging
●●●	Established
○○○	No data/unknown

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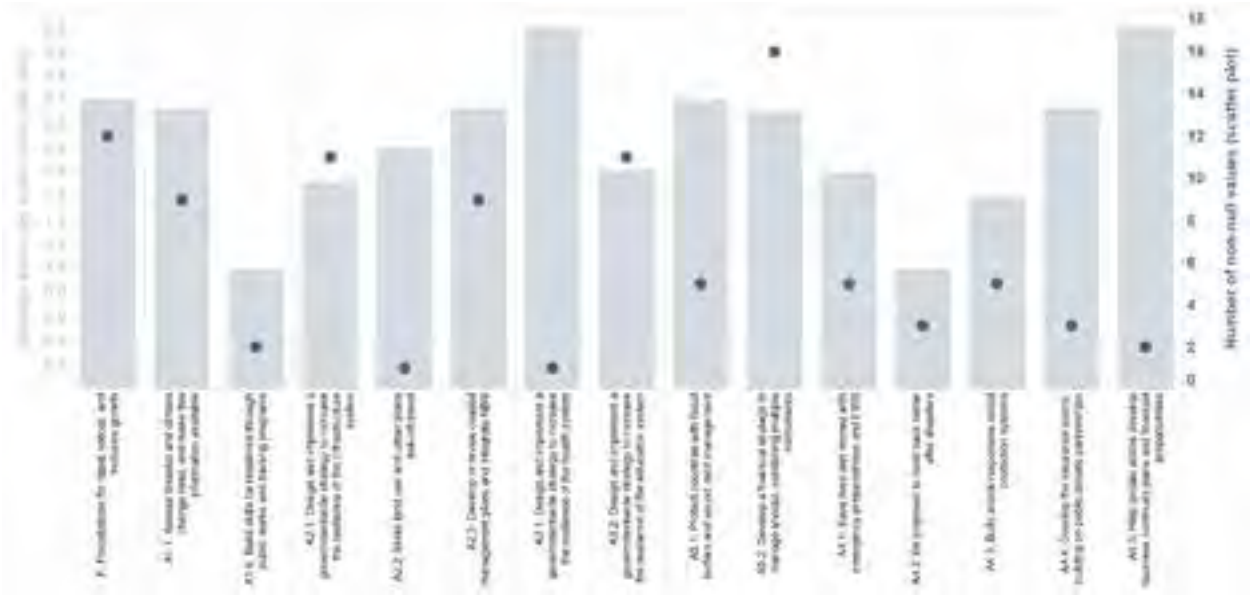

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●●○	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available	
●●○	Hydromet data completeness
●●○	Hydromet data availability
●●●	High-resolution DTM data existance, coverage
●●○	Public availability of high-resolution DTM data
●○○	Local-scale hazard map availability (1:10.000 or larger)
●●●	National-scale hazard map availability (covering entire country)
●●○	National system exists for capturing past and current, small- and large-scale events
●●●	Community awareness of hazard and vulnerability levels
●●●	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives
Residual risk target level
Dedicated water resources management agencies
A1.3. Develop and implement technical solutions for resilience
Research and development for resilience
Climate-smart practices used in agriculture
Resilience tariff
A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people
Ease of getting credit for firms
Protecting minority investors
Access to finance for the poorest 40%
Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs
Complementary social protection measures for resilience
Inclusion and application of climate change and disaster risk reduction in education curriculum
Number of qualified planners
Presence of planning education
Professional planning association
Technical capability to incorporate disaster risk into planning
Human capital development for resilience
A1.6. Facilitate robust economic sectors and their diversification
Business environment
State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system
Water reliability index
Power reliability index
Transport infrastructure inventory
Water and sanitation infrastructure inventory
Asset management system
Adequate maintenance budget
Nonrevenue water levels
Resilient infrastructure agency
Long-term resilient infrastructure plan
National climate adaptation plan
Public asset management
Public investment management
Share of renewable energy-powered power plants
A2.2. Make land use and urban plans risk-informed
Planning regulations and institutional framework
Land administration

Building and construction regulatory system
Building regulation and implementation
Governance and politics in urban planning
Financing for planning
Financing for implementation
Use of disaster risk information in planning
A2.3. Develop or revise coastal management plans and integrate NBS
Integrated coastal zone management plan
Updated environmental laws
Climate change law/policy
Long-term strategy/sustainable development plan
Civil society organizations in climate change/resilience
Coastal zone management agency
Governmental agency responsible for climate change/resilience
Enforcement of environmental policies
Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system
Hospital facility safety
Health service provision
Emergency education for health workers
Adequate number of doctors, nurses, and midwives
Adequate number of CR-FELTP trained workers
Health information system
Health sector surveillance system

Health risk communication
Research capacity
Stockpile of medicines and medical and laboratory medicines
National health emergency framework
Decentralized decision making
Membership of relevant organizations
Emergency funding arrangements with external bodies
Costed and funded health system strengthening plans

continued on next page

★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system
Enabling environment for school safety
Availability of and alignment with plans and guidelines to enable a safe learning environment
Monitoring and evaluation framework for safe schools
Education facility maintenance plan
Operational standards for alternative use of schools
Education continuity plans
Remote learning content
Monitoring and evaluation of effectiveness of distance education
Resources to enable remote learning
Comprehensive, integrated education management information system
Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems
EP&R legislation
Disaster management information system for EP&R
Emergency operations centers
Urban firefighting equipment and capabilities
Formal EP&R training program
Impact-based forecasting
Communication and dissemination of warnings
Community disaster response plans
Early warning system feedback mechanisms
A4.2. Be prepared to build back better after disasters
Resilient recovery and reconstruction plans
Procurement planning
Procurement procedures
Procurement templates and documents
A4.3. Build shock-responsive social protection systems
Postdisaster household assessment collection and usage
Postdisaster benefit delivery
Interoperable social protection and DRM information systems
ASP operational processes
Disaster risk finance mechanism for ASP
ASP human resource capacity
ASP coordination
ASP policy structures
A4.4. Develop the insurance sector, building on public-private partnerships
Insurance penetration
Deposit insurance system
Resilience/adaptation insurance
A4.5. Help private actors develop business continuity plans and financial preparedness
Firms in tourism industry with business continuity plans
Firms in tourism industry with disaster insurance coverage

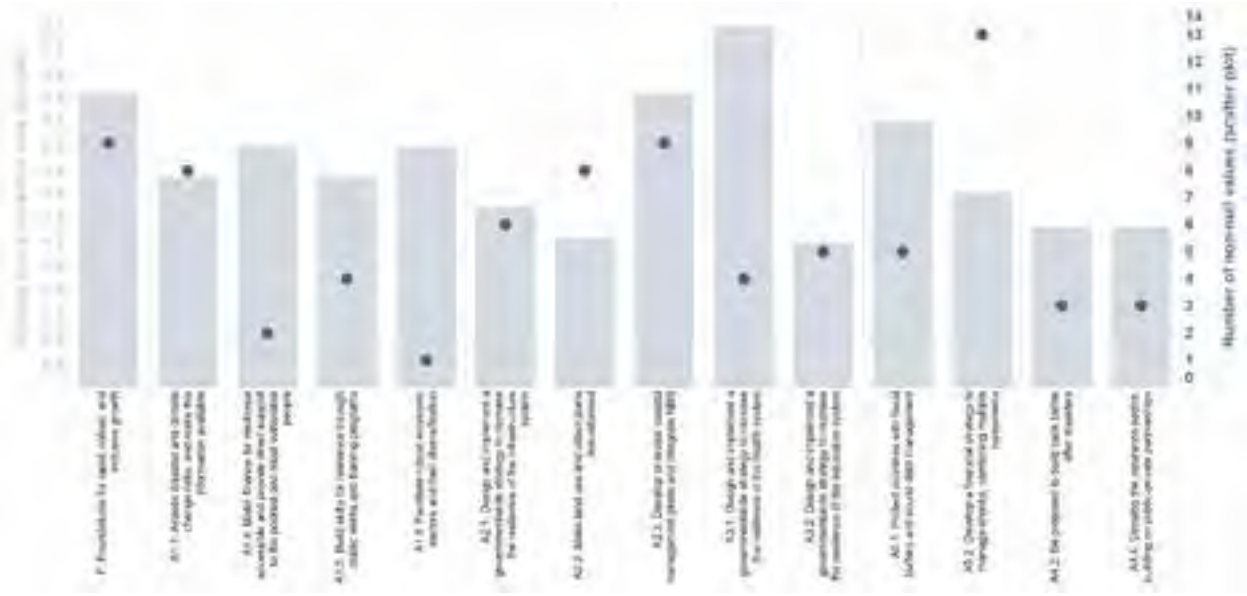
★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management
External debt
Fiscal balance
Fiscal rule
Monetary policy independence
Financial solvency risk
Liquidity risk
A5.2. Develop a financial strategy to manage shocks, combining multiple instruments
National DRF strategy
DRF assessment
Alternative risk transfer instruments
Ex post financial assistance
State contingent debt instruments
Traditional insurance
Parametric insurance
Contingent credit
Budget
Reserve fund
Resource planning
Budget appropriation
Gender-sensitive resource allocation
Expenditure controls
Expenditure tracking
Auditing practices
PFM rules and regulations
Institutional PFM arrangements
A5.3. Anticipate and plan for long-term macroeconomic impacts
Sector-level adaptation plans
Long-term plan to diversify tax revenues
Tax revenues originating from high-vulnerability sectors
Debt sustainability or financial sector assessment program considers climate and disaster impacts
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems
Specific disaster and climate risk requirements bank and large investor regulations
Climate and disaster risk stress tests for banks and large investors
Quantified estimates of their exposure to natural hazards by banks and large investors

GUYANA

●○○	Nascent
●●	Emerging
●●●	Established
○○○	No data/unknown

The indicators presented in the traffic light system (TLS) below form a non-exhaustive list to measure cross-sectoral progress towards resilience. It follows the framework of *The Adaptation Principles* but was adapted to the Caribbean context. Detailed descriptions of the indicators, sources, and criteria for rating are available in Annex B. The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. Due to lack of data, many countries are missing scores for different indicators. The TLS is intended to serve as a starting point for discussion, and the indicators and ratings can be modified based on additional country-level information.



Notes: Scores are based on 1 = nascent (the country includes areas that are only starting to or do not address the standard at all); 2 = emerging (the country partly meets the standard and has progressed beyond the initiation point but has not reached the final point); 3 = established (the country meets the standard entirely). All indicators are given equal weight and only those actions with available data are included in this summary graph.

FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●○○	Governance
●●●	GDP per capita growth
○○○	Poverty rate
○○○	Targeting of main social safety nets
○○○	Coverage of main social safety nets
●○	Access to universal health coverage
●●●	Access to primary education
●●●	Access to secondary education
●●●	Access to basic water services
●●●	Access to basic sanitation services
●●●	Access to energy
○○○	Access to financial services
●○○	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available	
●●●	Hydromet data completeness
●●	Hydromet data availability
●●	High-resolution DTM data existance, coverage
●○○	Public availability of high-resolution DTM data
●○○	Local-scale hazard map availability (1:10.000 or larger)
●○○	National-scale hazard map availability (covering entire country)
●○○	National system exists for capturing past and current, small- and large-scale events
○○○	Community awareness of hazard and vulnerability levels
●●●	Local-scale climate change scenarios

continued on next page

★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives

- Residual risk target level
- Dedicated water resources management agencies

A1.3. Develop and implement technical solutions for resilience

- Research and development for resilience
- Climate-smart practices used in agriculture
- Resilience tariff

A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people

- Ease of getting credit for firms
- Protecting minority investors
- Access to finance for the poorest 40%
- Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs

- Complementary social protection measures for resilience
- Inclusion and application of climate change and disaster risk reduction in education curriculum
- Number of qualified planners
- Presence of planning education
- Professional planning association
- Technical capability to incorporate disaster risk into planning
- Human capital development for resilience

A1.6. Facilitate robust economic sectors and their diversification

- Business environment
- State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system

- Water reliability index
- Power reliability index
- Transport infrastructure inventory
- Water and sanitation infrastructure inventory
- Asset management system
- Adequate maintenance budget
- Nonrevenue water levels
- Resilient infrastructure agency
- Long-term resilient infrastructure plan
- National climate adaptation plan
- Public asset management
- Public investment management
- Share of renewable energy-powered power plants

A2.2. Make land use and urban plans risk-informed

- Planning regulations and institutional framework
- Land administration
- Building and construction regulatory system
- Building regulation and implementation
- Governance and politics in urban planning
- Financing for planning
- Financing for implementation
- Use of disaster risk information in planning

A2.3. Develop or revise coastal management plans and integrate NBS

- Integrated coastal zone management plan
- Updated environmental laws
- Climate change law/policy
- Long-term strategy/sustainable development plan
- Civil society organizations in climate change/resilience
- Coastal zone management agency
- Governmental agency responsible for climate change/resilience
- Enforcement of environmental policies
- Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system

- Hospital facility safety
- Health service provision
- Emergency education for health workers
- Adequate number of doctors, nurses, and midwives
- Adequate number of CR-FELTP trained workers
- Health information system
- Health sector surveillance system
- Health risk communication
- Research capacity
- Stockpile of medicines and medical and laboratory medicines
- National health emergency framework
- Decentralized decision making
- Membership of relevant organizations
- Emergency funding arrangements with external bodies
- Costed and funded health system strengthening plans

continued on next page

★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system
Enabling environment for school safety
Availability of and alignment with plans and guidelines to enable a safe learning environment
Monitoring and evaluation framework for safe schools
Education facility maintenance plan
Operational standards for alternative use of schools
Education continuity plans
Remote learning content
Monitoring and evaluation of effectiveness of distance education
Resources to enable remote learning
Comprehensive, integrated education management information system
Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems
EP&R legislation
Disaster management information system for EP&R
Emergency operations centers
Urban firefighting equipment and capabilities
Formal EP&R training program
Impact-based forecasting
Communication and dissemination of warnings
Community disaster response plans
Early warning system feedback mechanisms
A4.2. Be prepared to build back better after disasters
Resilient recovery and reconstruction plans
Procurement planning
Procurement procedures
Procurement templates and documents
A4.3. Build shock-responsive social protection systems
Postdisaster household assessment collection and usage
Postdisaster benefit delivery
Interoperable social protection and DRM information systems
ASP operational processes
Disaster risk finance mechanism for ASP
ASP human resource capacity
ASP coordination
ASP policy structures
A4.4. Develop the insurance sector, building on public-private partnerships
Insurance penetration
Deposit insurance system
Resilience/adaptation insurance
A4.5. Help private actors develop business continuity plans and financial preparedness
Firms in tourism industry with business continuity plans
Firms in tourism industry with disaster insurance coverage

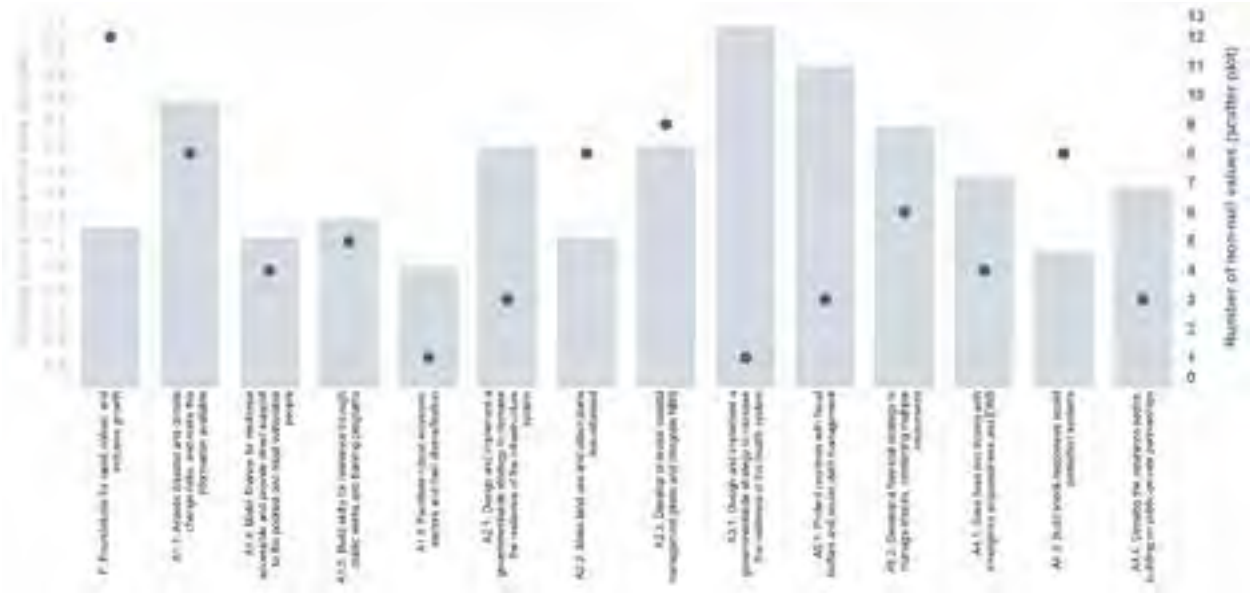
★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management
External debt
Fiscal balance
Fiscal rule
Monetary policy independence
Financial solvency risk
Liquidity risk
A5.2. Develop a financial strategy to manage shocks, combining multiple instruments
National DRF strategy
DRF assessment
Alternative risk transfer instruments
Ex post financial assistance
State contingent debt instruments
Traditional insurance
Parametric insurance
Contingent credit
Budget
Reserve fund
Resource planning
Budget appropriation
Gender-sensitive resource allocation
Expenditure controls
Expenditure tracking
Auditing practices
PFM rules and regulations
Institutional PFM arrangements
A5.3. Anticipate and plan for long-term macroeconomic impacts
Sector-level adaptation plans
Long-term plan to diversify tax revenues
Tax revenues originating from high-vulnerability sectors
Debt sustainability or financial sector assessment program considers climate and disaster impacts
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems
Specific disaster and climate risk requirements bank and large investor regulations
Climate and disaster risk stress tests for banks and large investors
Quantified estimates of their exposure to natural hazards by banks and large investors

HAITI

●○○	Nascent
●●○	Emerging
●●●	Established
○○○	No data/unknown

The indicators presented in the traffic light system (TLS) below form a non-exhaustive list to measure cross-sectoral progress towards resilience. It follows the framework of *The Adaptation Principles* but was adapted to the Caribbean context. Detailed descriptions of the indicators, sources, and criteria for rating are available in Annex B. The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. Due to lack of data, many countries are missing scores for different indicators. The TLS is intended to serve as a starting point for discussion, and the indicators and ratings can be modified based on additional country-level information.



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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●○○	Governance
●●●	GDP per capita growth
●○○	Poverty rate
●●○	Targeting of main social safety nets

●○○	Coverage of main social safety nets
●○○	Access to universal health coverage
●○○	Access to primary education
○○○	Access to secondary education
●●○	Access to basic water services

●○○	Access to basic sanitation services
●○○	Access to energy
●○○	Access to financial services
●○○	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available	
●●○	Hydromet data completeness
●○○	Hydromet data availability
●●●	High-resolution DTM data existance, coverage
●●●	Public availability of high-resolution DTM data

●○○	Local-scale hazard map availability (1:10.000 or larger)
●●●	National-scale hazard map availability (covering entire country)
○○○	National system exists for capturing past and current, small- and large-scale events
●●●	Community awareness of hazard and vulnerability levels
●●●	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives

- Residual risk target level
- Dedicated water resources management agencies

A1.3. Develop and implement technical solutions for resilience

- Research and development for resilience
- Climate-smart practices used in agriculture
- Resilience tariff

A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people

- Ease of getting credit for firms
- Protecting minority investors
- Access to finance for the poorest 40%
- Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs

- Complementary social protection measures for resilience
- Inclusion and application of climate change and disaster risk reduction in education curriculum
- Number of qualified planners
- Presence of planning education
- Professional planning association
- Technical capability to incorporate disaster risk into planning
- Human capital development for resilience

A1.6. Facilitate robust economic sectors and their diversification

- Business environment
- State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system

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- Asset management system
- Adequate maintenance budget
- Nonrevenue water levels
- Resilient infrastructure agency
- Long-term resilient infrastructure plan
- National climate adaptation plan
- Public asset management
- Public investment management
- Share of renewable energy-powered power plants

A2.2. Make land use and urban plans risk-informed

- Planning regulations and institutional framework
- Land administration
- Building and construction regulatory system
- Building regulation and implementation
- Governance and politics in urban planning
- Financing for planning
- Financing for implementation
- Use of disaster risk information in planning

A2.3. Develop or revise coastal management plans and integrate NBS

- Integrated coastal zone management plan
- Updated environmental laws
- Climate change law/policy
- Long-term strategy/sustainable development plan
- Civil society organizations in climate change/resilience
- Coastal zone management agency
- Governmental agency responsible for climate change/resilience
- Enforcement of environmental policies
- Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system

- Hospital facility safety
- Health service provision
- Emergency education for health workers
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- Adequate number of CR-FELTP trained workers
- Health information system
- Health sector surveillance system
- Health risk communication
- Research capacity
- Stockpile of medicines and medical and laboratory medicines
- National health emergency framework
- Decentralized decision making
- Membership of relevant organizations
- Emergency funding arrangements with external bodies
- Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system

- Enabling environment for school safety
- Availability of and alignment with plans and guidelines to enable a safe learning environment
- Monitoring and evaluation framework for safe schools
- Education facility maintenance plan
- Operational standards for alternative use of schools
- Education continuity plans
- Remote learning content
- Monitoring and evaluation of effectiveness of distance education
- Resources to enable remote learning
- Comprehensive, integrated education management information system
- Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

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- Disaster management information system for EP&R
- Emergency operations centers
- Urban firefighting equipment and capabilities
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- Resilient recovery and reconstruction plans
- Procurement planning
- Procurement procedures
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- ASP coordination
- ASP policy structures

A4.4. Develop the insurance sector, building on public-private partnerships

- Insurance penetration
- Deposit insurance system
- Resilience/adaptation insurance

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- Firms in tourism industry with business continuity plans
- Firms in tourism industry with disaster insurance coverage

★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management

- External debt
- Fiscal balance
- Fiscal rule
- Monetary policy independence
- Financial solvency risk
- Liquidity risk

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- DRF assessment
- Alternative risk transfer instruments
- Ex post financial assistance
- State contingent debt instruments
- Traditional insurance
- Parametric insurance
- Contingent credit
- Budget
- Reserve fund
- Resource planning
- Budget appropriation
- Gender-sensitive resource allocation
- Expenditure controls
- Expenditure tracking
- Auditing practices
- PFM rules and regulations
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A5.3. Anticipate and plan for long-term macroeconomic impacts

- Sector-level adaptation plans
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- Tax revenues originating from high-vulnerability sectors
- Debt sustainability or financial sector assessment program considers climate and disaster impacts

A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems

- Specific disaster and climate risk requirements bank and large investor regulations
- Climate and disaster risk stress tests for banks and large investors
- Quantified estimates of their exposure to natural hazards by banks and large investors

JAMAICA

●○○	Nascent
●●○	Emerging
●●●	Established
○○○	No data/unknown

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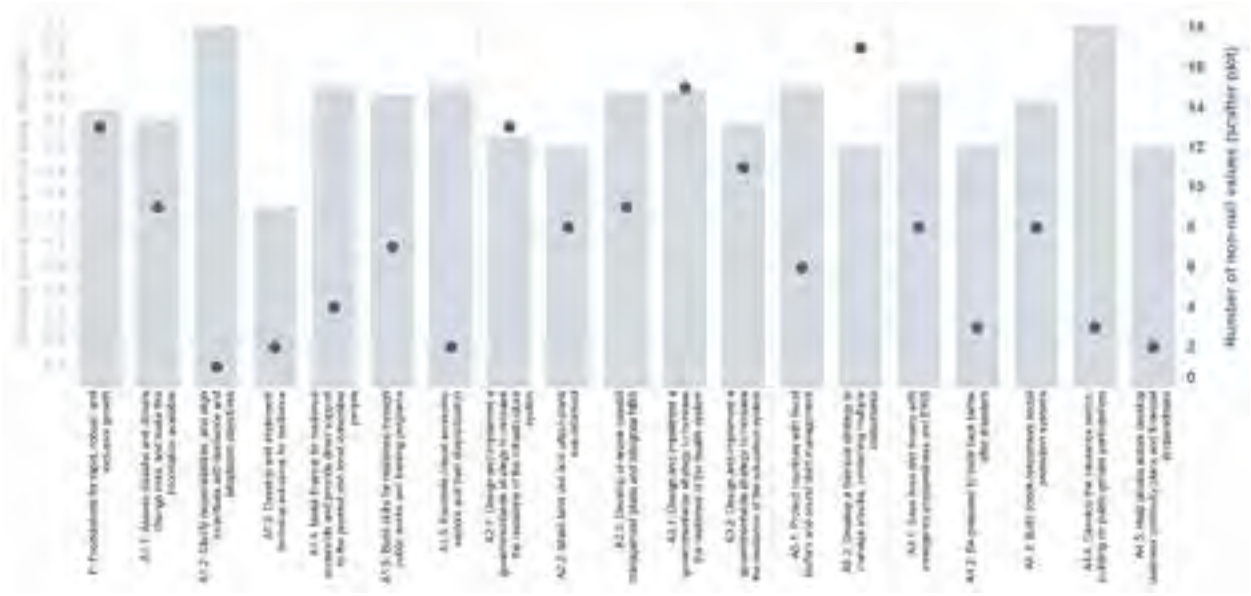

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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

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FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

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●●●	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives
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Presence of planning education
Professional planning association
Technical capability to incorporate disaster risk into planning
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A1.6. Facilitate robust economic sectors and their diversification
Business environment
State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

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National climate adaptation plan
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Public investment management
Share of renewable energy-powered power plants
A2.2. Make land use and urban plans risk-informed
Planning regulations and institutional framework
Land administration
Building and construction regulatory system
Building regulation and implementation
Governance and politics in urban planning
Financing for planning
Financing for implementation
Use of disaster risk information in planning
A2.3. Develop or revise coastal management plans and integrate NBS
Integrated coastal zone management plan
Updated environmental laws
Climate change law/policy
Long-term strategy/sustainable development plan
Civil society organizations in climate change/resilience
Coastal zone management agency
Governmental agency responsible for climate change/resilience
Enforcement of environmental policies
Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system
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Health service provision
Emergency education for health workers
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Adequate number of CR-FELTP trained workers
Health information system
Health sector surveillance system
Health risk communication
Research capacity
Stockpile of medicines and medical and laboratory medicines
National health emergency framework
Decentralized decision making
Membership of relevant organizations
Emergency funding arrangements with external bodies
Costed and funded health system strengthening plans

continued on next page

★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system
Enabling environment for school safety
Availability of and alignment with plans and guidelines to enable a safe learning environment
Monitoring and evaluation framework for safe schools
Education facility maintenance plan
Operational standards for alternative use of schools
Education continuity plans
Remote learning content
Monitoring and evaluation of effectiveness of distance education
Resources to enable remote learning
Comprehensive, integrated education management information system
Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems
EP&R legislation
Disaster management information system for EP&R
Emergency operations centers
Urban firefighting equipment and capabilities
Formal EP&R training program
Impact-based forecasting
Communication and dissemination of warnings
Community disaster response plans
Early warning system feedback mechanisms
A4.2. Be prepared to build back better after disasters
Resilient recovery and reconstruction plans
Procurement planning
Procurement procedures
Procurement templates and documents
A4.3. Build shock-responsive social protection systems
Postdisaster household assessment collection and usage
Postdisaster benefit delivery
Interoperable social protection and DRM information systems
ASP operational processes
Disaster risk finance mechanism for ASP
ASP human resource capacity
ASP coordination
ASP policy structures
A4.4. Develop the insurance sector, building on public-private partnerships
Insurance penetration
Deposit insurance system
Resilience/adaptation insurance
A4.5. Help private actors develop business continuity plans and financial preparedness
Firms in tourism industry with business continuity plans
Firms in tourism industry with disaster insurance coverage

★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management
External debt
Fiscal balance
Fiscal rule
Monetary policy independence
Financial solvency risk
Liquidity risk
A5.2. Develop a financial strategy to manage shocks, combining multiple instruments
National DRF strategy
DRF assessment
Alternative risk transfer instruments
Ex post financial assistance
State contingent debt instruments
Traditional insurance
Parametric insurance
Contingent credit
Budget
Reserve fund
Resource planning
Budget appropriation
Gender-sensitive resource allocation
Expenditure controls
Expenditure tracking
Auditing practices
PFM rules and regulations
Institutional PFM arrangements
A5.3. Anticipate and plan for long-term macroeconomic impacts
Sector-level adaptation plans
Long-term plan to diversify tax revenues
Tax revenues originating from high-vulnerability sectors
Debt sustainability or financial sector assessment program considers climate and disaster impacts
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems
Specific disaster and climate risk requirements bank and large investor regulations
Climate and disaster risk stress tests for banks and large investors
Quantified estimates of their exposure to natural hazards by banks and large investors

SINT MAARTEN

●○○	Nascent
●●○	Emerging
●●●	Established
○○○	No data/unknown

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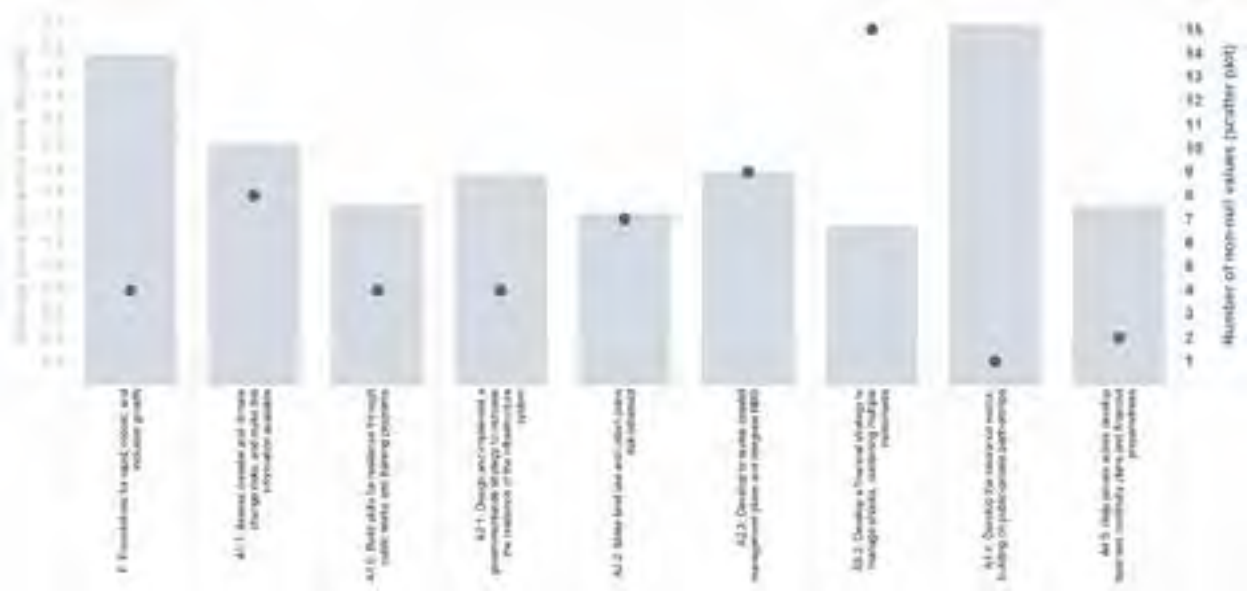

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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●●●	Governance
●●●	GDP per capita growth
●●●	Poverty rate
●●●	Targeting of main social safety nets
●●●	Coverage of main social safety nets
●●●	Access to universal health coverage
●●●	Access to primary education
●●○	Access to secondary education
●●●	Access to basic water services
●●●	Access to basic sanitation services
●●●	Access to energy
●●●	Access to financial services
●●●	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available	
●●○	Hydromet data completeness
●●●	Hydromet data availability
●●●	High-resolution DTM data existance, coverage
●●○	Public availability of high-resolution DTM data
●○○	Local-scale hazard map availability (1:10.000 or larger)
●○○	National-scale hazard map availability (covering entire country)
○○○	National system exists for capturing past and current, small- and large-scale events
●●●	Community awareness of hazard and vulnerability levels
●○○	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives

- Residual risk target level
- Dedicated water resources management agencies

A1.3. Develop and implement technical solutions for resilience

- Research and development for resilience
- Climate-smart practices used in agriculture
- Resilience tariff

A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people

- Ease of getting credit for firms
- Protecting minority investors
- Access to finance for the poorest 40%
- Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs

- Complementary social protection measures for resilience
- Inclusion and application of climate change and disaster risk reduction in education curriculum
- Number of qualified planners
- Presence of planning education
- Professional planning association
- Technical capability to incorporate disaster risk into planning
- Human capital development for resilience

A1.6. Facilitate robust economic sectors and their diversification

- Business environment
- State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system

- Water reliability index
- Power reliability index
- Transport infrastructure inventory
- Water and sanitation infrastructure inventory
- Asset management system
- Adequate maintenance budget
- Nonrevenue water levels
- Resilient infrastructure agency
- Long-term resilient infrastructure plan
- National climate adaptation plan
- Public asset management
- Public investment management
- Share of renewable energy-powered power plants

A2.2. Make land use and urban plans risk-informed

- Planning regulations and institutional framework
- Land administration
- Building and construction regulatory system
- Building regulation and implementation
- Governance and politics in urban planning
- Financing for planning
- Financing for implementation
- Use of disaster risk information in planning

A2.3. Develop or revise coastal management plans and integrate NBS

- Integrated coastal zone management plan
- Updated environmental laws
- Climate change law/policy
- Long-term strategy/sustainable development plan
- Civil society organizations in climate change/resilience
- Coastal zone management agency
- Governmental agency responsible for climate change/resilience
- Enforcement of environmental policies
- Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system

- Hospital facility safety
- Health service provision
- Emergency education for health workers
- Adequate number of doctors, nurses, and midwives
- Adequate number of CR-FELTP trained workers
- Health information system
- Health sector surveillance system
- Health risk communication
- Research capacity
- Stockpile of medicines and medical and laboratory medicines
- National health emergency framework
- Decentralized decision making
- Membership of relevant organizations
- Emergency funding arrangements with external bodies
- Costed and funded health system strengthening plans

continued on next page

★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system
Enabling environment for school safety
Availability of and alignment with plans and guidelines to enable a safe learning environment
Monitoring and evaluation framework for safe schools
Education facility maintenance plan
Operational standards for alternative use of schools
Education continuity plans
Remote learning content
Monitoring and evaluation of effectiveness of distance education
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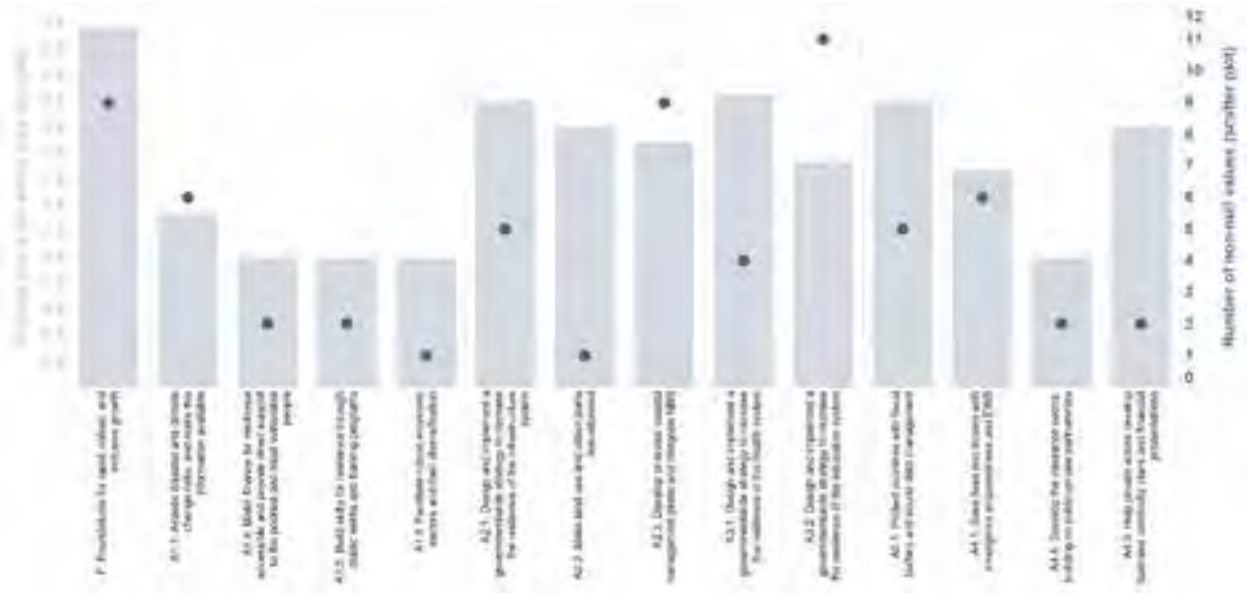
DRF assessment
Alternative risk transfer instruments
Ex post financial assistance
State contingent debt instruments
Traditional insurance
Parametric insurance
Contingent credit
Budget
Reserve fund
Resource planning
Budget appropriation
Gender-sensitive resource allocation
Expenditure controls
Expenditure tracking
Auditing practices
PFM rules and regulations
Institutional PFM arrangements
A5.3. Anticipate and plan for long-term macroeconomic impacts
Sector-level adaptation plans
Long-term plan to diversify tax revenues
Tax revenues originating from high-vulnerability sectors
Debt sustainability or financial sector assessment program considers climate and disaster impacts
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems
Specific disaster and climate risk requirements bank and large investor regulations
Climate and disaster risk stress tests for banks and large investors
Quantified estimates of their exposure to natural hazards by banks and large investors

ST. KITTS AND NEVIS

- Nascent
- Emerging
- Established
- No data/unknown

The indicators presented in the traffic light system (TLS) below form a non-exhaustive list to measure cross-sectoral progress towards resilience. It follows the framework of *The Adaptation Principles* but was adapted to the Caribbean context. Detailed descriptions of the indicators, sources, and criteria for rating are available in Annex B. The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. Due to lack of data, many countries are missing scores for different indicators. The TLS is intended to serve as a starting point for discussion, and the indicators and ratings can be modified based on additional country-level information.



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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

- Governance
- GDP per capita growth
- Poverty rate
- Targeting of main social safety nets
- Coverage of main social safety nets
- Access to universal health coverage
- Access to primary education
- Access to secondary education
- Access to basic water services
- Access to basic sanitation services
- Access to energy
- Access to financial services
- Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available

- Hydromet data completeness
- Hydromet data availability
- High-resolution DTM data existance, coverage
- Public availability of high-resolution DTM data
- Local-scale hazard map availability (1:10.000 or larger)
- National-scale hazard map availability (covering entire country)
- National system exists for capturing past and current, small- and large-scale events
- Community awareness of hazard and vulnerability levels
- Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives

- Residual risk target level
- Dedicated water resources management agencies

A1.3. Develop and implement technical solutions for resilience

- Research and development for resilience
- Climate-smart practices used in agriculture
- Resilience tariff

A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people

- Ease of getting credit for firms
- Protecting minority investors
- Access to finance for the poorest 40%
- Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs

- Complementary social protection measures for resilience
- Inclusion and application of climate change and disaster risk reduction in education curriculum
- Number of qualified planners
- Presence of planning education
- Professional planning association
- Technical capability to incorporate disaster risk into planning
- Human capital development for resilience

A1.6. Facilitate robust economic sectors and their diversification

- Business environment
- State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system

- Water reliability index
- Power reliability index
- Transport infrastructure inventory
- Water and sanitation infrastructure inventory
- Asset management system
- Adequate maintenance budget
- Nonrevenue water levels
- Resilient infrastructure agency
- Long-term resilient infrastructure plan
- National climate adaptation plan
- Public asset management
- Public investment management
- Share of renewable energy-powered power plants

A2.2. Make land use and urban plans risk-informed

- Planning regulations and institutional framework
- Land administration
- Building and construction regulatory system
- Building regulation and implementation
- Governance and politics in urban planning
- Financing for planning
- Financing for implementation
- Use of disaster risk information in planning

A2.3. Develop or revise coastal management plans and integrate NBS

- Integrated coastal zone management plan
- Updated environmental laws
- Climate change law/policy
- Long-term strategy/sustainable development plan
- Civil society organizations in climate change/resilience
- Coastal zone management agency
- Governmental agency responsible for climate change/resilience
- Enforcement of environmental policies
- Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system

- Hospital facility safety
- Health service provision
- Emergency education for health workers
- Adequate number of doctors, nurses, and midwives
- Adequate number of CR-FELTP trained workers
- Health information system
- Health sector surveillance system
- Health risk communication
- Research capacity
- Stockpile of medicines and medical and laboratory medicines
- National health emergency framework
- Decentralized decision making
- Membership of relevant organizations
- Emergency funding arrangements with external bodies
- Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system

- Enabling environment for school safety
- Availability of and alignment with plans and guidelines to enable a safe learning environment
- Monitoring and evaluation framework for safe schools
- Education facility maintenance plan
- Operational standards for alternative use of schools
- Education continuity plans
- Remote learning content
- Monitoring and evaluation of effectiveness of distance education
- Resources to enable remote learning
- Comprehensive, integrated education management information system
- Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems

- EP&R legislation
- Disaster management information system for EP&R
- Emergency operations centers
- Urban firefighting equipment and capabilities
- Formal EP&R training program
- Impact-based forecasting
- Communication and dissemination of warnings
- Community disaster response plans
- Early warning system feedback mechanisms

A4.2. Be prepared to build back better after disasters

- Resilient recovery and reconstruction plans
- Procurement planning
- Procurement procedures
- Procurement templates and documents

A4.3. Build shock-responsive social protection systems

- Postdisaster household assessment collection and usage
- Postdisaster benefit delivery
- Interoperable social protection and DRM information systems
- ASP operational processes
- Disaster risk finance mechanism for ASP
- ASP human resource capacity
- ASP coordination
- ASP policy structures

A4.4. Develop the insurance sector, building on public-private partnerships

- Insurance penetration
- Deposit insurance system
- Resilience/adaptation insurance

A4.5. Help private actors develop business continuity plans and financial preparedness

- Firms in tourism industry with business continuity plans
- Firms in tourism industry with disaster insurance coverage

★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management

- External debt
- Fiscal balance
- Fiscal rule
- Monetary policy independence
- Financial solvency risk
- Liquidity risk

A5.2. Develop a financial strategy to manage shocks, combining multiple instruments

- National DRF strategy
- DRF assessment
- Alternative risk transfer instruments
- Ex post financial assistance
- State contingent debt instruments
- Traditional insurance
- Parametric insurance
- Contingent credit
- Budget
- Reserve fund
- Resource planning
- Budget appropriation
- Gender-sensitive resource allocation
- Expenditure controls
- Expenditure tracking
- Auditing practices
- PFM rules and regulations
- Institutional PFM arrangements

A5.3. Anticipate and plan for long-term macroeconomic impacts

- Sector-level adaptation plans
- Long-term plan to diversify tax revenues
- Tax revenues originating from high-vulnerability sectors
- Debt sustainability or financial sector assessment program considers climate and disaster impacts

A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems

- Specific disaster and climate risk requirements bank and large investor regulations
- Climate and disaster risk stress tests for banks and large investors
- Quantified estimates of their exposure to natural hazards by banks and large investors

ST. LUCIA

●○○	Nascent
●●	Emerging
●●●	Established
○○○	No data/unknown

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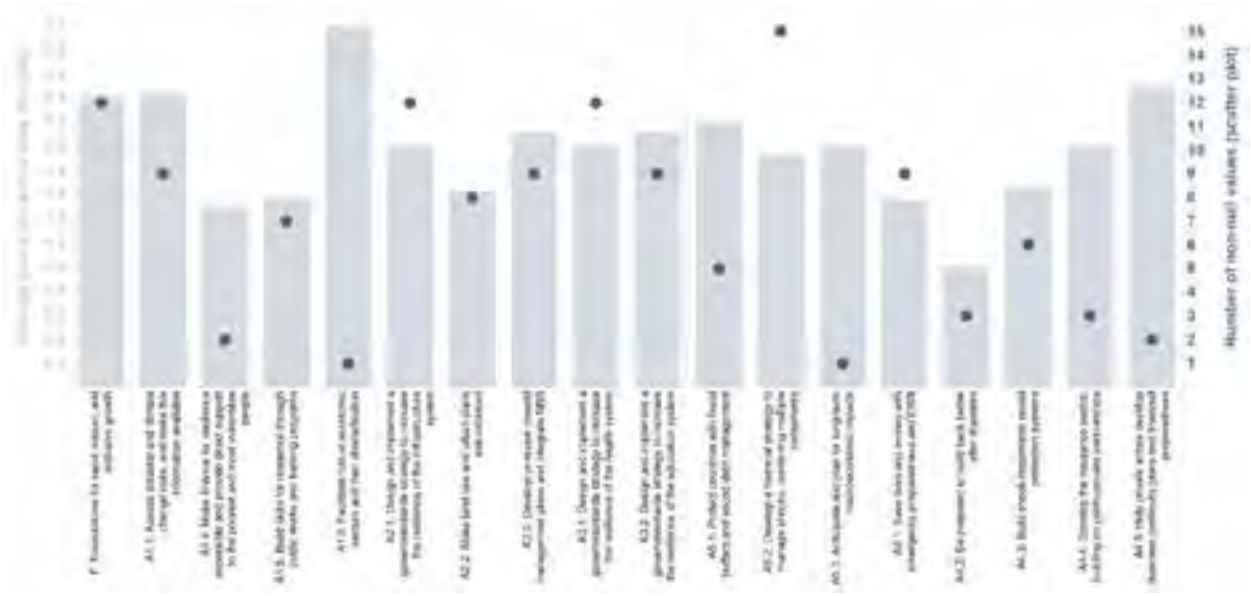

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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●●●	Governance
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●●●	Access to energy
○○○	Access to financial services
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FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

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●●●	Hydromet data availability
●●●	High-resolution DTM data existance, coverage
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●○○	Local-scale hazard map availability (1:10.000 or larger)
●●●	National-scale hazard map availability (covering entire country)
●●○	National system exists for capturing past and current, small- and large-scale events
●●●	Community awareness of hazard and vulnerability levels
●●●	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives
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Membership of relevant organizations
Emergency funding arrangements with external bodies
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continued on next page

★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

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ST. VINCENT AND THE GRENADINES

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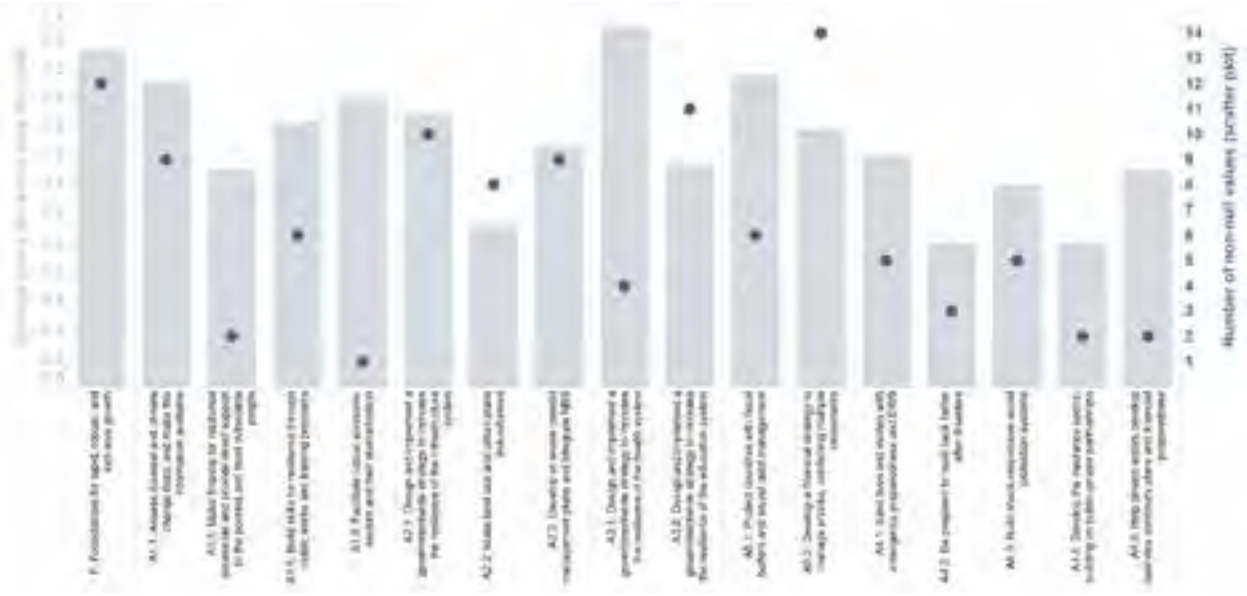

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●●●	Access to basic water services
●●●	Access to basic sanitation services
●●●	Access to energy
○○○	Access to financial services
●○○	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate risks, and make the information available	
●●○	Hydromet data completeness
●●○	Hydromet data availability
●●●	High-resolution DTM data existance, coverage
●●●	Public availability of high-resolution DTM data
●○○	Local-scale hazard map availability (1:10.000 or larger)
●●●	National-scale hazard map availability (covering entire country)
●○○	National system exists for capturing past and current, small- and large-scale events
●●●	Community awareness of hazard and vulnerability levels
●○○	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives

- Residual risk target level
- Dedicated water resources management agencies

A1.3. Develop and implement technical solutions for resilience

- Research and development for resilience
- Climate-smart practices used in agriculture
- Resilience tariff

A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people

- Ease of getting credit for firms
- Protecting minority investors
- Access to finance for the poorest 40%
- Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs

- Complementary social protection measures for resilience
- Inclusion and application of climate change and disaster risk reduction in education curriculum
- Number of qualified planners
- Presence of planning education
- Professional planning association
- Technical capability to incorporate disaster risk into planning
- Human capital development for resilience

A1.6. Facilitate robust economic sectors and their diversification

- Business environment
- State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system

- Water reliability index
- Power reliability index
- Transport infrastructure inventory
- Water and sanitation infrastructure inventory
- Asset management system
- Adequate maintenance budget
- Nonrevenue water levels
- Resilient infrastructure agency
- Long-term resilient infrastructure plan
- National climate adaptation plan
- Public asset management
- Public investment management
- Share of renewable energy-powered power plants

A2.2. Make land use and urban plans risk-informed

- Planning regulations and institutional framework
- Land administration
- Building and construction regulatory system
- Building regulation and implementation
- Governance and politics in urban planning
- Financing for planning
- Financing for implementation
- Use of disaster risk information in planning

A2.3. Develop or revise coastal management plans and integrate NBS

- Integrated coastal zone management plan
- Updated environmental laws
- Climate change law/policy
- Long-term strategy/sustainable development plan
- Civil society organizations in climate change/resilience
- Coastal zone management agency
- Governmental agency responsible for climate change/resilience
- Enforcement of environmental policies
- Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system

- Hospital facility safety
- Health service provision
- Emergency education for health workers
- Adequate number of doctors, nurses, and midwives
- Adequate number of CR-FELTP trained workers
- Health information system
- Health sector surveillance system
- Health risk communication
- Research capacity
- Stockpile of medicines and medical and laboratory medicines
- National health emergency framework
- Decentralized decision making
- Membership of relevant organizations
- Emergency funding arrangements with external bodies
- Costed and funded health system strengthening plans

continued on next page

★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system

- Enabling environment for school safety
- Availability of and alignment with plans and guidelines to enable a safe learning environment
- Monitoring and evaluation framework for safe schools
- Education facility maintenance plan
- Operational standards for alternative use of schools
- Education continuity plans
- Remote learning content
- Monitoring and evaluation of effectiveness of distance education
- Resources to enable remote learning
- Comprehensive, integrated education management information system
- Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems

- EP&R legislation
- Disaster management information system for EP&R
- Emergency operations centers
- Urban firefighting equipment and capabilities
- Formal EP&R training program
- Impact-based forecasting
- Communication and dissemination of warnings
- Community disaster response plans
- Early warning system feedback mechanisms

A4.2. Be prepared to build back better after disasters

- Resilient recovery and reconstruction plans
- Procurement planning
- Procurement procedures
- Procurement templates and documents

A4.3. Build shock-responsive social protection systems

- Postdisaster household assessment collection and usage
- Postdisaster benefit delivery
- Interoperable social protection and DRM information systems
- ASP operational processes
- Disaster risk finance mechanism for ASP
- ASP human resource capacity
- ASP coordination
- ASP policy structures

A4.4. Develop the insurance sector, building on public-private partnerships

- Insurance penetration
- Deposit insurance system
- Resilience/adaptation insurance

A4.5. Help private actors develop business continuity plans and financial preparedness

- Firms in tourism industry with business continuity plans
- Firms in tourism industry with disaster insurance coverage

★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management

- External debt
- Fiscal balance
- Fiscal rule
- Monetary policy independence
- Financial solvency risk
- Liquidity risk

A5.2. Develop a financial strategy to manage shocks, combining multiple instruments

- National DRF strategy
- DRF assessment
- Alternative risk transfer instruments
- Ex post financial assistance
- State contingent debt instruments
- Traditional insurance
- Parametric insurance
- Contingent credit
- Budget
- Reserve fund
- Resource planning
- Budget appropriation
- Gender-sensitive resource allocation
- Expenditure controls
- Expenditure tracking
- Auditing practices
- PFM rules and regulations
- Institutional PFM arrangements

A5.3. Anticipate and plan for long-term macroeconomic impacts

- Sector-level adaptation plans
- Long-term plan to diversify tax revenues
- Tax revenues originating from high-vulnerability sectors
- Debt sustainability or financial sector assessment program considers climate and disaster impacts

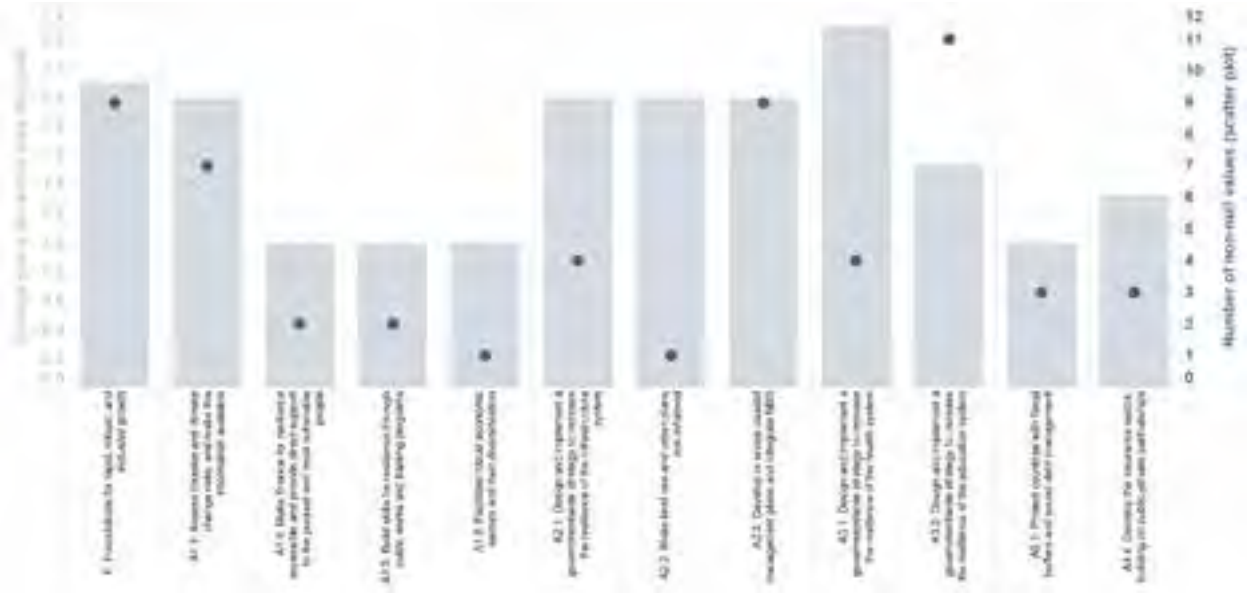
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems

- Specific disaster and climate risk requirements bank and large investor regulations
- Climate and disaster risk stress tests for banks and large investors
- Quantified estimates of their exposure to natural hazards by banks and large investors

SURINAME

●○○	Nascent
●●○	Emerging
●●●	Established
○○○	No data/unknown

The indicators presented in the traffic light system (TLS) below form a non-exhaustive list to measure cross-sectoral progress towards resilience. It follows the framework of *The Adaptation Principles* but was adapted to the Caribbean context. Detailed descriptions of the indicators, sources, and criteria for rating are available in Annex B. The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. Due to lack of data, many countries are missing scores for different indicators. The TLS is intended to serve as a starting point for discussion, and the indicators and ratings can be modified based on additional country-level information.



Notes: Scores are based on 1 = nascent (the country includes areas that are only starting to or do not address the standard at all); 2 = emerging (the country partly meets the standard and has progressed beyond the initiation point but has not reached the final point); 3 = established (the country meets the standard entirely). All indicators are given equal weight and only those actions with available data are included in this summary graph.

FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

●○○	Governance
●●○	GDP per capita growth
○○○	Poverty rate
○○○	Targeting of main social safety nets
○○○	Coverage of main social safety nets
●●○	Access to universal health coverage
●●●	Access to primary education
●○○	Access to secondary education
●●●	Access to basic water services
●●●	Access to basic sanitation services
●●●	Access to energy
○○○	Access to financial services
●○○	Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available	
●●●	Hydromet data completeness
●●○	Hydromet data availability
●○○	High-resolution DTM data existance, coverage
○○○	Public availability of high-resolution DTM data
●○○	Local-scale hazard map availability (1:10.000 or larger)
●○○	National-scale hazard map availability (covering entire country)
○○○	National system exists for capturing past and current, small- and large-scale events
●●●	Community awareness of hazard and vulnerability levels
●●●	Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives
Residual risk target level
Dedicated water resources management agencies
A1.3. Develop and implement technical solutions for resilience
Research and development for resilience
Climate-smart practices used in agriculture
Resilience tariff
A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people
Ease of getting credit for firms
Protecting minority investors
Access to finance for the poorest 40%
Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs
Complementary social protection measures for resilience
Inclusion and application of climate change and disaster risk reduction in education curriculum
Number of qualified planners
Presence of planning education
Professional planning association
Technical capability to incorporate disaster risk into planning
Human capital development for resilience
A1.6. Facilitate robust economic sectors and their diversification
Business environment
State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system
Water reliability index
Power reliability index
Transport infrastructure inventory
Water and sanitation infrastructure inventory
Asset management system
Adequate maintenance budget
Nonrevenue water levels
Resilient infrastructure agency
Long-term resilient infrastructure plan
National climate adaptation plan
Public asset management
Public investment management
Share of renewable energy-powered power plants
A2.2. Make land use and urban plans risk-informed
Planning regulations and institutional framework
Land administration
Building and construction regulatory system
Building regulation and implementation
Governance and politics in urban planning
Financing for planning
Financing for implementation
Use of disaster risk information in planning
A2.3. Develop or revise coastal management plans and integrate NBS
Integrated coastal zone management plan
Updated environmental laws
Climate change law/policy
Long-term strategy/sustainable development plan
Civil society organizations in climate change/resilience
Coastal zone management agency
Governmental agency responsible for climate change/resilience
Enforcement of environmental policies
Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system
Hospital facility safety
Health service provision
Emergency education for health workers
Adequate number of doctors, nurses, and midwives
Adequate number of CR-FELTP trained workers
Health information system
Health sector surveillance system
Health risk communication
Research capacity
Stockpile of medicines and medical and laboratory medicines
National health emergency framework
Decentralized decision making
Membership of relevant organizations
Emergency funding arrangements with external bodies
Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system
Enabling environment for school safety
Availability of and alignment with plans and guidelines to enable a safe learning environment
Monitoring and evaluation framework for safe schools
Education facility maintenance plan
Operational standards for alternative use of schools
Education continuity plans
Remote learning content
Monitoring and evaluation of effectiveness of distance education
Resources to enable remote learning
Comprehensive, integrated education management information system
Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems
EP&R legislation
Disaster management information system for EP&R
Emergency operations centers
Urban firefighting equipment and capabilities
Formal EP&R training program
Impact-based forecasting
Communication and dissemination of warnings
Community disaster response plans
Early warning system feedback mechanisms
A4.2. Be prepared to build back better after disasters
Resilient recovery and reconstruction plans
Procurement planning
Procurement procedures
Procurement templates and documents
A4.3. Build shock-responsive social protection systems
Postdisaster household assessment collection and usage
Postdisaster benefit delivery
Interoperable social protection and DRM information systems
ASP operational processes
Disaster risk finance mechanism for ASP
ASP human resource capacity
ASP coordination
ASP policy structures
A4.4. Develop the insurance sector, building on public-private partnerships
Insurance penetration
Deposit insurance system
Resilience/adaptation insurance
A4.5. Help private actors develop business continuity plans and financial preparedness
Firms in tourism industry with business continuity plans
Firms in tourism industry with disaster insurance coverage

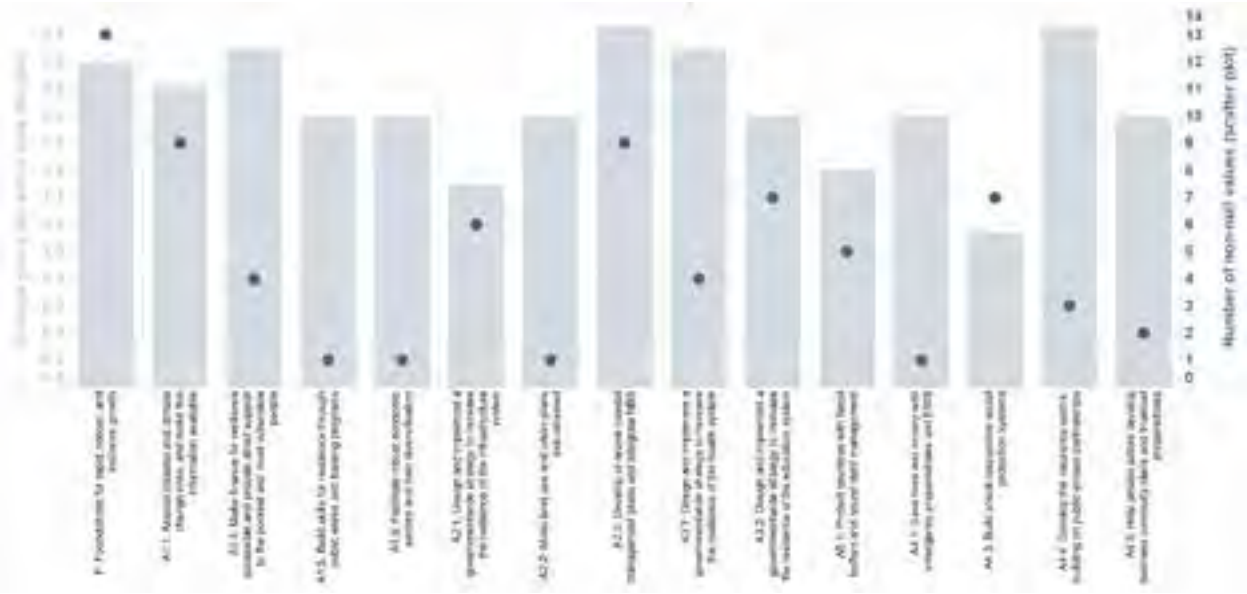
★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management
External debt
Fiscal balance
Fiscal rule
Monetary policy independence
Financial solvency risk
Liquidity risk
A5.2. Develop a financial strategy to manage shocks, combining multiple instruments
National DRF strategy
DRF assessment
Alternative risk transfer instruments
Ex post financial assistance
State contingent debt instruments
Traditional insurance
Parametric insurance
Contingent credit
Budget
Reserve fund
Resource planning
Budget appropriation
Gender-sensitive resource allocation
Expenditure controls
Expenditure tracking
Auditing practices
PFM rules and regulations
Institutional PFM arrangements
A5.3. Anticipate and plan for long-term macroeconomic impacts
Sector-level adaptation plans
Long-term plan to diversify tax revenues
Tax revenues originating from high-vulnerability sectors
Debt sustainability or financial sector assessment program considers climate and disaster impacts
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems
Specific disaster and climate risk requirements bank and large investor regulations
Climate and disaster risk stress tests for banks and large investors
Quantified estimates of their exposure to natural hazards by banks and large investors

TRINIDAD AND TOBAGO

- Nascent
- Emerging
- Established
- No data/unknown

The indicators presented in the traffic light system (TLS) below form a non-exhaustive list to measure cross-sectoral progress towards resilience. It follows the framework of *The Adaptation Principles* but was adapted to the Caribbean context. Detailed descriptions of the indicators, sources, and criteria for rating are available in Annex B. The TLS and rating scheme were developed by World Bank sector specialists in consultation with some countries. Due to lack of data, many countries are missing scores for different indicators. The TLS is intended to serve as a starting point for discussion, and the indicators and ratings can be modified based on additional country-level information.



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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

- Governance
- GDP per capita growth
- Poverty rate
- Targeting of main social safety nets
- Coverage of main social safety nets
- Access to universal health coverage
- Access to primary education
- Access to secondary education
- Access to basic water services
- Access to basic sanitation services
- Access to energy
- Access to financial services
- Access to ICT

FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

1: Facilitate risk reduction decisions by firms and households

A1.1. Assess disaster and climate change risks, and make the information available

- Hydromet data completeness
- Hydromet data availability
- High-resolution DTM data existance, coverage
- Public availability of high-resolution DTM data
- Local-scale hazard map availability (1:10.000 or larger)
- National-scale hazard map availability (covering entire country)
- National system exists for capturing past and current, small- and large-scale events
- Community awareness of hazard and vulnerability levels
- Local-scale climate change scenarios

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives

- Residual risk target level
- Dedicated water resources management agencies

A1.3. Develop and implement technical solutions for resilience

- Research and development for resilience
- Climate-smart practices used in agriculture
- Resilience tariff

A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people

- Ease of getting credit for firms
- Protecting minority investors
- Access to finance for the poorest 40%
- Gender gap in access to finance

A1.5. Build skills for resilience through public works and training programs

- Complementary social protection measures for resilience
- Inclusion and application of climate change and disaster risk reduction in education curriculum
- Number of qualified planners
- Presence of planning education
- Professional planning association
- Technical capability to incorporate disaster risk into planning
- Human capital development for resilience

A1.6. Facilitate robust economic sectors and their diversification

- Business environment
- State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system

- Water reliability index
- Power reliability index
- Transport infrastructure inventory
- Water and sanitation infrastructure inventory
- Asset management system
- Adequate maintenance budget
- Nonrevenue water levels
- Resilient infrastructure agency
- Long-term resilient infrastructure plan
- National climate adaptation plan
- Public asset management
- Public investment management
- Share of renewable energy-powered power plants

A2.2. Make land use and urban plans risk-informed

- Planning regulations and institutional framework
- Land administration
- Building and construction regulatory system
- Building regulation and implementation
- Governance and politics in urban planning
- Financing for planning
- Financing for implementation
- Use of disaster risk information in planning

A2.3. Develop or revise coastal management plans and integrate NBS

- Integrated coastal zone management plan
- Updated environmental laws
- Climate change law/policy
- Long-term strategy/sustainable development plan
- Civil society organizations in climate change/resilience
- Coastal zone management agency
- Governmental agency responsible for climate change/resilience
- Enforcement of environmental policies
- Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system

- Hospital facility safety
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- Adequate number of doctors, nurses, and midwives
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- Health risk communication
- Research capacity
- Stockpile of medicines and medical and laboratory medicines
- National health emergency framework
- Decentralized decision making
- Membership of relevant organizations
- Emergency funding arrangements with external bodies
- Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system

- Enabling environment for school safety
- Availability of and alignment with plans and guidelines to enable a safe learning environment
- Monitoring and evaluation framework for safe schools
- Education facility maintenance plan
- Operational standards for alternative use of schools
- Education continuity plans
- Remote learning content
- Monitoring and evaluation of effectiveness of distance education
- Resources to enable remote learning
- Comprehensive, integrated education management information system
- Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems

- EP&R legislation
- Disaster management information system for EP&R
- Emergency operations centers
- Urban firefighting equipment and capabilities
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- Sector-level adaptation plans
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- Debt sustainability or financial sector assessment program considers climate and disaster impacts

A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems

- Specific disaster and climate risk requirements bank and large investor regulations
- Climate and disaster risk stress tests for banks and large investors
- Quantified estimates of their exposure to natural hazards by banks and large investors

TURKS AND CAICOS

- Nascent
- Emerging
- Established
- No data/unknown

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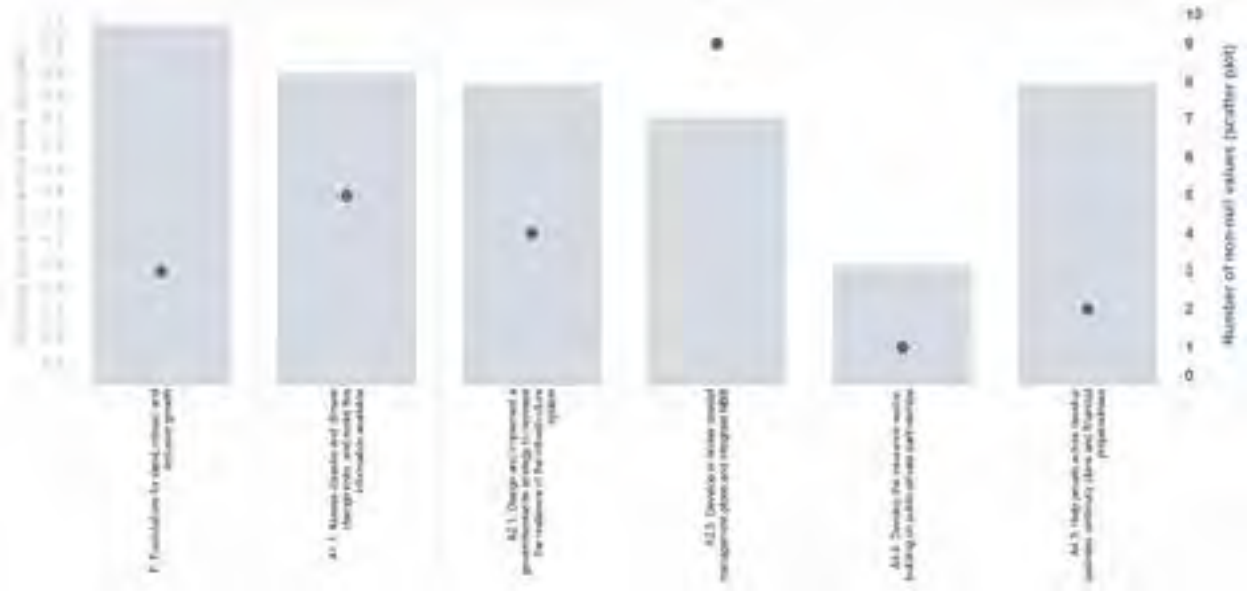

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FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH

- Governance
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- Coverage of main social safety nets
- Access to universal health coverage
- Access to primary education
- Access to secondary education
- Access to basic water services
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- Access to energy
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FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

FACILITATE RISK REDUCTION DECISIONS BY FIRMS AND HOUSEHOLDS *continued*

A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives
Residual risk target level
Dedicated water resources management agencies
A1.3. Develop and implement technical solutions for resilience
Research and development for resilience
Climate-smart practices used in agriculture
Resilience tariff
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Ease of getting credit for firms
Protecting minority investors
Access to finance for the poorest 40%
Gender gap in access to finance

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Presence of planning education
Professional planning association
Technical capability to incorporate disaster risk into planning
Human capital development for resilience
A1.6. Facilitate robust economic sectors and their diversification
Business environment
State-owned enterprises include DRM and climate change in their decision making

★ 2:Design resilient infrastructure systems, urban and coastal planning

A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system
Water reliability index
Power reliability index
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Nonrevenue water levels
Resilient infrastructure agency
Long-term resilient infrastructure plan
National climate adaptation plan
Public asset management
Public investment management
Share of renewable energy-powered power plants
A2.2. Make land use and urban plans risk-informed
Planning regulations and institutional framework
Land administration
Building and construction regulatory system
Building regulation and implementation
Governance and politics in urban planning
Financing for planning
Financing for implementation
Use of disaster risk information in planning
A2.3. Develop or revise coastal management plans and integrate NBS
Integrated coastal zone management plan
Updated environmental laws
Climate change law/policy
Long-term strategy/sustainable development plan
Civil society organizations in climate change/resilience
Coastal zone management agency
Governmental agency responsible for climate change/resilience
Enforcement of environmental policies
Existence of environmental or climate change taxes or incentives

★ 3: Build resilient health and education systems

A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system
Hospital facility safety
Health service provision
Emergency education for health workers
Adequate number of doctors, nurses, and midwives
Adequate number of CR-FELTP trained workers
Health information system
Health sector surveillance system
Health risk communication
Research capacity
Stockpile of medicines and medical and laboratory medicines
National health emergency framework
Decentralized decision making
Membership of relevant organizations
Emergency funding arrangements with external bodies
Costed and funded health system strengthening plans

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★ FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT

BUILD RESILIENT HEALTH AND EDUCATION SYSTEMS *continued*

A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system
Enabling environment for school safety
Availability of and alignment with plans and guidelines to enable a safe learning environment
Monitoring and evaluation framework for safe schools
Education facility maintenance plan
Operational standards for alternative use of schools
Education continuity plans
Remote learning content
Monitoring and evaluation of effectiveness of distance education
Resources to enable remote learning
Comprehensive, integrated education management information system
Teacher training (technical, pedagogical skills for remote instruction)

★ 4: Help firms and people manage residual risks and natural disasters

A4.1. Save lives and money with emergency preparedness and early warning systems
EP&R legislation
Disaster management information system for EP&R
Emergency operations centers
Urban firefighting equipment and capabilities
Formal EP&R training program
Impact-based forecasting
Communication and dissemination of warnings
Community disaster response plans
Early warning system feedback mechanisms
A4.2. Be prepared to build back better after disasters
Resilient recovery and reconstruction plans
Procurement planning
Procurement procedures
Procurement templates and documents

A4.3. Build shock-responsive social protection systems
Postdisaster household assessment collection and usage
Postdisaster benefit delivery
Interoperable social protection and DRM information systems
ASP operational processes
Disaster risk finance mechanism for ASP
ASP human resource capacity
ASP coordination
ASP policy structures
A4.4. Develop the insurance sector, building on public-private partnerships
Insurance penetration
Deposit insurance system
Resilience/adaptation insurance
A4.5. Help private actors develop business continuity plans and financial preparedness
Firms in tourism industry with business continuity plans
Firms in tourism industry with disaster insurance coverage

★ 5: Anticipate and manage macrofiscal and financial issues

A5.1. Protect countries with fiscal buffers and sound debt management
External debt
Fiscal balance
Fiscal rule
Monetary policy independence
Financial solvency risk
Liquidity risk
A5.2. Develop a financial strategy to manage shocks, combining multiple instruments
National DRF strategy
DRF assessment
Alternative risk transfer instruments
Ex post financial assistance
State contingent debt instruments
Traditional insurance
Parametric insurance
Contingent credit
Budget
Reserve fund

Resource planning
Budget appropriation
Gender-sensitive resource allocation
Expenditure controls
Expenditure tracking
Auditing practices
PFM rules and regulations
Institutional PFM arrangements
A5.3. Anticipate and plan for long-term macroeconomic impacts
Sector-level adaptation plans
Long-term plan to diversify tax revenues
Tax revenues originating from high-vulnerability sectors
Debt sustainability or financial sector assessment program considers climate and disaster impacts
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems
Specific disaster and climate risk requirements bank and large investor regulations
Climate and disaster risk stress tests for banks and large investors
Quantified estimates of their exposure to natural hazards by banks and large investors

ANNEX B

Indicator	Description	Nascent	Emerging	Established	Source
F. FOUNDATIONS FOR RAPID, ROBUST, AND INCLUSIVE GROWTH					
Governance	Based on six governance dimensions: voice and accountability; stability and absence of violence; government effectiveness; regulatory quality; rule of law; and control of corruption	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	Worldwide Governance Indicators
GDP per capita growth	Average GDP per capita growth between 2016 and 2019	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	World Development Indicators
Poverty rate	Poverty rate as % of total population	Top third among other Caribbean countries	Middle third among other Caribbean countries	Bottom third among other Caribbean countries	Beazley and Williams 2021
Targeting of main social safety nets	Targeting methods used by main social protection (SP) programs to identify eligible individuals, households and groups, for the purposes of transferring resources or preferential access to social services	Targeting methods rely on subjective assessments and/or undocumented processes	Targeting is based on objective and transparent methods, but there may be challenges with inclusion or exclusion errors or outdated data to inform targeting	Targeting is based on objective and transparent methods, with few inclusion and exclusion errors; data to inform targeting updates are current	Beazley and Williams 2021
Coverage of main social safety nets	Degree of coverage of main SP programs among the poor	Coverage of the main poverty reduction SP programs among the poor is low	There is reasonable coverage of the main poverty reduction SP programs among the poor	There is broad coverage of the main poverty reduction SP programs among the poor	Beazley and Williams 2021
Access to universal health coverage	Coverage index for essential health services (%)	<64% coverage	64–79% coverage	>80% coverage	World Development Indicators
Access to primary education	Net primary school enrollment (%)	<64% coverage	64–79% coverage	>80% coverage	World Development Indicators
Access to secondary education	Net secondary school enrollment (%)	<64% coverage	64–79% coverage	>80% coverage	World Development Indicators
Access to basic water services	Access to basic water services (% of total population)	<64% coverage	64–79% coverage	>80% coverage	World Development Indicators
Access to basic sanitation services	Access to basic sanitation services (% of total population)	<64% coverage	64–79% coverage	>80% coverage	World Development Indicators
Access to energy	Access to energy (% of total population)	<64% coverage	64–79% coverage	>80% coverage	World Development Indicators
Access to financial services	Account ownership at a financial institution or with a mobile money service provider (% of population aged 15+)	<64% coverage	64–79% coverage	>80% coverage	World Development Indicators
Access to ICT	Based on the UN Telecommunications Infrastructure Index, which is composed of the number of active mobile broadband subscriptions, internet users, mobile subscribers, and fixed broadband subscriptions per 100 inhabitants	UN Telecommunications Infrastructure Index <53	UN Telecommunications Infrastructure Index 53–70	UN Telecommunications Infrastructure Index >70	United Nations 2020
FIVE PRIORITY AREAS FOR RESILIENT DEVELOPMENT					
P1. Facilitate risk reduction decisions by firms and households					
A1.1. Assess disaster and climate change risks, and make this information available					
Hydromet data completeness	Time series of hydromet observations are long enough to produce probabilistic hazard maps (e.g. availability of a baseline)	Not available	Available in limited locations, representative of limited rainfall regimes	Available in multiple locations, representative of different rainfall regimes	Authors
Hydromet data availability	Time series of hydromet observations are available	Available within government	Available upon request/payment of fee	Publicly available on a web platform	Authors
High-resolution Digital Terrain Model (DTM) data existence and coverage	High-resolution and accurate DTM and/or point cloud data exist and are complete (measured by share of country covered)	High-resolution DTM data are largely nonexistent	High-resolution DTM data cover <60% of the country	High-resolution DTM data cover >60% of the country	Authors
Public availability of high-resolution DTM data	High-resolution and accurate DTM and/or point cloud data are available to the public	High-resolution DTM data are available within the government	High-resolution DTM data are available upon request/payment of fee	High-resolution DTM data are publicly available on a web platform	Authors
Local-scale hazard map availability (1:10.000 or larger)	Local-scale hazard maps are available in an open GIS format and are complete (e.g. metadata are available and complete)	Local-scale hazard maps are available within the government	Local-scale hazard maps are available upon request/payment of fee	Local-scale hazard maps are publicly available on a web platform	Authors
National-scale hazard map availability (covering entire country)	National-scale hazard maps are available in an open GIS format and are complete (e.g. metadata are available and complete)	National-scale hazard maps are available within the government	National-scale hazard maps are available upon request/payment of fee	National-scale hazard maps are publicly available on a web platform	Authors
National system exists for capturing past and current, small- and large-scale events	In addition to platforms such as DesInventar or EM-DAT, the country has a national system to record events	A national system for capturing past and current events is not available	A national system for capturing past and current events is available but not up to date	A national system for capturing past and current events is available, applied, and up to date	Authors
Community awareness of hazard and vulnerability levels	Hazard and/or vulnerability maps have been validaded with community members and therefore the community is aware of the hazard levels	Hazard and vulnerability maps have not been validated with the community	Hazard and vulnerability maps have been validated to a certain extent with the community	Hazard and vulnerability maps have been validated with the community	Authors
Local-scale climate change scenarios	Local-scale climate change scenarios are available	Local-scale climate change scenarios are not available	Local-scale climate change scenarios are in development or need updating	Local-scale climate change scenarios are available	Valero, Miranda and Murisic 2021
A1.2. Clarify responsibilities and align incentives with resilience and adaptation objectives					
Residual risk target level	Target level of residual risks published and publicly available—for example, through maps of residual flood risks	Residual risk targets have not been established	Residual risk targets are there, but do not account for all relevant current and future hazards	Residual risk targets are there and account for all relevant current and future hazards	No data were available for this indicator
Dedicated water resource management agencies	Dedicated water resource management agencies exist and have the capacities, financing, and tools needed to strengthen water security against backdrop of different shocks	Dedicated water resources management agencies do not exist	Dedicated water resources management agencies exist but lack the necessary capacities, tools, or financing	Dedicated water resource management agencies exist and have the capacities, tools, and financing needed to effectively strengthen water security	Country consultations
A1.3. Develop and implement technical solutions for resilience					
Research and development (R&D) for resilience	Share of R&D (or % of patents) related to climate change adaptation or total amount invested in R&D on adaptation- or resilience-related challenges	There is no to insufficient investment in adaptation and resilience	There is some investment in adaptation and resilience, but this can be improved	Investment in adaptation and resilience is adequate to prepare the country for future shocks	No data were available for this indicator

Indicator	Description	Nascent	Emerging	Established	Source
Climate-smart practices used in agriculture	Share of farmers using improved crops and climate-smart practices	Farmers do not use climate-smart agricultural practices	Some farmers use climate-smart agricultural practices	Most farmers use climate-smart agricultural practices	Country consultations
Resilience tariff	Availability of a tariff applied to imports of resilience-related technologies	There is no tariff in place	A tariff is being implemented	An adequate tariff is in place	Country consultations
A1.4. Make finance for resilience accessible and provide direct support to the poorest and most vulnerable people					
Ease of getting credit for firms	Measures the strength of credit reporting systems and the effectiveness of collateral and bankruptcy laws in facilitating lending	Overall ease of getting credit for firms score ≤55	Overall ease of getting credit for firms score 55–63	Overall ease of getting credit for firms score ≥63	Ease of Doing Business 2020
Protecting minority investors	Measures the protection of minority investors from conflicts of interest and shareholders' rights in corporate governance	Overall protecting minority investors score ≤55	Overall protecting minority investors score 55–63	Overall protecting minority investors score ≥63	Ease of Doing Business 2020
Access to financial services for the poorest 40%	Account ownership at a bank, other financial institution or with a mobile money service provider among the poorest 40% (% of population aged 15+)	<50% of the poorest have access to a bank account	<80% of the poorest have access to a bank account	>80% of the poorest have access to a bank account	World Development Indicators
Gender gap in bank account access	Difference between male and female account ownership at a bank, other financial institution or with a mobile money service provider (% of population aged 15+)	The gap is smaller than 20%	The gap is smaller than 10%	The gap is smaller than 5%	World Development Indicators
A1.5. Build skills for resilience through public works and training programs					
Complementary SP measures for resilience	Degree to which risk is integrated into existing SP programs; productive and economic inclusion interventions are available for beneficiaries and well coordinated with other sectors; effective social care and case management for postdisaster support is systematically deployed for affected households; benefit delivery facilitates financial inclusion, including saving	SP programs—cash transfers, public works, etc.—are not risk-informed and have no interventions to address beneficiary risk; there are no productive and economic inclusion interventions for SP beneficiaries; there is no social care or case management for postdisaster support; benefit delivery does not facilitate financial inclusion	Risk is integrated on a limited scale in one or two flagship programs; productive and economic inclusion interventions for SP beneficiaries are implemented on a pilot or small scale and not broadly coordinated with other sectors; social care and case management for postdisaster support are in place, but not well established and are implemented on an ad hoc basis; benefit delivery facilitates some links to financial inclusion by improving financial access, but does not facilitate savings	Risk is integrated into most programs or comprehensively integrated into flagship programs through risk information and reduction efforts; productive and economic inclusion interventions are available for most SP beneficiaries and well coordinated with other sectors; effective social care and case management for postdisaster support is systematically deployed for affected households; benefit delivery facilitates financial inclusion, including savings	Beazley and Williams 2021
Inclusion and application of climate change and disaster risk reduction (DRR) in education curriculum	Degree to which an age-specific climate change and DRR curriculum is in place and applied in schools	An age-specific climate change and DRR curriculum does not exist	An age-specific climate change and DRR curriculum is in place and used in < 95% of schools	An age-specific climate change and DRR curriculum is in place and in use in ≥ 95% of schools	Bellony and Powers 2021
Number of qualified planners	The benchmark for an adequate number of planners is 1/30,000 people for Caribbean countries	Insufficient number of planners, far below 1/30,000 people	Planner numbers are close to 1/30,000 people	Adequate number of planners: ≥ 1/30,000 people	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Presence of planning education	Extent of access to an in-country or regional planning school	There is little to no access to planning education in the country	There is some access to planning education, but planners are mostly educated abroad	There is a professional planning program in the country	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Professional planning association	Existence of an active in-country or regional professional planning association	There is no planning association, or it is largely defunct	There is a planning association, but it is not very active	There is an active professional planning association and accreditation of planners	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Technical capability to incorporate disaster risk into planning	Degree to which planners have the technical capability to incorporate disaster risk into planning	Planners are not trained or have little training in incorporating disaster risk into planning	There is some capacity for incorporating disaster risk into planning, but not in every location/ not everywhere in the country	There is in-house technical capacity to incorporate disaster risk into planning across the range of national and local planning offices	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Human capital development for resilience	Availability and implementation of an up-to-date human capital development plan to expand skills for resilience	Human capital development plan is in progress and 50& complete, or plan is nonexistent	Human capital development plan to expand skills for resilience exists and is somewhat used	Human capital development plan to expand skills for resilience exists, is up to date and is used	Bellony and Powers 2021
A1.6. Facilitate robust economic sectors and their diversification					
Business environment	Composite Ease of Doing Business score measuring the regulations that enhance business activity and those that constrain it. It covers 10 areas: starting a business; dealing with construction permits; getting electricity; registering property; getting credit; protecting minority investors; paying taxes; trading across borders; enforcing contracts; and resolving insolvency	Overall Ease of Doing Business score ≤55	Overall Ease of Doing Business score 55–63	Overall Ease of Doing Business score ≥63	Ease of Doing Business 2020
State-owned enterprises (SOEs) include disaster risk management (DRM) and climate change in their decision making	SOEs have included DRM and climate change in their long-term strategy and decision making	No SOEs have included DRM and climate change in their long-term strategy and decision making	Some SOEs have included DRM and climate change in their long-term strategy and decision making	All SOEs have included DRM and climate change in their long-term strategy and decision making	Authors
P2. Design resilient infrastructure systems, urban and coastal planning					
A2.1. Design and implement a governmentwide strategy to increase the resilience of the infrastructure system					
Water reliability index	Based on the frequency and length of water outages among Caribbean firms in the tourism industry	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	Erman et al. 2021
Power reliability index	Based on the frequency and length of electricity outages among Caribbean firms in the tourism industry	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	Erman et al. 2021
Transport infrastructure inventory	A transport infrastructure inventory exists and is regularly updated	A transport infrastructure inventory does not exist or only includes ancillary information on road characteristics	A transport infrastructure inventory exists and includes mapping information	A transport infrastructure inventory exists and includes mapping information and budgeting and other asset management features	Authors
Water and sanitation infrastructure inventory	A water and sanitation infrastructure inventory exists and is regularly updated	A water and sanitation infrastructure inventory does not exist or only includes ancillary information on intake characteristics	A water and sanitation infrastructure inventory exists and includes mapping information	A water and sanitation infrastructure inventory exists and includes mapping information and budgeting and other asset management features	Authors
Asset management system	Asset management systems with evidence-based maintenance plans are in place	There is no asset management system in place	An asset management system is in place, but not regularly updated	An asset management system is in place, regularly updated and used in decision making	Authors

Indicator	Description	Nascent	Emerging	Established	Source
Adequate maintenance budget	There is adequate maintenance budget for critical infrastructure (water and transport)	The maintenance budget for critical infrastructure is not adequate	The maintenance budget for critical infrastructure is only partially adequate	The maintenance budget for critical infrastructure is adequate	Authors
Nonrevenue water levels	The ratio of water "lost" over total water produced	Utilities' nonrevenue water levels are >30%	There is no emerging category for this indicator	Utilities' nonrevenue water levels are <30%	Medina, Kullmann and Felter 2021
Resilient infrastructure agency	An agency is in place that is charge of coordinating resilience of built and operational critical assets and infrastructure	There is no resilient infrastructure agency in place	A resilient infrastructure agency is being implemented	A resilient infrastructure agency is in place and functioning	Authors
Long-term resilient infrastructure plan	A long-term resilient infrastructure plan is in place	There is no long-term resilient infrastructure plan in place	A long-term resilient infrastructure plan is being implemented or reviewed, or it exists but is outdated or incomplete	A long-term resilient infrastructure plan is in place, complete and up to date	Valero, Miranda and Murisic 2021
National climate adaptation plan	A national climate adaptation plan is in place	There is no national climate adaptation plan	A national climate adaptation plan is in progress	A national climate adaptation plan is in place	Valero, Miranda and Murisic 2021
Public asset management	An up-to-date, risk-informed consolidated registry of physical assets exists and is maintained by a single government budgetary unit that is explicitly responsible for maintaining the physical assets registry	The government does not have a risk-informed consolidated registry of physical assets	The government has a risk-informed consolidated registry of physical assets, but the registry is either out-of- date or not maintained by a single government budgetary unit that is explicitly responsible for its maintenance	The government has a risk-informed consolidated registry of physical assets that is up to date and maintained by a single government budgetary unit that is explicitly responsible for its maintenance	April and Zrinski 2021
Public investment management (PIM)	Disaster risk and climate change considerations are considered in investment planning, including for project identification, appraisal, and selection	The government does not include disaster risk and climate change considerations in its investment planning	The government includes disaster risk and climate change considerations in its investment planning, but this is not systematically applied throughout the PIM cycle	The government includes disaster risk and climate change considerations in its investment planning, including for identifying, appraising, and selecting projects	April and Zrinski 2021
Share of renewable energy-powered power plants	Ratio of renewable over fossil energy-powered power plants (irrespective of the capacity installed)	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	Schweikert et al. 2021
A2.2. Make land use and urban plans risk-informed					
Planning regulations and institutional framework	There is clear national legislation with clear lines of responsibility for urban planning, preparing and regularly updating plans; legislation requires planning to make use of multihazard risk information, participatory approaches, and linkages across administrative boundaries and socioeconomic development plans	Legislation is weak or nonexistent	There is legislation and an institutional framework, but it may be lacking in some areas or not put into practice—e.g. it may not mandate the use of multihazard information; consultation of stakeholders; and linkages with socioeconomic development	Well-functioning, flexible and enabling national legislation and institutional frameworks require planning to make use of multihazard information; mandate stakeholder engagement; and have clear linkages with socioeconomic planning	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Land administration	Land is administered through an efficient and up-to-date cadastral system and an affordable and efficient land registration process, providing strong tenure security	The cadastral system is nonexistent or weak; the land registration process is weak but might be usable for larger projects; there is a lack of land tenure security	There is a functioning cadastral system, but it lacks information or is out of date; some land is registered but the registration process is lengthy and costly, so is often not used for smaller parcels; there are some weaknesses in land tenure security	A digitized cadastral system provides all the necessary information; all land is registered, and the registration process is easy and affordable for most people; land tenure security is sufficient to strong and most people perceive their rights to land as secure	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Building and construction regulatory system	Building codes and standards are locally relevant, affordable and achievable for most builders and the building approval and permit system is both efficient and affordable	Local building code is absent, weak, or in progress; building approvals system is absent, weak, or seldom used because it is overly long, complicated, or expensive and possible to bypass	There is a locally relevant building code, but many builders cannot afford this standard; only large projects or certain kinds of project apply for building permits, due to the expense or time involved in building approvals	There are affordable, locally relevant building codes and standards and most buildings are up to standard; the building permit system is efficient and affordable and the majority or all projects undergo the process	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Building regulation and implementation	Building regulations exist and are implemented, measured by six indices: quality of building regulations; quality control before, during, and after construction; liability and insurance regimes; and professional certifications indices	Building regulations and the processes to implement them are nonexistent or weak and in need of priority attention	Building regulations and the processes to implement them are in place, but need strengthening to enable greater compliance	Building regulations and processes to implement them are satisfactory	Benavidez 2021
Governance and politics in urban planning	Includes the degree of decentralization and political importance of urbanization, urban and spatial planning, and risk reduction	There is little or no decentralization; there is little or no mention of urban planning as part of the political agenda; and DRR is a low priority	Decentralization is in progress, there is a local government, but is not fully functional; urban planning is mentioned as part of the political agenda; and DRR is a medium to high priority (e.g. high after a disaster)	There is a country-wide accountable and functional local government system; urban planning is mentioned as a priority issue in key documents; and DRR is consistently a high priority	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Financing for planning	Plans are up to date and aligned with national objectives, consider disaster risk, and accompanied by implementation plans; communities and stakeholders are involved in planning	Plans are frequently out of date; disaster risk considerations do not feature regularly in plans; implementation plans are weak or nonexistent; participation is weak or nonexistent	Some plans are up to date, others exist but are pending approval; disaster risk considerations are present but not always implemented; implementation plans are infrequent; stakeholders are consulted but not well engaged at all stages of planning	There are up-to-date regional, local, and urban plans that are aligned to national objectives, consider disaster risk, tackle cross-cutting issues in an integrated way, and consider urban typologies; there are clear plans for implementation; relevant stakeholders are involved in planning	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Financing for implementation	Planning guides urban development; budget is available for implementation; DRR is used for planning and development-related activities	Very little development is guided by plans; budget is insufficient or almost nonexistent; and there is little to no DRR budget	Some urban development and infrastructure is guided by plans, planning regulations, and approvals; budget is somewhat insufficient for implementing delaying activities; planning, infrastructure, and built environment-related activities are not easily seen as DRR activities	Most urban development and infrastructure is guided by plans, planning regulations, and approvals; plans have satisfactory budget for implementation and most objectives or activities are achieved within the timeframe; planning, infrastructure, and built environment-related activities are an important part of DRR activities	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
Use of disaster risk information in planning	Quality risk maps are applied in planning	Very little or no disaster risk information is available	Risk maps are in development, or exist but miss some elements	Risk maps are available and used (e.g., in planning) and there are accompanying guidelines for achieving risk-sensitive development	Johnson, Caroca Fernandez, and Restrepo Cadavid 2021
A2.3. Develop or revise coastal management plans and integrate NBS					
Integrated coastal zone management (ICZM) plan	ICZM plans are in place	There is no ICZM plan in place	An ICZM plan is in progress	An ICZM plan is in place	Valero, Miranda and Murisic 2021
Updated environmental laws	Environmental laws were enacted or have been revised in the last seven years	Environmental laws are outdated or not in place	Environmental laws are in under review	Environmental laws are enacted or revised to the latest seven years ago	Valero, Miranda and Murisic 2021
Climate change law/policy	Updated and revised climate change law/policy is in place	There is no climate change law or policy	A climate change law or policy is under development or review	An up-to-date climate change law or policy is in place	Valero, Miranda and Murisic 2021
Long-term strategy/sustainable development plan	Long-term strategy/sustainable development plan is in place	There is no long-term strategy or sustainable development plan in place	A long-term strategy or sustainable development plan is in progress	A long-term strategy or sustainable development plan is in place	Valero, Miranda and Murisic 2021

Indicator	Description	Nascent	Emerging	Established	Source
Civil society organizations (CSOs) in climate change/resilience	CSOs play a strong role in climate change/resilience	CSOs do not have a strong role in climate change or resilience	CSOs have a somewhat strong role in climate change or resilience	CSOs are present and have a strong role in climate change or resilience	Valero, Miranda and Murisic 2021
Coastal zone management agency	There is a fully functional coastal zone management agency, institute or unit in place	There is no coastal zone management agency	A coastal zone management agency is being developed, or is in place but not fully functional	A coastal zone management agency is in place	Valero, Miranda and Murisic 2021
Governmental agency responsible for climate change/resilience	There is a named interministerial committee or governmental body responsible for climate change/resilience	There is no governmental agency responsible for climate change/resilience	A governmental agency responsible for climate change/resilience is being implemented or reviewed	A governmental agency responsible for climate change/resilience is in place	Valero, Miranda and Murisic 2021
Enforcement of environmental policies	There is evidence that policies and regulations related to environment, climate change, and natural resources have been and are being enforced	Policies and regulations related to environment, climate change, and natural resources are not enforced	Policies and regulations related to environment, climate change, and natural resources are somewhat enforced	Policies and regulations related to environment, climate change, and natural resources are enforced	Valero, Miranda and Murisic 2021
Existence of environmental or climate change taxes or incentives	Environmental or climate change taxes and incentives exist	Environmental or climate change taxes or incentives are not in place	Environmental or climate change taxes or incentives are being implemented or are somewhat in place	Environmental or climate change taxes or incentives are in place	Valero, Miranda and Murisic 2021
P3. Build resilient health and education systems					
A3.1. Design and implement a governmentwide strategy to increase the resilience of the health system					
Hospital facility safety	Health Safety Index (HSI) scores place a facility in Category A, B or C for hospital safety. Category A facilities are deemed able to protect the life of their occupants and likely to continue functioning in disaster situations; Category B facilities can resist a disaster, but equipment and critical services are at risk; and in Category C facilities, lives and safety of occupants are deemed to be at risk during disasters	Most hospitals and health facilities have an HSI score that places them in Category C	Most hospitals and health facilities have an HSI score that places them in Category B	Most hospitals and health facilities have an HSI score that places them in Category A	Harnam and Khan 2021
Health service provision	There is core capacity for health service provision, including case management capacity for International Health regulation (IHR)-relevant hazards; capacity for infection prevention and control; and chemical and radiation contamination	IHR score <21	IHR score = 21–62	IHR score >62	WHO 2019
Emergency education for health workers	Emergency preparedness and response education is a component of academic curriculums (including ongoing medical education) for health care and public health providers	Relevant emergency education is not a component of the academic curriculums for clinical and public health professionals	Relevant emergency education is a component of the academic curriculums for clinical and public health professionals, but it is not a requirement for ongoing education	Relevant emergency education is a component of the academic curriculums and required ongoing education for clinical and public health professionals	Harnam and Khan 2021
Adequate number of doctors, nurses, and midwives	There is enough capacity in the health workforce to meet surge demand in emergency situations	There are not enough clinical and public health professionals to provide any surge capacity	There is some surge capacity among clinical and public health professionals, but gaps in key specialties remain	There is an adequate number of clinical and public health to provide surge capacity in all specialties	Harnam and Khan 2021
Adequate number of Caribbean Regional Field Epidemiology and Laboratory Training Programme (CR-FELTP) trained workers	There is enough capacity in the health workforce to meet surge demand in emergency situations	There are not enough CR-FELTP-trained clinical and public health professionals to provide any surge capacity	There is some surge capacity among CR-FELTP-trained clinical and public health professionals, but gaps in key specialties remain	There is an adequate number of CR-FELTP-trained clinical and public health to provide surge capacity in all specialties	Harnam and Khan 2021
Health information system	Degree to which a health information system is integrated, maintained and used in facilities in the country	There is no health information system in place	A health information system is implemented in some facilities	A health information system is integrated in all health facilities and used in surveillance, monitoring and evaluation, and for tracking medical supplies	Harnam and Khan 2021
Health sector surveillance system	A health sector surveillance system exists and is in use, which captures the changing needs of the population	There is no health surveillance system	A health surveillance system exists, but is inadequate or inactive	There is a dedicated and active health sector surveillance system	Harnam and Khan 2021
Health risk communication	Mechanisms for effective risk communication during a public health emergency are established and functioning, including a national risk communications plan	IHR score <21	IHR score = 21–61	IHR score >61	WHO 2019
Research capacity	There are well-trained, dedicated health research staff, that have a sustainable source of funding and a prioritized research agenda guiding health system resilience plans	There is no research capacity at the executive level of the health sector	Research capacity at the executive level of the health sector exists, but is inadequate	There is dedicated and active research capacity at the executive level of the health sector	Harnam and Khan 2021
Stockpile of medicines and medical and laboratory medicines	There is a regularly maintained stockpile of medical supplies, including personal protective equipment (PPE), medicines, and lab supplies within the country and region	There is no stockpile of medical supplies (including PPE), medicines, or lab supplies	There is a stockpile of medical supplies (including PPE), medicines, and lab supplies within the region	A regularly maintained stockpile of medical supplies (including PPE), medicines, and lab supplies exists within the country and the region	Harnam and Khan 2021
National health emergency framework	There is core capacity for national emergency framework, including mechanisms for planning for emergency preparedness and response, managing health emergency response operations, and mobilizing emergency resources	IHR score <23	IHR score = 21–63	IHR score >63	WHO 2019
Decentralized decision making	Extent of decentralized decision making	Decision making is centralized	Decentralized decision making exists, but is limited	Decision making is appropriately decentralized to allow rapid responses	Harnam and Khan 2021
Membership of relevant organizations	Countries are members of relevant local, regional, and international organizations and signatory to relevant agreements	Country is member of few relevant local, regional, and/or international organizations and is signatory to few or no agreements that can provide technical and financial support/guidance to the national health sector in emergencies	Country is member of some relevant local, regional, and international organizations and is signatory to some agreements that can provide technical and financial support/guidance to the national health sector in emergencies	Country is member of all relevant local, regional, and international organizations and signatory to all agreements that can provide technical and financial support/guidance to the national health sector in emergencies	Harnam and Khan 2021
Emergency funding arrangements with external bodies	Degree to which countries have emergency funding agreements with relevant local, regional, and international organizations	Emergency health sector funding arrangements with national, regional and/or international organizations are ad hoc	Emergency health sector funding arrangements are established with some relevant national, regional and/or international organizations	Emergency health sector funding arrangements with all relevant national, regional and international organizations are formally established and updated regularly	Harnam and Khan 2021
Costed and funded health system strengthening plans	Health system strengthening plans exist, are costed and funded	There are no health system strengthening plans	Health system strengthening plans exist, but have been neither costed nor funded	Health system strengthening plans are costed and funded	Harnam and Khan 2021
A3.2. Design and implement a governmentwide strategy to increase the resilience of the education system					
Enabling environment for school safety	School safety is included in legislation and policy, school safety plans are aligned with DRM plans and resources are allocated for safe schools	Legislation, policy, safe school plans, and institutional frameworks are either in progress or do not exist	Some legislation, policy, and safe school plans exist and include school safety, but they require amendment	Appropriate national legislation and policy exist, include school safety, and are in use	Bellony and Powers 2021

Indicator	Description	Nascent	Emerging	Established	Source
Availability of and alignment with plans and guidelines to enable a safe learning environment	National safe school policy, safe school standards, and model safe school guidelines are in place, up to date and aligned to national DRM plans, and schools are aligned to these documents	There are no school safety documents, or these are in place in less than 50% of schools, and more than 25% of these are aligned with national DRM plan	Up-to-date school safety documents are in place in 50–95% of schools, and more than 50% of these plans are aligned with the national DRM plan	Up-to-date school safety documents are in place in at least 95% of schools and are aligned with national DRM plan	Bellony and Powers 2021
Monitoring and evaluation framework for safe schools	A monitoring and evaluation framework for national school safety plan exists and is updated biannually	There is no monitoring and evaluation framework for the National School Safety Plan	There is a monitoring and evaluation framework for the National School Safety Plan, and it is updated annually or less frequently	There is a monitoring and evaluation framework for the National School Safety Plan, and it is updated biannually	Bellony and Powers 2021
Education facility maintenance plan	Education facility maintenance plans are available and implemented in schools and maintenance budgets are adequate	There are no functioning maintenance plans in schools or less than 50% of schools have a functioning maintenance plan and assigned budget	There are maintenance plans in place, with assigned budget, for 50–95% of schools	Education facility maintenance plans are available and implemented for at least 95% of schools and the budget for these is adequate	Bellony and Powers 2021
Operational standards for alternative use of schools	Availability and enforcement of operational standards on alternative use of schools as shelters during emergency situations	School use operational standards lack policy on their use as emergency shelters	School use operational standards includes some guidance limiting the use of schools as emergency shelters	School use operational standards curtail their use as emergency shelters	Bellony and Powers 2021
Education continuity plans	Education continuity plans exist and are implemented in schools	Education continuity plans are either incomplete or used in <50% of schools	Education continuity plans exist and are used in 50–95% of schools	Educational continuity plans exist and are used in ≥95% of schools	Bellony and Powers 2021
Remote learning content	Availability and appropriateness of remote learning content	Appropriate content in digital and other media for teaching and learning at different educational levels is still in development or not yet available	Appropriate content in digital and other media is available for teaching and learning for some educational levels and subject areas	Appropriate content in digital and other media is available for teaching and learning in all educational levels and subject areas	Bellony and Powers 2021
Monitoring and evaluation of effectiveness of distance education	Effectiveness of distance education is monitored and evaluated	There is no monitoring and evaluation plan for the effectiveness of distance education	A monitoring and evaluation plan is available but not used to assess the effectiveness of distance education modalities	A monitoring and evaluation plan is available and used to assess the effectiveness of distance education	Bellony and Powers 2021
Resources to enable remote learning	Degree to which households have access to resources such as internet, devices, electricity, television, and radio to enable remote learning	<50% of households with school-aged children have access to resources to support distance learning	50–95% of households with school-aged children have access to resources to support distance learning	≥95% of households with school-aged children have access to resources to support distance learning	Bellony and Powers 2021
Comprehensive and integrated education management information system (EMIS)	Availability and implementation of an up-to-date EMIS	There is no EMIS or there is one, but it is not linked to other administrative databases	There is an EMIS and it is securely linked to some key administrative databases	There is an EMIS and it is securely linked to the most pertinent administrative databases to inform policy decisions	Bellony and Powers 2021
Teacher training (technical and pedagogical skills for remote instruction)	Teachers have the technical and pedagogical skills needed to deliver distance education	<50% of teachers have the skills to lead distance education by digital and other media	50–95% of teachers have the skills to lead distance education using digital and other media	≥95% of teachers have the skills to lead instruction using digital and other media	Bellony and Powers 2021
P4. Help firms and people manage residual risks and natural disasters					
A4.1. Save lives and money with emergency preparedness and early warning systems					
Emergency preparedness and response (EP&R) legislation	For an EP&R system to function well at any government scale and across scales, emergency management legislation and related policy instruments must exist. These instruments must clearly assign accountabilities to specific government departments and ministries to ensure public safety service delivery and resilience.	0–2 of the following statements are true: 1) Accountabilities are clear for all phases of emergency management, including central coordination as well as short- and long-term risk reduction activities; 2) Resilience requirements for time-critical public and private sector services are clearly stated and universally applied; 3) Agencies with emergency response roles are required to have detailed plans and report annually on improvements to their state of preparedness; 4) Emergency management accountabilities are clear across all levels of government, reducing or eliminating jurisdictional ambiguity; 5) The legislation and policy framework requires a collaborative, risk-informed, progressive approach from accountable agencies	3–4 of the following statements are true: 1) Accountabilities are clear for all phases of emergency management, including central coordination as well as short- and long-term risk reduction activities; 2) Resilience requirements for time-critical public and private sector services are clearly stated and universally applied; 3) Agencies with emergency response roles are required to have detailed plans and report annually on improvements to their state of preparedness; 4) Emergency management accountabilities are clear across all levels of government, reducing or eliminating jurisdictional ambiguity; 5) The legislation and policy framework requires a collaborative, risk-informed, progressive approach from accountable agencies	All of the following statements are true: 1) Accountabilities are clear for all phases of emergency management, including central coordination as well as short- and long-term risk reduction activities; 2) Resilience requirements for time-critical public and private sector services are clearly stated and universally applied; 3) Agencies with emergency response roles are required to have detailed plans and report annually on improvements to their state of preparedness; 4) Emergency management accountabilities are clear across all levels of government, reducing or eliminating jurisdictional ambiguity; 5) The legislation and policy framework requires a collaborative, risk-informed, progressive approach from accountable agencies	Campbell, Gonzalez-Escalada Mena and McAllister 2021
Disaster management information system (DMIS) for EP&R	The use of a common DMIS by all emergency management personnel improves overall situational awareness, decision making, and response coordination. A system based on commercial off-the-shelf software that is interoperable with common systems used by regional and/or international agencies, can improve overall response effectiveness and increase training opportunities for personnel across agencies.	0–2 of the following statements are true: 1) The DMIS has an uptime of 99% or higher with established redundancy and a recovery plan; 2) A common DMIS is used by all emergency operations centers (EOCs), even if only codified in policy as common email, work processing and spreadsheet tools; 3) The DMIS is interoperable with common DMIS platforms in use by regional and/or international disaster support agencies; 4) The DMIS uses commonly available commercial off-the-shelf software or networked/cloud-based applications; 5) EOC personnel and other DMIS users receive ongoing training on DMIS use	3–4 of the following statements are true: 1) The DMIS has an uptime of 99% or higher with established redundancy and a recovery plan; 2) A common DMIS is used by all EOCs, even if only codified in policy as common email, work processing and spreadsheet tools; 3) The DMIS is interoperable with common DMIS platforms in use by regional and/or international disaster support agencies; 4) The DMIS uses commonly available commercial off-the-shelf software or networked/cloud-based applications; 5) EOC personnel and other DMIS users receive ongoing training on DMIS use	All of the following statements are true: 1) The DMIS has an uptime of 99% or higher with established redundancy and a recovery plan; 2) A common DMIS is used by all EOCs, even if only codified in policy as common email, work processing and spreadsheet tools; 3) The DMIS is interoperable with common DMIS platforms in use by regional and/or international disaster support agencies; 4) The DMIS uses commonly available commercial off-the-shelf software or networked/cloud-based applications; 5) EOC personnel and other DMIS users receive ongoing training on DMIS use	Campbell, Gonzalez-Escalada Mena and McAllister 2021
Emergency operations centers	An EOC must be supported by sufficient backup systems, including electricity, heating and cooling, communications, staff and operational resources (such as security, break rooms, planning/meeting rooms, media center, etc.). Ideally, an EOC would have a backup facility that is geographically diverse and fully capable of operation if the primary EOC is not available.	0–2 of the following statements are true: 1) EOCs have resilient systems to ensure continuous operation despite critical service disruptions; 2) Primary EOCs have an established backup site in the event they require evacuation or are unavailable; 3) EOCs are staffed, or have staff on call, 24 hours a day, 365 days a year, who can serve as duty/watch officers; 4) The government has established an operational program budget, including capital funding for facility, personnel, and training improvements, and annual testing; 5) EOCs are fully equipped with the tools and technology necessary to coordinate response activities within their jurisdiction	3–4 of the following statements are true: 1) EOCs have resilient systems to ensure continuous operation despite critical service disruptions; 2) Primary EOCs have an established backup site in the event they require evacuation or are unavailable; 3) EOCs are staffed, or have staff on call, 24 hours a day, 365 days a year, who can serve as duty/watch officers; 4) The government has established an operational program budget, including capital funding for facility, personnel, and training improvements, and annual testing; 5) EOCs are fully equipped with the tools and technology necessary to coordinate response activities within their jurisdiction	All of the following statements are true: 1) EOCs have resilient systems to ensure continuous operation despite critical service disruptions; 2) Primary EOCs have an established backup site in the event they require evacuation or are unavailable; 3) EOCs are staffed, or have staff on call, 24 hours a day, 365 days a year, who can serve as duty/watch officers; 4) The government has established an operational program budget, including capital funding for facility, personnel, and training improvements, and annual testing; 5) EOCs are fully equipped with the tools and technology necessary to coordinate response activities within their jurisdiction	Campbell, Gonzalez-Escalada Mena and McAllister 2021

Indicator	Description	Nascent	Emerging	Established	Source
Urban firefighting equipment and capabilities	Volunteer fire services are an option in rural or less populated areas. However, full-time services will tend to respond to a greater variety of incidents as their training level increases with time, experience and resources. Equipment and training are a major factor in any fires services' ability to respond. The fire service's tactics will necessarily reflect their equipment capabilities if responder safety has been fully considered.	0–2 of the following statements are true: 1) Jurisdictional fire prevention programs exist and are delivered by the fire service; 2) A network of jurisdictional fire services exists with professional and volunteer firefighters that are equipped with modern PPE and enough functional equipment to safety suppress exterior and interior fires; 3) Industrial firefighting capability exists in either the public or private sector, including marine fire suppression where appropriate; 4) Fire services are able to extinguish fires in high buildings, including residential and commercial structures; 5) Jurisdictional budgets exist, are reviewed regularly to support urban firefighting readiness, and consider training, equipment needs, employee costs, deployment costs, prevention/mitigation efforts, and management/administration costs	3–4 of the following statements are true: 1) Jurisdictional fire prevention programs exist and are delivered by the fire service; 2) A network of jurisdictional fire services exists with professional and volunteer firefighters that are equipped with modern PPE and enough functional equipment to safety suppress exterior and interior fires; 3) Industrial firefighting capability exists in either the public or private sector, including marine fire suppression where appropriate; 4) Fire services are able to extinguish fires in high buildings, including residential and commercial structures; 5) Jurisdictional budgets exist, are reviewed regularly to support urban firefighting readiness, and consider training, equipment needs, employee costs, deployment costs, prevention/mitigation efforts, and management/administration costs	All of the following statements are true: 1) Jurisdictional fire prevention programs exist and are delivered by the fire service; 2) A network of jurisdictional fire services exists with professional and volunteer firefighters that are equipped with modern PPE and enough functional equipment to safety suppress exterior and interior fires; 3) Industrial firefighting capability exists in either the public or private sector, including marine fire suppression where appropriate; 4) Fire services are able to extinguish fires in high buildings, including residential and commercial structures; 5) Jurisdictional budgets exist, are reviewed regularly to support urban firefighting readiness, and consider training, equipment needs, employee costs, deployment costs, prevention/mitigation efforts, and management/administration costs	Campbell, Gonzalez-Escalada Mena and McAllister 2021
Formal EP&R training program	Those within an organization who may be involved in planning for and responding to an emergency should be appropriately prepared. This requires a clear understanding of roles and responsibilities and how they fit in to the wider emergency preparedness and response system. Training should build capability and capacity for emergency response incidents. It should also extend beyond those employed by the jurisdiction and include contractors and the staff of voluntary organizations who might support emergency planning or response operations.	0–2 of the following statements are true: 1) Training programs exist for those with legislated emergency response job requirements; 2) Training programs exist for all primary emergency response personnel; 3)Training programs exists for nontraditional emergency response roles such as logistics specialists, disaster relief coordinators, hospital staff, and emergency social services; 4) Training programs are tiered and establish skillsets and experience required for attaining each level; 5) A comprehensive training evaluation/ review exists to ensure ongoing improvement of the training program	3–4 of the following statements are true: 1) Training programs exist for those with legislated emergency response job requirements; 2) Training programs exist for all primary emergency response personnel; 3)Training programs exists for nontraditional emergency response roles such as logistics specialists, disaster relief coordinators, hospital staff, and emergency social services; 4) Training programs are tiered and establish skillsets and experience required for attaining each level; 5) A comprehensive training evaluation/ review exists to ensure ongoing improvement of the training program	All of the following statements are true: 1) Training programs exist for those with legislated emergency response job requirements; 2) Training programs exist for all primary emergency response personnel; 3)Training programs exists for nontraditional emergency response roles such as logistics specialists, disaster relief coordinators, hospital staff, and emergency social services; 4) Training programs are tiered and establish skillsets and experience required for attaining each level; 5) A comprehensive training evaluation/ review exists to ensure ongoing improvement of the training program	Campbell, Gonzalez-Escalada Mena and McAllister 2021
Impact-based forecasting (IBF)	An impact-based approach is applied for hydromet hazards	Country is not using IBF	Country is developing or has started using IBF approaches	IBF is a well-established and functional forecasting approach	Authors
Communication and dissemination of warnings	Early warning message recipients are efficiently notified and take notice of the warning on time	A mass communication channel exists for disseminating warnings, but it has limitations for reaching the whole population	Multichannel dissemination approach and the common alerting protocol (CAP) implementation is increasing notification capabilities	Country uses a multichannel approach and CAP implementation, and has the possibility of geotargeting warning recipients	Authors
Community disaster response plans	Community disaster response plans are in place	There are no community disaster response plans in place	Community disaster response plans are in place, but for few communities and they are not systematically revised	Community disaster response plans are in place for the most at-risk communities and are revised systematically	Authors
Early warning system (EWS) feedback mechanisms	End-to-end feedback mechanisms are in place to evaluate performance after events	There are no EWS feedback mechanisms in place	Some EWS feedback mechanisms are in place	Feedback mechanisms are in place along the end-to-end EWS and are used to improve performance of the EWS	Authors
A4.2. Be prepared to build back better after disasters					
Resilient recovery and reconstruction plans	Resilient recovery and reconstruction plans are ready for implementation (with revised land use and standards)	There are no resilient recovery and reconstruction plans in place	Resilient recovery and reconstruction plans are in place, but outdated	Resilient recovery and reconstruction plans are in place and up to date	Authors
Procurement planning	Procurement plans include provisions for responding to disasters and these are included in the annual budget	The government's annual or multiannual procurement plans do not include provisions for responding to disasters	The government's annual or multiannual procurement plans include provisions for responding to disasters, but these are not included in the annual budget	The government's annual or multiannual procurement plans include provisions for responding to disasters and are included in the annual budget	April and Zrinski 2021
Procurement procedures	Procuring entities with disaster relief and response responsibilities have up-to-date disaster emergency procurement procedures in place, such as standard operating procedures (SOPs), handbooks, user guides, or other manuals, that instruct how procurement is to be conducted in postdisaster situations; and the procedures are systematically applied	There are no emergency procurement procedures in place	Some emergency procurement procedures are in place, but these are not systematically applied or are not up to date	Procuring entities with disaster relief and response responsibilities have up-to-date disaster emergency procurement procedures in place—such as SOPs, handbooks, user guides, or other manuals that guide procurement in postdisaster situations—and these are systematically applied	April and Zrinski 2021
Procurement templates and documents	Procuring entities with disaster relief and response responsibilities have up-to-date disaster emergency procurement templates and documents in place, that instruct how procurement is to be documented in postdisaster situations; and these are systematically applied	There are no emergency procurement templates and documents in place	Some emergency procurement templates and documents are in place, but these are not systematically applied or are not up to date	Procuring entities with disaster relief and response responsibilities have up-to-date disaster emergency procurement templates and documents in place that guide procurement documentation in postdisaster situations; and these are systematically applied	April and Zrinski 2021
A4.3. Build shock-responsive SP systems					
Postdisaster household assessment (PDHA) collection and usage	PDHA data collection is electronic and supported by an information system that links to the social registry; its processes are established in manuals; staff are trained in these processes ex ante; and the data collected are used to inform postdisaster SP responses	Ad hoc PDHAs are developed for each disaster; data collection is paper-based; there is no dedicated information system for storing PDHA data and no coordination or data sharing among agencies carrying out PDHAs	PDHA data collection is mainly electronic, but includes offline functionality or paper format as backup; it may not be supported by a dedicated information system and is not linked to the social registry; PDHA processes may not be established in manuals and not all staff are trained in these processes; PDHA informs government SP response, but is not used by external agencies	PDHA data collection is mainly electronic, but includes offline functionality or paper format as backup; it is supported by an information system that links to the social registry; PDHA processes are established in manuals and staff are trained in processes ex ante; PDHA data are used by most SP actors to inform postdisaster SP response	Beazley and Williams 2021
Postdisaster benefit delivery	Multiple and accessible benefit delivery mechanisms help facilitate adaptations to the post-shock environment and choice of beneficiary	Benefit delivery mechanisms in post-shock context is limited to a single method, with no adaptability to the post-shock environment	There is some flexibility in benefit delivery in the post-shock context	Multiple and accessible benefit delivery mechanisms help facilitate adaptation to the post-shock environment and choice of beneficiary	Beazley and Williams 2021
Interoperable SP and disaster risk management information systems	Interoperable SP and disaster risk management information systems are available, risk-informed, and used to inform DRM actions	Systems are largely absent, so there is no data sharing nor interoperability between SP and DRM	There is some data sharing between SP and DRM, but very limited interoperability	SP registries are risk-informed and interoperable with other risk information systems, including those for PDHAs; DRM actions are informed by SP data (e.g. risk maps use SP data about vulnerability)	Beazley and Williams 2021

Indicator	Description	Nascent	Emerging	Established	Source
Adaptive SP (ASP) operational processes	ASP operational processes exist and are implemented, implying that operation manuals include protocols for shock-responsive ASP and contingency protocols allow for ASP adjustments in response to shocks	There are no contingency protocols for ASP adjustments	Operations manuals do not cover shock-responsive ASP delivery processes; contingency protocols for ASP adjustments exist, but do not include alternative delivery mechanisms	Operation manuals include protocols for shock-responsive SP; there are effective contingency protocols for ASP adjustments that include alternative delivery mechanisms	Beazley and Williams 2021
Disaster risk finance (DRF) mechanism for ASP	DRF mechanism for ASP exists and is implemented	ASP to be taken into consideration when devising a national DRF strategy, but ex-ante financial protection strategies are inadequate (often over-relying on budget reallocations and humanitarian aid); there is no established financing coordinating vehicle for streamlining ASP funding mechanisms, which can include capitalized reserves and risk transfer micro-, meso-, and macroinstruments; no direct ASP-related DRF tool is available	ASP financing arm is integrated into a wider DRF agenda; different DRF instruments are in place, but not fully aligned and optimized for financing ASP needs; there is no sectorial or programmatic disaggregation of financing resources and mechanisms for ASP; at least one ASP-related DRF instrument is available	An established ASP financing strategy is included in the wider national DRF strategy; different DRF instruments are combined and optimized with respect to probable ASP financing needs; sectorial and programmatic financing for ASP is considered and in place (e.g. complementary financing strategies for agriculture, fisheries, small businesses, infant nutrition, etc.); multiple tools are available	Beazley and Williams 2021
ASP human resource (HR) capacity	There is adequate human and financial capacity in DRM leading agencies and HR capacity for all roles in regular SP delivery; contingency measures are in place to ensure adequate HR capacity for postdisaster SP operations	DRM and SP leading agencies have very limited capacity (inadequate human and financial resources)	DRM leading agencies have limited capacity (inadequate human and financial resources); HR capacity for major roles in regular SP delivery is adequate, but there are no measures in place to ensure contingency HR capacity for postdisaster SP operations	DRM leading agencies have adequate capacity in terms of both human and financial resources; HR capacity for all roles in regular SP delivery is adequate, and contingency measures are in place to ensure adequate HR capacity for postdisaster SP operations	Beazley and Williams 2021
ASP coordination	There are effective coordination mechanisms horizontally between SP and DRM agencies, government, and nongovernmental actors, and vertically between different levels of government	Coordination mechanisms between SP and DRM agencies, government, and nongovernmental actors, and vertically between different levels of government are weak	Coordination mechanisms between SP and DRM agencies, government, and nongovernmental actors, and vertically between different levels of government are active, but not effective	There are effective coordination mechanisms between SP and DRM agencies, government, and nongovernmental actors, and vertically between different levels of government	Beazley and Williams 2021
ASP policy structures	A DRM policy or strategy with a defined role for SP is in place	DRM and SP policies are either nonexistent or outdated and ASP considerations are not mainstreamed in DRM and SP ministry or agency mandates and regulations	DRM legislation and national strategy is fairly up to date, but adequate roles for SP are not clearly established; SP national strategy does not include concrete strategies for strengthening resilience; some ASP considerations are integrated into DRM and SP mandates and regulations, but these are limited	DRM national strategies establish roles for SP; SP national strategy includes resilience strengthening as a key objective; detailed ASP considerations are mainstreamed into DRM and SP regulations and mandates	Beazley and Williams 2021
A4.4. Develop the insurance sector, building on public-private partnerships					
Insurance penetration	Extent of insurance penetration, measured through premiums as % of GDP, benchmarked against other Caribbean countries	Insurance penetration ≤2% of GDP	Insurance penetration = 2–5% of GDP	Insurance penetration ≥5% of GDP	Masetti 2021
Deposit insurance system	A deposit insurance system is in place and funded, protecting small and unsophisticated savers in the event of a banking crisis by guaranteeing a share of their savings	There is no formal deposit insurance system in place	A formal deposit insurance system is under consideration or in place, but lacks adequate funding	A formal deposit insurance system is in place and properly funded	Masetti 2021
Resilience/adaptation insurance	Insurance schemes are in place that increase the resilience of the private and public sectors, e.g. farmers' insurance against climate change impacts, climate risk insurance or other resilience-related insurance schemes	There is no resilience or adaptation insurance in place	Resilience or adaptation insurance is being implemented or reviewed	Resilience or adaptation insurance is in place	Valero, Miranda and Murisic 2021
A4.5. Help private actors develop business continuity plans and financial preparedness					
Firms in tourism industry with business continuity plans	Fraction of tourism firms with business continuity plans	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	Erman et al. 2021
Firms in tourism industry with disaster insurance coverage	Fraction of tourism firms with disaster insurance coverage	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	Erman et al. 2021
P5. Anticipate and manage macrofiscal and financial issues					
A5.1. Protect countries with fiscal buffers and sound debt management					
External debt	External debt as % of GDP	Top third among other Caribbean countries	Middle third among other Caribbean countries	Bottom third among other Caribbean countries	Li 2021
Fiscal balance	Overall fiscal balance as % of GDP	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	Li 2021
Fiscal rule	Use and design of fiscal rules covering national and supranational fiscal rules, covering four types of rule (budget balance, debt, expenditure, and revenue rules) and applying to central or general government or the public sector	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	Li 2021
Monetary policy independence	There is a fixed or managed exchange rate regime	Bottom third among other Caribbean countries	Middle third among other Caribbean countries	Top third among other Caribbean countries	Li 2021
Financial solvency risk	Weighted average of share of regulatory capital to risk-weighted assets; nonperforming loans to total loans; and provisions—funds put aside to cover future anticipated losses—to nonperforming loans	Financial solvency risk >2	Financial solvency risk = 1.5–2	Financial solvency risk <1.5	Masetti 2021
Liquidity risk	Weighted average of share of liquid assets to total assets and liquid assets to total short-term liabilities	Liquidity risk >2	Liquidity risk between 1.5 and 2	Liquidity risk <1.5	Masetti 2021
A5.2. Develop a financial strategy to manage shocks, combining multiple instruments					
National DRF strategy	Institutional adoption of a national DRF strategy	No national DRF strategy has been adopted	A national DRF strategy is in progress	A national DRF strategy has been adopted	Justiniano et al. 2021
DRF assessment	Assessment of gaps and strengths related to DRF	No DRF assessment has been undertaken	A DRF assessment is in progress	A DRF assessment has taken place	Justiniano et al. 2021
Alternative risk transfer instruments	Instruments exist that can help the government increase its immediate financial response capacity against natural hazards and better protect its fiscal balance	Alternative risk transfer instruments are under development	Alternative risk transfer instruments are operational, but have limited geographical cover	Alternative risk transfer instruments are operational and cover a large geographical area	Justiniano et al. 2021
Ex-post financial assistance	Financial assistance measures are operationalized after a disaster, such as international loans and assistance or national fund for reconstruction	There are few arrangements for ex-post financial assistance	There are several regional arrangements for ex-post financial assistance	There are several regional arrangements for ex-post financial assistance; the country actively contributes to regional arrangements	Justiniano et al. 2021

Indicator	Description	Nascent	Emerging	Established	Source
State contingent debt instruments	State contingent debt instruments exist and are used	There is no contingent debt instrument	A contingent debt instrument is in place, but parameters are not strategically applied	A contingent debt instrument is in place and is part of the national DRF strategy	Justiniano et al. 2021
Traditional insurance	Availability of traditional insurance, which requires an assessment of individual losses on the ground	Market penetration is low, and few traditional insurance products are available	Market penetration is average, and few traditional insurance products are available	Market penetration is significant, and multiple traditional insurance products are available	Justiniano et al. 2021
Parametric insurance	Availability of parametric insurance, which relies on a payout disbursement that is contingent on the intensity of an event (e.g. major hurricanes and earthquakes)	Available insurance covers few perils; coverage levels are low	Insurance covers several perils; coverage levels are significant	Insurance covers several perils; coverage is significant and optimized with respect to retention capacities	Justiniano et al. 2021
Contingent credit	Availability of contingent credit, which is more cost-effective than risk transfer solutions for intermediate layers of risk like tropical storms and low-intensity hurricanes (Catastrophe Deferred Drawdown)	Contingency credit arrangements are depleted or nonexistent	Contingency credit is in place, but credit levels are low	Contingency credit is in place, and levels of contingency credit are sufficient	Justiniano et al. 2021
Budget	There is efficient budget to finance recurrent low-severity events like localized floods, storms, or landslides	Guidelines on emergency budget reallocation are vague or nonexistent	Guidelines on emergency budget reallocation are clear but used minimally	There is minimal strategic use of loss-informed budget reallocation	Justiniano et al. 2021
Reserve fund	Accessibility of contingency reserves earmarked only for natural hazards for public contingent liabilities for immediate postdisaster relief	A reserve fund is legally defined, but no recurrent capitalization	A reserve fund is legally defined, which has recurrent capitalization	A reserve fund is legally defined, with adequate recurrent capitalization and disbursement rules	Justiniano et al. 2021
Resource planning	National budget is used as a policy instrument for setting priorities on disaster risk reduction and climate adaptation over the short and medium terms	There is no DRR and climate adaption policy, or the policy is not reflected in the budget	There is DRR and climate adaptation policy, and this is partially reflected in the budget	The national budget is used as a policy instrument for setting DRR and climate adaptation priorities over the short and medium terms	April and Zrinski 2021
Budget appropriation	Budget systematically identifies and addresses specific needs or challenges experienced by population segments as a result of disasters	There is no DRR and climate adaption policy, or the policy is not reflected in the budget	There is DRR and climate adaptation policy, and this is partially reflected in the budget	The national budget is used as a policy instrument for setting DRR and climate adaptation priorities over the short and medium terms	April and Zrinski 2021
Gender-sensitive resource allocation	Resource allocation is gender sensitive	The government does not identify and provide budget to address specific needs or challenges experienced by population segments due to disasters	The government identifies specific needs of some population segments due to disasters but does not provide budget to address their needs or budget allocations are not sufficient	The government systematically identifies and provides budget to address specific needs or challenges experienced by population segments due to disasters	April and Zrinski 2021
Expenditure controls	Postdisaster expenditures are systematically independently reviewed, with recommendations issued, and follow-ups to recommendations conducted	Postdisaster expenditures are not reviewed by independent bodies	Postdisaster expenditures are occasionally reviewed, or reviewed by external development partners, or reviewed systematically but with no required follow-up recommendations	Postdisaster expenditures are systematically independently reviewed, with recommendations issued, and follow-ups to recommendations conducted	April and Zrinski 2021
Expenditure tracking	Government has the capacity to track disaster-related external assistance commitments and/or aid inflows, and to track disaster-related expenditure by type	The government has no capacity to track disaster-related expenditure, or no awareness of the need to track this type of expenditure	The government has the capacity to track disaster-related expenditures, but not by type or nature	The government has the capacity to track: disaster-related external assistance commitments and/or aid inflows, and disaster-related expenditure by both type and nature	April and Zrinski 2021
Auditing practices	Legislature systematically reviews expenditures incurred and/or financial reports submitted for a disaster, issues recommendations, and follows up on their implementation	The legislature does not scrutinize postdisaster expenditure	The legislature occasionally scrutinizes postdisaster expenditure or scrutinizes it systematically, but does not issue recommendations or follow up on their implementation	The legislature systematically reviews expenditures incurred and/or financial reports submitted for disaster, issues recommendations, and follows up on their implementation	April and Zrinski 2021
PFM rules and regulations	Legal and/or regulatory framework clearly defines procedures for accelerated (re)allocation, execution, accounting, and oversight of disaster-related expenditures	There are no PFM regulations in place, indicating low awareness of postdisaster response as a functional imperative of the overall PFM system, or regulations for allocating, executing, accounting, and overseeing disaster-related expenditure are outdated	The legal and/or regulatory framework outlines procedures for accelerated PFM, but does not provide details on all the procedures concerned with (re) allocating, executing, accounting, and overseeing disaster-related expenditure	The legal and/or regulatory framework clearly defines procedures for accelerated (re) allocation, execution, accounting, and oversight of disaster-related expenditures	April and Zrinski 2021
Institutional PFM arrangements	Central finance agency has clearly granted powers/ authority during states of emergency to enhance public finance management as needed to expedite disaster response, including clearly defined coordination mechanisms with national disaster management agency	There is no or limited authority granted to the central finance agency for PFM during states of emergency; coordination with national disaster agency is limited	The central finance agency has authority over PFM during states of emergency, but duties and activities—including coordinating with national disaster management agency—are not clearly specified	The central finance agency has clearly granted powers or authority during states of emergency to enhance PFM as needed to expedite disaster response, including clearly defined coordination mechanisms with national disaster management agency	April and Zrinski 2021
A5.3. Anticipate and plan for long-term macroeconomic impacts					
Sector-level adaptation plans	Sector-level adaptation plans are collected, harmonized, and costed, and an estimate of public adaptation spending needs is produced	There are no sector-level adaptation plans	Sector-level adaptation plans exist, but are not costed and/or implemented	Sector-level adaptation plans exist, are costed and implemented	Authors
Long-term plan to diversify tax revenues	A long-term plan to diversify tax revenues away from vulnerable sectors has been approved	There is no long-term plan to diversify tax revenues	A long-term plan to diversify tax revenues is under development	A long-term plan to diversify tax revenues is in place	No data were available for this indicator
Tax revenues originating from high-vulnerability sectors	Share of tax revenues originating from high-vulnerability sectors	The tax level is high, posing a significant risk for government revenues	The tax level is somewhat high, posing a moderate risk for government revenues	The tax level is low, posing a minimum risk for government revenue	No data were available for this indicator
Debt sustainability or financial sector assessment program considers climate and disaster impacts	Climate and disaster impacts are included in debt sustainability assessment or financial sector assessment program	There is no debt sustainability or financial sector assessment program that considers climate and disaster impacts	A debt sustainability or financial sector assessment program that considers climate and disaster impacts is under development/ consideration	Debt sustainability or financial sector assessment program is in place and considers climate and disaster impacts	No data were available for this indicator
A5.4. Improve transparency on disaster and climate risk exposure of the financial sector and pension systems					
Specific disaster and climate risk requirements for bank and large investor regulations	Bank and large investor regulations include specific disaster and climate risks requirements	There are no specific disaster and climate risk requirements bank and large investor regulations	Specific disaster and climate risk requirements bank and large investor regulations are under consideration	Specific disaster and climate risk requirements bank and large investor regulations are in place	No data were available for this indicator
Climate and disaster risk stress tests for banks and large investors	All banks and large investors conduct stress tests for climate and disaster risks, including at least two climate scenarios	There are no climate and disaster risk stress tests for banks and large investors	Climate and disaster risk stress tests for banks and large investors are under consideration	Climate and disaster risk stress tests for banks and large investors are in place	No data were available for this indicator
Quantified estimates of their exposure to natural hazards by banks and large investors	All banks and large investors have to provide a quantified estimate of their exposure to natural hazards	There are no quantified estimates of their exposure to natural hazards by banks and large investors	Quantified estimates of their exposure to natural hazards by banks and large investors are under consideration	Quantified estimates of their exposure to natural hazards by banks and large investors are in place	No data were available for this indicator

Notes: Whenever benchmarking was possible, each country was scored relative to their peers in the region, and depending on the indicator, those in the bottom or top third were assigned *nascent* or *established*, and those in the middle third were assigned *emerging*. Where *authors* are stated as the source, the rating is based on a compilation of information from multiple sources, including government and other websites, news articles, journal articles and research publications, government publications, and personal communications with persons in the country.

Caribbean countries have a history of dealing with large economic and natural hazards, from swings in global commodity prices to hurricanes, earthquakes, and volcanic eruptions. The region has built relatively high levels of resilience over time, and despite recurring damages from shocks, has been able to achieve long-term development progress. But resilience in the region relies largely on informal mechanisms that do not systematically protect the poor and most vulnerable. As a result, some people are left behind. To tackle the challenges posed by climate change, new diseases, and changing socioeconomic contexts, countries need a new strategy that considers the social, micro, and macroeconomic aspects of resilience in an integrated framework, and is tailored to the Caribbean context.

This report takes a 360-degree approach to resilience, assessing progress and identifying gaps across all sectors and 17 Caribbean countries. It presents a comprehensive framework to help countries in this region piece together their mostly scattered sectoral efforts into a comprehensive strategy for building resilience to a new generation of shocks.

European Union
GFDRR Global Facility for Disaster Reduction and Recovery
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