Research for Action on Climate Change and Health in the Caribbean:
A Public, Private, People's and Planetary Agenda

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CONTENTS

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LIST OF ABBREVIATIONS

ABBREVIATION	DEFINITION
AAD	average annual displacement
AC	air conditioning
AF	Adaptation Fund
BPOA	Barbados Programme of Action
CAIHR	Caribbean Institute for Health Research
CALGA	Caribbean Association of Local Government Authorities
CANPA	Caribbean Alliance of National Psychological Associations
CAPHCC	Caribbean Action Plan on Health and Climate Change
CARDI	Caribbean Agricultural Research & Development Institute
CariCOF	Caribbean Climate Outlook Forum
CARICOM	Caribbean Community
CARIFORUM	Caribbean Forum
CariSAM	Caribbean Society for Agricultural Meteorology
CARPHA	Caribbean Public Health Agency
CAST	Caribbean Alliance for Sustainable Tourism
CCC	Caribbean Council of Churches
CCCCC	Caribbean Community Climate Change Centre
CCH IV	Caribbean Cooperation in Health IV
CCHSRD	Caribbean Centre for Health Systems Research and Development
CCREEE	Caribbean Centre for Renewable Energy and Energy Efficiency
CDB	Caribbean Development Bank
CDC	Centers for Disease Control and Prevention
CDEMA	Caribbean Disaster Emergency Management Agency
CER	certified emission reduction
CERMES	Centre for Resource Management and Environmental Studies
CHTA	Caribbean Hotel and Tourism Association
CIF	Climate Investment Funds
CIMH	Caribbean Institute for Meteorology and Hydrology
COC	conference organising committee
CRAA	Caribbean Research for Action Agenda
CRCC	Caribbean Regional Climate Centre
CRRP	Climate Resilience and Recovery Plan
CSA	climate-smart agriculture
CSO	civil society organisation
CTO	Caribbean Tourism Organization

CWWA	Caribbean Water and Wastewater Association
EU	European Union
EWS	early warning system
EWISACT	Early Warning Information Systems Across Climate Timescale
FCDO	Foreign, Commonwealth and Development Office of the United Kingdom
FEWER	Fisheries Early Warning and Emergency Response
GA-CDRC	George Alleyne Chronic Disease Research Centre
GCCHE	Global Consortium on Climate and Health Education
GEF	Global Environment Facility
GHG	greenhouse gas
GI	gastrointestinal
GIS	geographic information system
HEAT	Health Economic Assessment Tool
HFC	hydrofluorocarbon
HIVRA	hazard, impact, vulnerability or risk assessment
H-NAP	Health National Adaptation Plan
HSI	Hospital Safety Index
IGDS	Institute for Gender and Development Studies
INSMET	Instituto de Meteorología de la República de Cuba
IRB	institutional review board
IRM	integrated risk management
IVM	integrated vector management
IWRM	integrated water resource management
KABP	knowledge, attitudes, beliefs and practices
KAP	knowledge, attitudes and practice
MGL	Maya Golden Landscape
NCD	noncommunicable disease
n.d.	no date
NDCs	nationally determined contributions
NGO	nongovernmental organisation
NOAA	National Oceanic and Atmospheric Administration
OECS	Organisation of Eastern Caribbean States
PAHO	Pan American Health Organization
PFA	psychological first aid
PICSA	Participatory Integrated Climate Services for Agriculture
PPCR	Pilot Programme for Climate Resilience
PTSD	posttraumatic stress disorder
R4ACCHC	Research for Action on Climate Change and Health in the Caribbean

SDG	Sustainable Development Goal
SHCFC	Smart Health Care Facilities in the Caribbean
SIDS	Small Island Developing States
SLR	sea level rise
SSB	sugar-sweetened beverage
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNGD	United Nations General Debate
UWI	University of the West Indies
VBD	vector-borne disease
WASH	water, sanitation and hygiene
WHO	World Health Organization
WINDREF	Windward Islands Research and Education Foundation
XCD	Eastern Caribbean dollar

INTRODUCTION, METHODOLOGY AND MAIN FINDINGS

The statement by the World Health Organization (WHO) in 2015 that “Climate change is the greatest threat to global health in the 21st century” (WHO, 2015) focused attention on the relationship between climate change and health at the global level. The timing of this statement coincided with the 2015 Paris Agreement, a legally binding international agreement on climate change with the goal to limit “the increase in the global average temperature to well below 2 °C above pre-industrial levels” and to pursue efforts “to limit the temperature increase to 1.5 °C above pre-industrial levels” (UNFCCC, 2019).

Small island developing states (SIDS) are vulnerable to climate change because of a number of factors, including their small land area and human resource base, remote location, dependence on marine resources, and concentrations of populations and infrastructure near coastlines. These factors also affect health, for example through their impact on the availability of human resources for health; access to medical supplies, water and healthy food; and the vulnerability of key infrastructure, livelihoods and nutrition to the oceanic and meteorological outcomes of climate change, such as sea level rise, ocean acidification and more frequent and severe hurricanes. This is coupled with the fact that Caribbean economies are small and rely heavily on international trade, making them highly vulnerable to climate change-related shocks such as hurricanes (Allen et al., 2021a). International initiatives and agreements have recognised the severity of climate change impacts on health in SIDS, notably the WHO Special Initiative on Climate Change and Health in Small Island Developing States (WHO, 2017, 2018). Governmental and nongovernmental advocates from Caribbean and other SIDS were instrumental in achieving this international recognition (Benjamin and Thomas, 2016). Under the WHO initiative, the “Third Global Conference on Health and Climate Change: Special Focus on SIDS” included a meeting of ministers of health in Grenada, who agreed on a Caribbean Regional Action Plan to address health and climate change priorities in SIDS under the four pillars of the initiative: Empowerment, Evidence, Implementation and Resources (PAHO, 2018).

At the Caribbean regional level, intergovernmental and civil society agencies have increased their focus on climate change and health. A crucial example of this is an initiative, of which this report is a part, entitled “Research for Action on Climate Change and Health in the Caribbean: A Public, Private, People’s and Planetary Agenda” (known as R4ACCHC). The broad goal of R4ACCHC is to develop and implement the Caribbean Research for Action Agenda (CRAA) on climate change and health, which aims to accelerate achievement of climate and health goals for the Caribbean. The specific objectives of the CRAA are to:

- Provide an **evidence base** for action by public, private and civil society actors.
- Suggest areas for **advocacy** by actors.
- Identify critical **knowledge gaps** to inform action linking climate and health.
- Provide a basis for further **research and education**.
- Identify needs for building **research capacity**.
- Provide a foundational document for **partnerships** between actors.
- Propose ways of **disseminating information** to different audiences.

The initiative was started in 2020 when representatives from five nongovernmental organisations and academic institutions – EarthMedic/EarthNurse, the University of the West Indies, the Center on Climate Change and Health at Yale School of Public Health, the Emory Rollins School of Public Health and the Pan American Health Organization – came together to form a conference organising committee (COC) for a groundbreaking conference on climate change and health in the Caribbean, as described in the next section.

HOW THE CARIBBEAN RESEARCH FOR ACTION AGENDA WAS DEVELOPED

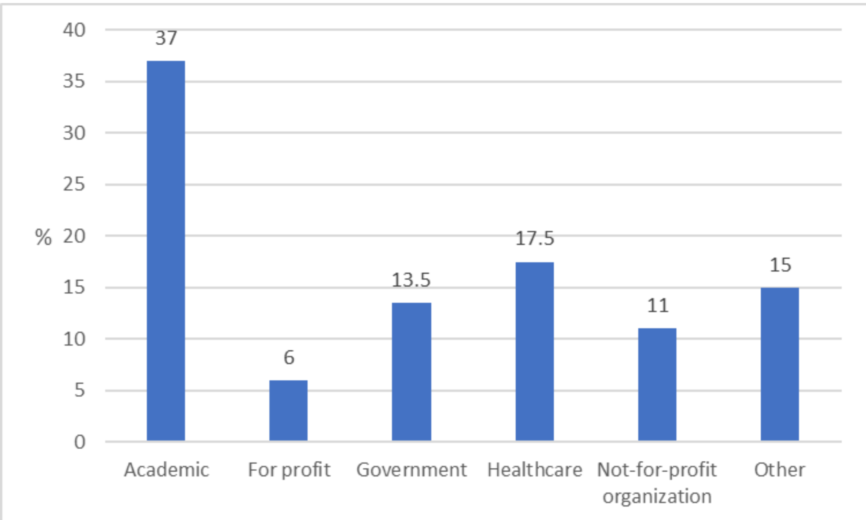
Step 1: Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean

The first stage in developing the CRAA was to plan and host the landmark virtual "Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean", held on 5–8 October 2021 (henceforth "the Conference"). The COC was supported by over 25 regional and international organisations in sponsoring the Conference. The three objectives of the Conference were to:

- Provide an overview of the health impacts of climate change in the Caribbean, mitigation and adaptation actions to address these impacts, and impediments to these actions.
- Understand and prioritise knowledge gaps that will define an action-oriented research and implementation agenda to reduce the adverse health impacts of climate change.
- Foster multisectoral and regional, North–South and South–South collaboration, innovation and sharing, to facilitate implementation of a research agenda for climate change and health.

The Conference provided a rich source of information for the CRAA by bringing together experts and advocates from the region and around the world to share information about climate change and health in Caribbean SIDS. Conference presentations and lightning talks were delivered by 162 presenters from academic, technical and civil society organisations. The 1057 general registrants were based in more than 80 countries and territories, including 31 SIDS, most of them Caribbean SIDS. Attendees were from various types of organisations (Figure 1).

Figure 1: Organisation types represented by the 2021 Conference's general registrants



Following the Conference, the COC collaborated closely with Blue Sky Development Consulting, a small consultancy company specialising in climate change and health research based in Trinidad and Tobago, under the umbrella of R4ACCHC, to develop the CRAA presented in this publication. This involved the methodological steps outlined below.

Step 2: Development of the conceptual framework

To develop the CRAA, a conceptual and organisational framework was created, taking into account the wide range of pathways linking climate change and health. Existing frameworks on climate change and health were reviewed, including the WHO's operational framework for building climate resilient health systems (Shumake-Guillemot et al., 2015), the United States Global Change Research Program's primary exposure pathways by which climate change affects health (USGCRP, 2016) and the Lancet Countdown's monitoring framework on health impacts of climate change (Romanello et al., 2021).

In preparation for the Conference, members of R4ACCHC and another colleague wrote documents on the following topics, which were thought to be key to the eventual content of the CRAA, and provided Caribbean examples for each topic:

- Leadership, governance and financing;
- Research on impact of climate on health;
- Climate-resilient health systems;
- Emergency preparedness and management;
- Management of environmental determinants of health;
- Health co-benefits of mitigation and adaptation.

These documents were presented to conference participants for feedback. We analysed the content of and feedback on these documents to assess their coherence with the three main frameworks under consideration. We also mapped the main topics covered at the Conference against the domains covered by the frameworks.

The findings of the mapping and analysis process determined that the *Lancet* Countdown framework was the framework that was most consistent with the subject matter of preparatory documents for, and main topics covered at, the Conference (Table 1). The *Lancet* Countdown framework was also found to be consistent with the topics covered in the most comprehensive review of Caribbean evidence on climate change and health to date: the report "State of public health in the Caribbean 2017–2018 – climate and health: averting and responding to an unfolding health crisis" by the Caribbean Public Health Agency (CARPHA, 2018). The *Lancet* Countdown uses a broad ecological framework that considers social and environmental determinants of health, which include characteristics of healthcare systems. A broad framework is appropriate since pathways between climate change and health are mediated by actions in non-health sectors such as energy, water, sanitation and transport. The *Lancet* Countdown framework offers a relatively simple way to organise information about the health impacts of climate change, actions in various sectors relating to climate change mitigation and adaptation that can impact on health, and the economic and political context (Table 1).

Table 1: Comparison of the domains of the *Lancet* Countdown framework with the main topics of the Conference

The Lancet Countdown domains	Conference main topics
1. **Health** impacts, exposures and vulnerability	• Day 1: The Varied Effects of Climate Change on Health
2. **Adaptation**, planning and resilience for health	• Day 2: Immediate Health Benefits of Climate Change Mitigation and Adaptation
3. **Mitigation** actions and health co-benefits	• Day 3: The Health Sector and its Role in Addressing Climate Change and Health
4. **Economics and finance**	• Day 4: Participation, Representation, and Collaboration to Implement the Research Agenda
5. Public and political **engagement**	

Further analysis of information presented at the Conference and in the CARPHA report on the state of public health in the Caribbean in relation to climate and health led to the adaptation of the *Lancet* Countdown framework for the purposes of the CRAA. *Lancet* Countdown Domains 4 ("Economics and finance") and 5 ("Public and political engagement") were merged into a domain we call "Resources and engagement for climate change and health action".

Thus, the final framework for organising evidence relating to climate change and health in the Caribbean consisted of the following four domains:

1. Climate change **health** impacts, exposures and vulnerability;
2. **Adaptation**, planning and resilience for health;
3. **Mitigation** actions and health co-benefits;
4. **Resources and engagement** for climate change and health action.

Step 3: Methodology for choosing Priority Areas for the Caribbean Research for Action Agenda

The CRAA should correspond with the issues that are the most pressing and the most important for preserving and promoting health in the context of climate change in Caribbean SIDS. Establishing a method to determine issues of importance in Caribbean SIDS was therefore necessary.

The *Lancet* Countdown monitoring framework is based on tracking indicators, which are grouped into one of the five *Lancet* Countdown domains shown in Table 1. In 2020–21, the *Lancet* Countdown conducted qualitative research with expert stakeholders in Caribbean and Pacific SIDS. The 24 participants, including 17 from the Caribbean, were asked during online interviews to provide a constructive critique of the indicator areas included in the *Lancet* Countdown monitoring framework in terms of their relevance to SIDS. Participants recommended 24 areas, some of which were based on the *Lancet* Countdown indicator areas, as relevant for the development of indicators, research and action on climate change and health in SIDS. At a subsequent workshop where findings of the assessment were presented, stakeholders engaged in a prioritisation exercise, which narrowed down the number of recommended areas to eight Priority Areas, as follows (Allen et al., 2021a, b):

1. Injury and long-term impacts of severe weather events;
2. Vulnerability to vector-borne diseases (VBDs);
3. Water, sanitation and hygiene;
4. Noncommunicable diseases (NCDs) and risk factors;
5. Collaboration between agencies;
6. Research and surveillance systems;
7. Investment in climate and health surveillance and research;
8. Government engagement in health and climate change.

Including these 8 areas in the CRAA was considered highly important, and the remaining 16 of the 24 areas identified by participants in the *Lancet* Countdown research were also considered for inclusion.

As the largest gathering of experts and advocates on climate change and health in Caribbean SIDS to date, the Conference was a critical resource in determining which issues were priorities for the region. The Conference session topics and presentations, and the lightning talk titles, were therefore also reviewed. In addition, previously published reviews of Caribbean research and action on climate change and health were analysed (CARPHA, 2018; Rise et al., 2022; Taylor et al., 2010).

To help ensure that the Priority Areas chosen for the CRAA were in line with the experiences and views of stakeholders, R4ACCHC presented a tentative list of priorities in a series of stakeholder meetings in 2022 and 2023 with the following organisations:

- Healthy Caribbean Coalition;
- Caribbean Hotel and Tourism Association;
- Faculty of Medical Sciences, University of the West Indies (UWI), Mona, Jamaica;
- School of Clinical Medicine and Research, UWI, the Bahamas;
- Caribbean Alliance of National Psychological Associations;

- Caribbean College of Family Physicians;
- Caribbean Broadcasting Union;
- Caribbean Association of Local Government Authorities;
- Sir Arthur Lewis Community College, Saint Lucia;
- Ministry of Health and Wellness, Saint Lucia;
- Health and Social Cluster, Organisation of Eastern Caribbean States Commission.

Step 4: Priority Areas for research and action on climate change and health in the Caribbean

Resulting from the Step 3 review, analysis and consultation process, 18 Priority Areas for research and action on climate change and health in the Caribbean were chosen (Table 2).

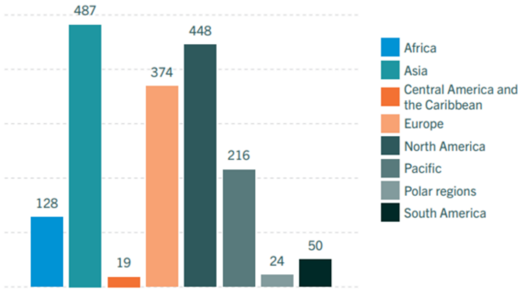
Table 2: 18 Priority Areas

Domain 1: Climate change health impacts, exposures and vulnerability
1. Health impacts of extreme weather events
2. Vulnerability to vector-borne diseases
3. Water, sanitation and hygiene
4. Noncommunicable diseases and risk factors
5. Air quality
6. Heat-related illness
7. Mental health
8. Population displacement and migration
9. Distribution, equity and justice in climate change and health
Domain 2: Adaptation, planning and resilience for health
10. Collaboration between agencies
11. Research and surveillance on climate change and health
12. Agriculture, food safety and security
13. Awareness- and skills-building
Domain 3: Mitigation actions and health co-benefits
14. Marine resources and health
15. Climate-friendly health-promoting infrastructure
16. Smart health facilities
Domain 4: Resources and engagement for climate change and health action
17. Funding streams for climate and health action
18. Government engagement in health and climate change

Step 5: How the evidence on each Priority Area was gathered

A key rationale for developing the CRAA was the observation that the evidence base on climate change and health in the Caribbean is weak. For example, a WHO (2021) review found only 19 peer-reviewed journal articles on climate change and health in Central America and the Caribbean for the whole period 2008–2019 – the lowest number of all global regions included in the review (Figure 2). A more recent review focusing on original research on climate change and health in the Caribbean covering the period 2006–2021 found a greater number of pieces of research (27), but nevertheless concurred with the WHO review in concluding that the Caribbean is the subject of fewer peer-reviewed publications related to climate and health than other regions (Rise et al., 2022).

Figure 2: Geographical distribution of articles reviewed, by region, in the WHO review of climate change and health research 2008–2019



Source: WHO (2021), licensed under CC BY-NC-SA 3.0 IGO.

The publications identified in the WHO and Rise et al. reviews were included in the evidence used for reporting on the Priority Areas. The authors also included literature referred to in CARPHA's (2018) report on climate and health and the state of public health in the Caribbean and the *Lancet* Countdown report on climate change and health in SIDS (Allen et al., 2021a). Using the PubMed database, further searches for peer-reviewed journal articles were conducted for the period 2018–2022. Titles and abstracts were searched, combining "climate" and "health" with "Caribbean" or individual names of countries or territories in the region as follows:

("climat*") AND ("health") AND ("Caribbean") OR ("Anguilla") OR ("Antigua") OR ("Aruba") etc.

A total of 147 articles were initially judged to be relevant based on their titles, including articles containing empirical research; commentaries; and reviews covering human, animal and environmental health (in line with the One Health approach). It should be noted that the scope of the search was wider than the searches conducted by WHO and Rise et al., which included only empirical research. Abstracts and papers were then reviewed for relevance to the 18 Priority Areas. Further targeted searches were conducted on PubMed for evidence from the Caribbean for each of the 18 areas. It was acknowledged, based on experience of the Caribbean research landscape, that many pieces of research in the region are not submitted to peer-reviewed journals. Many are presented at conferences and meetings of academic institutions or technical agencies, and are thus subjected to expert review. Some are published in books and technical reports, with those published by regional publishers often not appearing in global online searches. An important reason behind the low rate of publication in international peer-reviewed literature is that Caribbean researchers have many professional responsibilities in addition to publishing in peer-reviewed journals, given the scarcity of their expertise in the SIDS context. A further line of enquiry was therefore to review the websites of reputable academic and technical agencies and contact researchers to obtain their publications.

Major sources of evidence for the 18 Priority Areas were the Conference and notes from the meetings with stakeholders conducted by R4ACCHC sources were particularly important as, for some of the Priority Areas, little or no formal empirical evidence was available for the Caribbean. Presenters at the Conference and participants in the meetings with R4ACCHC drew on their own expertise to reflect on the issues of most relevance to the region and how to address them. At the Conference, some speakers presented empirical findings from elsewhere in the world and reflected on how they may be relevant to the Caribbean, with recommendations based on their experience. For instance, Dr John Kotcher presented results of a multinational survey on the views of health professionals on climate change and health. While very few of the survey participants were from the Caribbean, the findings were useful in pointing to issues that must be addressed to build skills among health professionals and enable them to apply these skills in addressing climate change and health challenges (Kotcher, 2021; Kotcher et al., 2021). Some Caribbean researchers at the Conference had not yet conducted empirical research combining climate change and health but presented examples of relevant work. For example, Renelle Sarjeant, an urban planner, presented work on the development of "blue" and "green" infrastructure in the Caribbean. These infrastructure types mitigate climate change by reducing greenhouse gas emissions while also having health co-benefits by reducing urban heat island effects and providing pleasant environments for physical exercise (Sarjeant, 2021).

It should be noted that the initial online literature search was restricted to articles in English, thus could have missed some research from non-English-speaking countries and territories of the Caribbean. However, this limitation was to some extent compensated for by including presentations and lightning talks from the Conference in the review. Presenters included participants from Spanish-, Dutch- and French-speaking Caribbean countries and territories. In addition to reviewing the presentations of these speakers, the authors sought out their other publications. For instance, several publications from the Cuban Institute for Meteorology were included in the review.

Step 6: Reporting on the 18 Priority Areas

For each of the Priority Areas, two documents were developed:

1. A situational analysis (what is happening?);
2. Recommended actions arising from the situational analysis (what should be done?).

The situational analysis documents summarised empirical evidence on what is happening in the Caribbean and relevant evidence from elsewhere. They presented gaps in the evidence from research and surveillance in the Caribbean.

The recommended actions documents were informed by an ecological approach to health determinants, looking first at what individuals and communities can do, and second at structural determinants and what governments, the private sector and other organizations can do to address the challenges identified in the situational analyses. Each action document was divided into sections with the following headings:

- Individual and community actions and how to support them;
- Structural/governmental and private sector actions;
- Research gaps and how to address them;
- Surveillance gaps and how to address them;
- Research and surveillance capacity-strengthening needs.

First drafts of the documents were reviewed by members of R4ACCHC and by Caribbean experts selected according to the Priority Area under review.

An online "stakeholder dialogue" was held on 9–10 May 2023 to present the findings to stakeholders and gather their feedback. Invitees included participants of the Conference, attendees of previous stakeholder meetings with individual organizations, other selected experts, policymakers and civil society advocates. Seventy-eight people participated. For each Priority Area, a breakout room was provided, where the findings were presented and participants were invited to provide their feedback and make additional recommendations for action and research if applicable. The feedback and recommendations from participants in the stakeholder dialogue were included in the final version of the documents.

CROSS-CUTTING THEMES EMERGING FROM THE ANALYSES OF THE 18 PRIORITY AREAS

Most published research and data collected relevant to climate change and health in the Caribbean relate to Domain 1 of the conceptual framework: climate change health impacts, exposures and vulnerability. There is relatively little primary research or surveillance data relating to Domains 2–4, on adaptation, mitigation, and resources and engagement.

Domain 1: Climate change health impacts, exposures and vulnerability

Some Priority Areas within Domain 1 have received more attention from Caribbean researchers than others. The Caribbean has been conducting groundbreaking work on arbovirology since the 1950s. Research on the links between climate change and VBDs has been conducted since the early 2000s, and, recently, work has concentrated on the development and adoption of early warning systems (EWSs) for VBDs. A growing body of research focuses on understanding the health outcomes of extreme weather events, increasing the resilience of health systems to severe tropical storms and hurricanes, and developing models of multisectoral action to address the health consequences of extreme events. A further rapidly emerging area of research is the impact of climate change on the incidence of NCDs and on health outcomes for people living with NCDs. Most Caribbean studies on climate change and air quality concentrate on the impact of Saharan dust on respiratory disease. Saharan dust is only one of the air quality drivers of ill health associated with climate change.

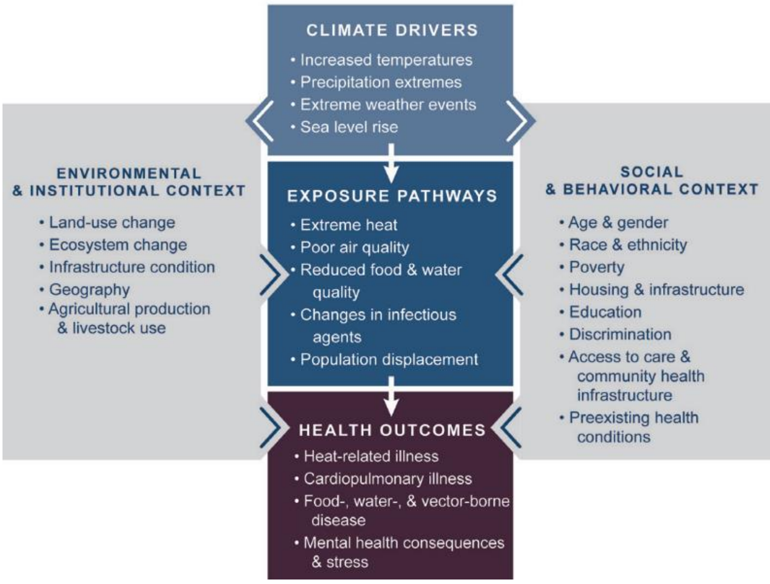
For the other Priority Areas under Domain 1, there is only a handful of Caribbean empirical studies. There is a dearth of studies on mental health, heat-related illness, population displacement and migration, and water, sanitation and hygiene (WASH). Only one Caribbean empirical study on heat-related illness was identified. Caribbean studies on mental health, population displacement and migration, and WASH do not generally consider how these issues are affected by climate change.

Surveillance data on climate change health impacts and exposures in the Caribbean are weak. Some mosquito-borne diseases are reportable by Caribbean Member States of CARPHA, and confirmatory testing is available for these diseases from CARPHA and in selected countries. Some food- and waterborne diseases that may be associated with WASH status are reportable to and monitored by CARPHA. CARPHA also conducts syndromic surveillance of fever and gastrointestinal illness to enable responses to infectious disease outbreaks in general. Some countries are developing registries for selected NCDs. COVID-19 cases are reportable, and syndromic surveillance includes cases of fever and cough, but little other systematic reporting of respiratory diseases takes place. Scarcely any data are systematically collected on mental health conditions or heat-related illnesses. No system is in place to monitor population displacement within countries, and migration data do not systematically include indications of reasons for migration. The few data systematically collected on health outcomes of severe weather events are usually restricted to mortality during or in the immediate aftermath of the event. However, since the 2017 hurricanes, studies in several countries have compared mortality during a period of several months post hurricane with mortality during the same period in previous years, showing substantial increases in deaths during the post-hurricane months.

There is also a lack of disaggregated data that enable the analysis of the distribution of health effects of climate change. Some data are disaggregated by sex and age group, but this is not universal. Often the implications of differences found between the sexes are not analysed from a gender perspective, so opportunities to redress gender inequities are missed. Similarly, data disaggregated by age are not usually analysed to develop appropriate strategies for each age category across the life course. Data on the distribution of climate-sensitive health conditions by other indicators of vulnerability such as income, race, ethnicity and disability are generally unavailable. There is limited use of geographic information systems (GISs), with such systems mostly used for the development of VBD and air quality EWSs. GISs have not been used to map climate-sensitive health conditions against indicators of social and economic deprivation. Studies of the health status of indigenous people are rare, and their health is not systematically monitored alongside data on the environmental hazards they face, some of which are related to climate change. In sum, there is a shortage of data to inform the channelling of interventions to vulnerable groups and people.

Very few Caribbean studies demonstrate mediating factors on the pathways between climate drivers such as precipitation extremes and health outcomes such as food-, water- and vector-borne diseases. The United States Global Change Research Program's conceptual framework shows that environmental, institutional, social and behavioural contextual factors mediate the impact of climate change on health (Figure 3) (USGCRP, 2016). Studies have looked at climate drivers and health outcomes without considering the contextual factors that may be subject to human intervention and thus provide the potential for preventing and reducing adverse climate change impacts. Some studies look at individual contextual factors such as infrastructure condition. Such studies do not generally measure the health outcomes of different types of intervention, such as different infrastructural designs. This lack of an integrated approach means that there are very few Caribbean evidence-based interventions to reduce the negative impacts of climate change on health or to demonstrate the health co-benefits of climate change mitigation or adaptation measures.

Figure 3: Primary exposure pathways by which climate change affects health



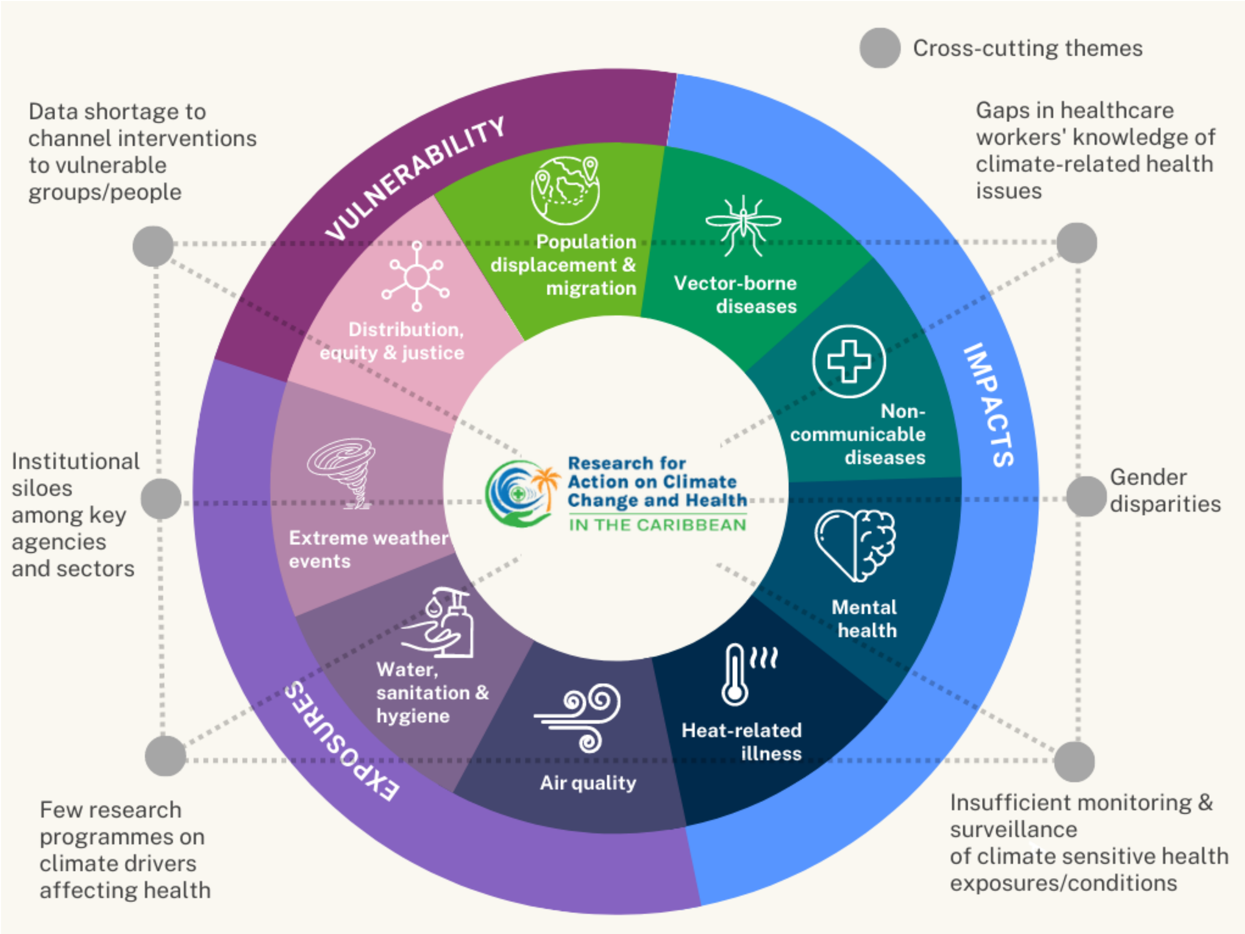
Source: USGCRP (2016).

Meteorological data are increasingly being used in research projects on health, especially in air quality and VBD research in the Caribbean. The Caribbean Institute for Meteorology and Hydrology and CARPHA are collaborating to integrate data and provide health forecasts based on weather forecasting. However, integration of data is hampered by the fact that reporting periods for health data are generally much longer (e.g. yearly or monthly) than for meteorological data (e.g. daily).

There is also very little information on what health professionals know about the impacts of climate change on health and the extent to which they use this knowledge in their professional practice. Gathering such information will be important for informing awareness and skills development.

Figure 4 presents the health impacts, exposures and vulnerability Priority Areas considered under Domain 1 of the CRAA, along with the cross-cutting themes that emerged from the analysis and have been presented in this section.

Figure 4: Priority Areas and cross-cutting themes on climate change health impacts, exposures and vulnerability



Domains 2–4: Adaptation, mitigation, and resources and engagement

Very few research projects have assessed adaptation, mitigation and other policy measures to address climate change in terms of their impacts on health outcomes. Most adaptation and mitigation projects in the Caribbean, with the exception of the Smart Health Facilities initiative, are not specifically designed with health outcomes in mind. The evidence for the Priority Areas under Domains 2–4 came mostly from the Conference, the stakeholder meetings hosted by R4ACCHC and the final stakeholder dialogue. Experts and stakeholders presented the work they do in various sectors and discussed how it could be leveraged and adapted to improve climate change-related health outcomes. Because of a lack of empirical research and surveillance systems, the most likely health outcomes of adaptation and mitigation measures are difficult to predict.

As indicated above, surveillance of climate-sensitive health outcomes must be strengthened. There is also a need for far more extensive documentation and monitoring and evaluation of policies, projects and social/behavioural interventions aimed at addressing climate change. Stronger research designs are needed, including stronger experimental designs comparing innovative interventions with the status quo or other interventions. Data-sharing practices and protocols, and ethics review mechanisms, are needed to overcome the limitations of individual SIDS and to benefit from shared expertise and economies of scale.

Participants in the Conference and in other aspects of the CRAA development process shared their expertise and experiences to share recommendations presented in the following paragraphs. These were only sometimes backed up with empirical evidence from the Caribbean, so strengthening the evidence base is paramount.

Increased funding must be provided for climate change and health research and action in Caribbean SIDS. This is a matter of justice, since SIDS are very minimally responsible for greenhouse gas emissions and other human activities that exacerbate climate change and its impacts. While funding related to climate change and designed for developing countries and SIDS has increased, it has not generally included research funding. Caribbean research is limited by the allocation of research funding according to country income classification, which is used by some donors. With the exception of Haiti, Caribbean countries and territories are classed as high income or upper-middle income. This makes research funding less likely, especially for the high-income countries and territories, and prevents collaborations between countries/territories at different income levels that nevertheless share climate change-related vulnerabilities.

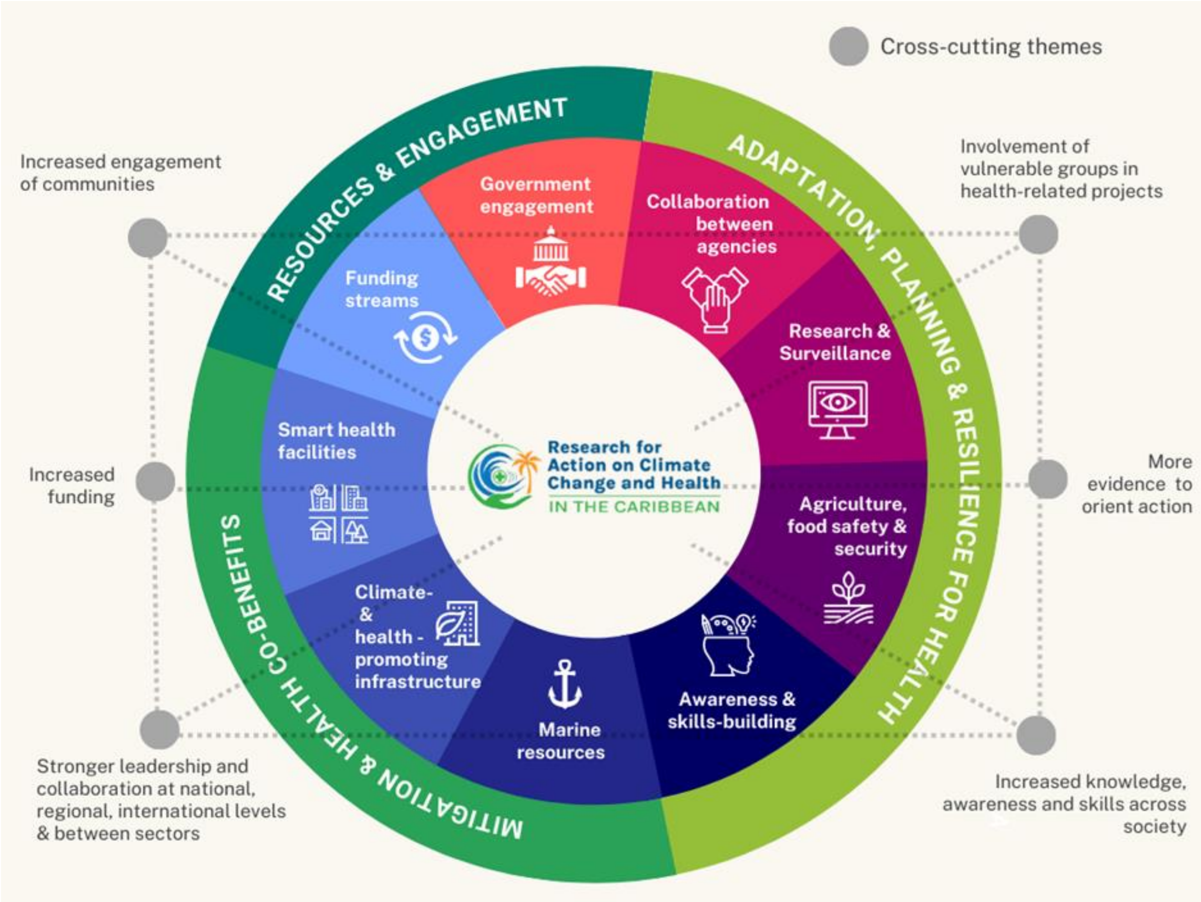
Analyses of the Priority Areas under Domains 2–4 show that collaborative mechanisms must be actively established and maintained between countries, agencies and sectors. The health sector cannot go it alone in addressing the climate change-related determinants of health. Institutional siloes are difficult to overcome, and leadership is needed at every level to reach out and involve others in a spirit of partnership. Legal and institutional agreements between partners are needed for sustainability.

There is a need for increased knowledge, awareness and skills across society to effect the necessary cultural and political shifts towards climate change resilience and environmental sustainability. Communities of all types must be increasingly engaged. Leaders of all types of organisations should inform and empower people to become involved and take the necessary steps. Media and educational institutions must be involved.

Young people play a particularly important role in helping to determine health outcomes for future generations and can leverage their communications skills, especially if empowered by scientific information communicated in appropriate ways. To reduce the adverse health outcomes of climate change in vulnerable populations, it is critical to involve these populations in climate change and health decision-making and action. Involving vulnerable populations can also help in developing viable solutions for all of society, since others can benefit from their experiences and adaptive strategies. The resilience of communities must be built through education, active involvement and access to financial and other resources. National and regional initiatives will not be successful without the collaboration and cooperation of people "on the ground" in local communities and agencies.

Figure 5 presents the Priority Areas considered under Domains 2–4 of the CRAA, along with the cross-cutting themes that emerged from the analysis and that have been presented in this section.

Figure 5: Priority Areas and cross-cutting themes on adaptation, mitigation, and resources and engagement



CONCLUSION

The CRAA presents the existing evidence for the Caribbean and draws on the expertise of Caribbean and other stakeholders to make recommendations for research and action in the 18 Priority Areas. It is based on a broad ecological approach to health, considering multiple determinants across different sectors affected by climate change.

Empirical evidence for the Caribbean was found to be lacking, and what is known is not readily available to those who need to act. For all Priority Areas, there is a need for further research and much stronger surveillance systems. Evidence on what works is also sorely lacking. Attention must be paid to strengthening operational and policy research and assessing the effectiveness of interventions. Scientific information must be communicated in accessible ways to a variety of audiences. To implement all of this, funding must be provided for research, surveillance and communication.

Addressing the health challenges that Caribbean SIDS face as a result of climate change will take a huge collaborative effort. By assembling available evidence and presenting recommendations, the CRAA aims to assist in the development of community-level and multi-agency, multi-country and multisectoral approaches and to contribute to North–South and South–South cooperation, to overcome these challenges in the interest of a sustainable future.

Cross-cutting research questions arising from this process for the four domains of the CRAA are as follows.

Domain 1: Climate change health impacts, exposures and vulnerability

- What are the impacts of climate change on health? What contextual factors mediate the impact of climate change on health?
- Who are the vulnerable populations and how are they affected?

Domain 2: Adaptation, planning and resilience for health

- How effective are adaptation measures in protecting health?

Domain 3: Mitigation actions and health co-benefits

- What are the health co-benefits of climate change mitigation?

Domain 4: Resources and engagement for climate change and health action

- What are the costs of climate and health research/action?
- How can financial resources be mobilised?
- How do we join up silos between communities, researchers, health professionals, government agencies, businesses, advocates and other stakeholders?

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DOMAIN 1: CLIMATE CHANGE HEALTH IMPACTS, EXPOSURES AND VULNERABILITY

1. HEALTH IMPACTS OF EXTREME WEATHER EVENTS

1.1. WHAT IS HAPPENING?

Extreme events are occurrences of unusually severe weather or climate conditions that can have devastating impacts on communities and agricultural and natural ecosystems, and multiply the threats to human health (Dubrow, 2021). Extreme events relevant to Caribbean Small Island Developing States (SIDS) include hurricanes, heavy downpours, floods, heatwaves (see Chapter 6, "Heat-related illness"), drought and wildfire outbreaks (U.S. Department of Agriculture Climate Hubs, 2022). Climate change increases the frequency, intensity and duration of these events and interferes with traditional seasonal patterns.

Extreme events often coincide or follow each other, with a cascade of devastating consequences (Taylor, 2021). For instance, heavy downpours following drought lead to landslides and flooding. Prolonged hot periods can lead to drought and wildfires. New patterns of precipitation are predicted in Caribbean countries as the average temperature in the region approaches 1.5 °C above the 1860–1900 pre-industrial average. This is likely to be followed by overall drier conditions interspersed with heavier downpours and more severe hurricanes as the temperature increase reaches 2 °C, which is projected to happen by about the 2050s (Taylor et al., 2013, 2018). We are already seeing storm events of unprecedented severity in the region (Bell et al., 2018). Each year from 2016 to 2021, the Atlantic hurricane season saw more frequent storms than normal, with 2020 being the most active Atlantic hurricane season on record, with 30 named storms (Beven, 2021; Klotzbach et al., 2022; Wikipedia, 2022). In 2017, the region was hit by Hurricane Irma, the strongest Atlantic storm on record, and Hurricane Maria, which devastated Dominica and Puerto Rico (Government of the Commonwealth of Dominica, 2017; NASA Earth Observatory, 2017). In 2019, Hurricane Dorian devastated several islands of the Bahamas as it moved across them very slowly over three days with Category 3 to 5 strength (Greig et al., 2020). Hurricanes are becoming even more destructive as a result of heightened storm surges linked to climate change-induced sea level rise and loss of natural barriers, including coral reefs (which are being damaged by ocean warming and acidification) and mangrove forests (which are being destroyed by coastal development and pollution) (Dubrow, 2021).

The geography and topography of Caribbean countries place people at risk (Weaver, 2021). In Dominica, torrential downpours brought by Hurricane Maria cascaded down mountainsides, destroying bridges, roads, houses, water pipes, power lines, health centres and crops (Government of the Commonwealth of Dominica, 2017). Other Caribbean countries, such as Trinidad and Tobago, have large, inhabited plains that are prone to flooding (R4ACCHC, 2022a). Some settlements, such as Georgetown, Guyana, are built below sea level, while some entire islands, such as most of the Bahamas, are at low elevation, making them very vulnerable to storm surges (CARPHA, 2018; Greig et al., 2020).

Because these extreme manifestations of climate change are diverse, so are their impacts on health – particularly the systems that sustain health. Most directly, health facilities, equipment, medication and supplies can be damaged. Hurricanes affecting sources of medical supplies, such as those that affect the United States of America, can affect health in the Caribbean (Dubrow, 2021). Caribbean economies, infrastructure, agriculture and healthcare systems have been constructed under certain assumptions about the climate, weather and seasonality. For instance, buildings are constructed to withstand and provide shelter from certain levels of rain and wind (Weaver, 2021). In the words of Professor Michael Taylor, "We depend on familiarity" (Taylor, 2021). This also applies to animals and plants, with climate change reducing biodiversity and threatening ecosystems such as coral reefs. Major economic sectors on which Caribbean people depend for their livelihoods and therefore to maintain their health, such as tourism and fisheries, are severely threatened because of these impacts on the natural environment (Dubrow, 2021; R4ACCHC, 2022b). For instance, the Caribbean Hotel and

Tourism Association has estimated that 25% of the Caribbean tourism industry was affected by Hurricanes Irma and Maria in 2017, with closures, loss of business and government revenue, and loss of jobs (R4ACCHC, 2022c).

Floods and storms are climate-related hazards that pose a high mortality risk in Caribbean countries. An ecological study was conducted investigating risk factors for flood and storm lethality in Caribbean Community (CARICOM) nations for the 1980–2012 period. Significant predictors of lethality – deaths versus no deaths per disaster event – included the percentage of total land dedicated to agriculture and the percentage of the population living in urban areas. Deaths were more likely in the 2000–2012 period than in the 1980–1989 period. The authors indicated that changes in land use that had damaged natural ecosystems may help to explain the findings. Urbanisation marked by the absence of effective land use planning, which led to low-income households residing in hazardous areas, may be another explanation (Andrewin et al., 2015).

Official death tolls from hurricanes tend to mostly include only deaths occurring during or immediately after the event and directly caused by forces related to the event (e.g. drowning, trauma), and that have been confirmed as such by a medical examiner or forensic scientist (CARPHA, 2018). Deaths after the event – particularly from infectious diseases (e.g. waterborne infections due to damaged water supply and sanitary systems) and noncommunicable diseases (NCDs) left untreated because of a lack of access to medical care (due to damaged infrastructure, e.g. electric power, transport, communication, and healthcare facilities themselves) (Dubrow, 2021) – do not tend to be included in official death tolls. These types of indirect deaths may occur weeks to months after the event. Recent studies have calculated excess deaths in the period after a hurricane compared with a previous period (e.g. the same season the year before) to help estimate hurricanes' impacts on health. For example, Kishore et al. (2018) estimated that excess deaths in Puerto Rico following Hurricane Maria were 70 times higher than official estimates (Kishore et al., 2018). Studies of excess morbidity are rare.

Being displaced by extreme events can cause mental stress and can lead to lack of access to medication, violence against women and girls, and increased risk of infectious diseases (CARPHA, 2018; Dargin et al., 2021; Government of the Commonwealth of Dominica, 2017; R4ACCHC, 2022b, d; Wang et al., 2021) (Box 1). The psychological impacts of destruction, displacement and illness following hurricanes can be severe and long-lasting (Benjamin, 2015; Herran and Biehler, 2021; Penn and Greaves, 2021; Ravaliere and Murphy, 2017; Shultz et al., 2020). People living with NCDs are particularly vulnerable because their access to medication, health care and healthy food supplies may be severely curtailed (Elias et al., 2021; Hassan et al., 2020; Joshipura, 2021; Martinez-Lozano et al., 2021). In addition, people with disabilities may not be able to use or access conventional forms of emergency assistance and disaster prevention arrangements (Carby, 2021).

Box 1: Health and other challenges of hurricanes in the Bahamas

"Being an archipelago provides challenges to displacement as any of the thirty inhabited islands can be affected. There can be great displacement and injuries, infections (including from injuries), lack of access to medication, anxiety and depression after hurricanes or other disasters. There is little warning for hurricanes – there are only hours before hurricanes may hit any of the islands. People get trapped due to the closure of land and air transportation. It's important that all islands are adequately stocked with medications."

Source: R4ACCHC (2022b).

People are particularly susceptible to waterborne, foodborne and vector-borne infectious diseases following hurricanes and floods (Allen et al., 2019a). This may be due to damage to utilities such as water and sanitation facilities and electricity for refrigeration and cooking. Furthermore, hurricanes and floods create additional pools of water where mosquitoes can breed (CARPHA, 2017, 2018; Medlock, 2021). The bacteria that cause leptospirosis are spread through the urine of infected animals, which can get into water or soil and survive there for weeks to months. Flood conditions are particularly conducive to the spread of leptospirosis (Boston and Kurup, 2016; CARPHA, 2017; Chery et al., 2020).

Infectious and chronic respiratory diseases, including COVID-19, are likely to be aggravated by severe weather events. Both humidity and dusty conditions are associated with increased healthcare admissions for asthma (Cadelis et al., 2014; Hambleton, 2008; Prospero et al., 2008). Floods can lead to the growth of mould, which can become airborne in hot, dry weather. Hurricanes can create fine particles of airborne debris. Wildfires and fires deliberately set to dispose of debris adversely affect respiratory health (Allen et al., 2019b; CARPHA, 2018).

Extreme weather events of all sorts harm the agriculture sector, which relies on predictable weather conditions (Gamble et al., 2010). Hurricanes can destroy all agricultural crops in an individual SIDS, as happened in Dominica following Hurricane Maria (CARPHA, 2018). Food security is a challenge in the Bahamas, and this was aggravated by Hurricane Dorian in 2019 (R4ACCHC, 2022b). Because land, equipment and supplies are also severely damaged by extreme weather events and some crops take years to grow, indigenous agriculture can take years to recover. Droughts, which are becoming more frequent and severe, can harm or kill crops and livestock. The increasing likelihood of alternating severely dry and severely wet conditions can prevent proper absorption of rainfall and aggravate drainage difficulties. Access to fresh foods critical to health and the prevention of NCDs is reduced. The food provided in emergency supplies is generally highly processed and may contribute to NCD risk, and the affected SIDS may continue to rely more than ever on imported, processed food as the agriculture sector struggles to recover (CARPHA, 2018; R4ACCHC, 2022e; Watson-Duff and Cooper, 1994).

Research on the health impacts of extreme climate events in the Caribbean is a relatively new field and has focused on the following areas:

- The use of post-hurricane morbidity or mortality statistics to estimate impact (Allen et al., 2019b; Cruz-Cano and Mead, 2019; Kishore et al., 2018);
- The impact on infectious and vector-borne diseases (Allen et al., 2019a; Boston and Kurup, 2016; Medlock, 2021);
- Health aspects of hurricane preparedness and response (Carby, 2021; Dargin et al., 2021; Greig et al., 2020; Harewood, 2021; Hassan, 2021; Joshipura, 2021);
- The impact on environmental determinants of health and on key economic sectors (Allen et al., 2019b; Dasent et al., 2021; Gamble et al., 2010; Medlock, 2021);
- Pathways affecting vulnerabilities associated with mental health, NCDs and/or disabilities (Benjamin, 2015; Carby, 2021; Elias et al., 2021; Hassan et al., 2020; Herran and Biehler, 2021; Joshipura, 2021; Kim and Hassan, 2021; Martinez-Lozano et al., 2021; Penn and Greaves, 2021; Ravaliere and Murphy, 2017; Watson-Duff and Cooper, 1994).

1.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Involve civil society in extreme event preparedness and response activities

Civil society organisations at the regional, national and local community levels should play an integral role in preparedness activities by receiving and delivering education about health risks associated with extreme events and how to avoid and respond to them. They should advise the government about local needs and appropriate responses. At the regional level, the Healthy Caribbean Coalition has been involved in awareness-raising and advocacy on these issues (R4ACCHC, 2022f). At the University of the West Indies, the Students Today Alumni Tomorrow organisation has a disaster mitigation and climate change arm, showing that young people are taking these issues seriously (R4ACCHC, 2022g).

Training should be provided to communities using a multihazard framework, given that different hazards can occur simultaneously or one after the other, including hurricanes, heavy downpours, inland and coastal floods, heatwaves, droughts and wildfire outbreaks. Community members can be specifically trained to prepare and respond to extreme events. Because they know first-hand the needs and wants of the community, such as medication and supplies, they can assist greatly in preparedness and response. Desktop exercises and simulations are important to help personnel to get familiar with each hazard and to forge new solutions. Pre- and post-training assessments are critical tools for consolidating information. Emergency medical and mental health teams can collaborate with community members to share skills (R4ACCHC, 2023).

Tailor disaster preparedness messages and increase access to them among people with noncommunicable diseases, disabilities and/or mental health challenges

People with NCDs (see Chapter 4, "Noncommunicable diseases and risk factors"), disabilities and/or mental health challenges (see Chapter 7, "Mental health") are particularly vulnerable to extreme weather events, as these events can aggravate their health conditions and cause crises, in part because of restricted access to health care (Carby, 2021; Elias et al., 2021; Harewood, 2021; Hassan et al., 2020; Joshipura, 2021; Kishore et al., 2018). There is evidence in the Caribbean that people with known risk factors such as obesity have a higher risk of developing NCDs such as diabetes following extreme weather events (Martinez-Lozano et al., 2021; R4ACCHC, 2023). People with these health conditions and risk factors should be provided with clear information about how to protect their health during and after severe weather events, tailored to each health condition or risk factor (Joshipura, 2021; R4ACCHC, 2023). A variety of traditional and social media, hard-copy booklets and in-person messaging from healthcare workers may be used. Information should include details of how to access supplies of medication and nutritious food. Information in braille and sign language should be provided (Carby, 2021).

Provide tailored disaster preparedness messages and training for healthcare workers

Healthcare workers experience the same devastating effects of severe weather events as the general population but face additional stress in providing services under traumatic conditions. To supplement the health and safety measures already in place, providing tailored information to healthcare workers is important, including information on specialised transport, emergency shelter arrangements and psychosocial support. Training on providing post-disaster health care can help to build resilience (Penn and Greaves, 2021). Emergency response providers should receive training on providing food, water and shelter in the aftermath of severe weather events (Dubrow, 2021).

Structural/governmental and private sector actions

Strengthen linkages between agencies responsible for health and disaster preparedness

Health needs to be more deeply integrated into disaster responses both nationally and regionally. Therefore, there is a need to strengthen collaborative mechanisms and for emergency management authorities and teams to integrate health into their planning and procedures (Kim and Hassan, 2021; R4ACCHC, 2023).

Include mental health in disaster preparedness and response

Training in psychological first aid can be provided to the general population as well as to healthcare workers and can strengthen psychological resilience in the face of disaster (Benjamin, 2015; Dominica Community Mental Health Team, 2017). Psychological resilience can be further boosted by providing clear post-disaster procedures to help life "get back to normal" (Ravaliere and Murphy, 2017; Sharma et al., 2018; R4ACCHC, 2023). Because of the additional stress placed on healthcare workers, especially the emergency services, mental health first aid should also be made available to these workers.

Collaboration between mental health teams in different countries and territories can boost the human resources available to deal with mental health challenges post disaster. For example, first responders, including psychologists, from the United States Virgin Islands assisted with recovery in Puerto Rico after Hurricanes Irma and Maria in 2017. It is important to sustain these links between countries and territories to assist with subsequent disasters (R4ACCHC, 2022g).

Strengthening disaster preparedness will reduce uncertainty and bolster mental resilience. Reducing uncertainty and increasing the adequacy of safety and security measures can increase the emotional well-being of populations affected by severe weather events and reduce the likelihood of mental ill health and negative consequences such as looting and violence. Having a comprehensive and well-established evacuation plan, safe and secure shelters with an adequate supply of water, food and electricity, and taking measures to secure workplaces and schools can bolster mental resilience in the population (Benjamin, 2015; Sharma et al., 2018).

Maintain local registers of people with noncommunicable diseases, disabilities and/or mental health issues and develop tailored disaster preparedness and response activities

People with NCDs, disabilities and/or mental health issues (including some older people; see Chapters 4, "Noncommunicable diseases and risk factors", and 7, "Mental health", for more detailed recommendations relating to NCDs and mental health, respectively) are highly vulnerable to the negative health impacts of severe weather events and find it particularly difficult to access health care (R4ACCHC, 2023). It is important to maintain a register of these people at the local level, such as the village or town level, and develop tailored disaster evacuation, shelter and healthcare plans for each person (CARPHA, 2018). Hurricane shelters should be adapted for people with mobility challenges or other disabilities (Carby, 2021). Stocks of medication to maintain care regimes should be stored in resilient healthcare facilities locally. The development of NCD kits to hand out in emergencies may be helpful (Harewood, 2021; Hassan et al., 2020). Systems to prioritise access to nutritious food supplies for vulnerable people should also be established.

Establish measures to prevent violence against women and girls and infectious disease transmission in emergency shelters

Emergency shelters and procedures should be designed to ensure protection from further health risks, including violence against women and girls and infectious disease transmission. Separate, secure sleeping and other arrangements can be put in place to protect women, children and other vulnerable people, such as older people and people with NCDs and disabilities. Protection from infectious diseases is inherently difficult during situations of displacement and when people from different households are gathered in shelters. Risks can be reduced by ensuring adequate water supply and sanitation facilities, providing toiletries (including sanitisers) and face masks, and maintaining separation between different family or friendship groups (Dargin et al., 2021). The sexual and reproductive health needs of displaced populations should also be addressed, including access to contraception, options for the prevention of HIV and other sexually transmitted infections, and antenatal and postnatal care (R4ACCHC, 2023).

Develop climate-resilient health facilities

Severe weather events can cause major damage to health centres and hospitals. For instance, 56% of Dominica's health centres were completely or partially nonfunctional after Hurricane Maria. One was completely destroyed by a river that broke its banks (Ministry of Health and the Environment, 2017). Severe events also damage critical support infrastructure, such as access roads, and utilities, such as electricity and water supplies. For these reasons, it is critical that health facilities are built and equipped to be highly resilient. Several Caribbean governments are collaborating with the Pan American Health Organization/World Health Organization (PAHO/WHO) to build and retrofit health facilities to climate-resilient standards through the Smart Health Facilities initiative (Hassan, 2021; PAHO, n.d., 2013). Further details are provided in Chapters 15, "Climate-friendly health-promoting infrastructure", and 16, "Smart health facilities".

Support building back better across sectors

Destroyed and damaged buildings, infrastructure delivering public utilities, and agricultural production and delivery facilities should be reconstructed according to building codes that will mean that they are better protected against damage from future extreme events. Mechanisms and actions to enforce building codes should be actively supported and publicised by governments. If fossil fuel power plants are destroyed, they should be replaced by renewable electricity power plants. See Chapter 15, "Climate-friendly health-promoting infrastructure".

Research gaps and how to address them

Increase research on the indirect impacts of extreme weather events on mortality and morbidity

Research that documents both the direct and indirect health impacts (both mortality and morbidity) of specific hurricane events is crucial to understanding the full impact of hurricanes; informing risk reduction, preparedness and adaptation measures aimed at lessening the adverse impacts of future hurricanes; and effectively communicating their full impacts, and strategies for lessening those impacts, to the policymakers and government and nongovernmental organisation officials responsible for hurricane preparedness and response, and to the general public. Only a few Caribbean studies have measured excess deaths and the impact of hurricanes and other extreme events on health systems; more of these studies must be carried out. There is a pressing need for research on the impacts of hurricanes and other extreme events on morbidity in particular (Dubrow, 2021). To achieve this, surveillance systems need to be strengthened as outlined below. New methodological approaches to measuring health outcomes of disasters, such as those of the United States National Academies of Sciences, Engineering and Medicine, should be applied to studies in the Caribbean (National Academies of Sciences, Engineering and Medicine, 2020; Stoto et al., 2021). Longitudinal studies are needed to capture pre-hurricane risk factors and health status, and assess the impacts of extreme events (Dubrow, 2021).

Research and monitor key aspects of hurricane preparedness and response

The role of hurricane preparedness and response in protecting health should be researched, and key aspects of the response should be monitored to assess effectiveness. Topics should include:

- Public awareness of the significance of climate change in leading to extreme events, with severe health consequences in the Caribbean (R4ACCHC, 2022b);
- Hurricane preparedness and the response of regional agencies and national and local governments during pandemics;
- How civil society organisations, communities and individuals respond to and assist and cope with extreme events, and how they contribute to mental health and access to health care (R4ACCHC, 2022f);
- The extent of adherence to evacuation and development of behavioural interventions to increase adherence and population safety (Harewood, 2021);
- Messaging regarding hurricane preparedness;
- Hurricane preparedness and response to meet the needs of vulnerable populations, including the elderly, children, people living with disabilities, indigenous people and people living with NCDs;
- Sustainable hurricane preparedness and response (e.g. provision of water filters and rainfall storage systems instead of single-use plastic water bottles) (Dubrow, 2021).

Conduct research to identify key elements for making health facilities and the agriculture sector resilient to extreme weather events in the Caribbean

Health facilities and the agriculture sector are essential to health, and programmes of research should be dedicated to both, to identify key elements that should be built into their design and processes so that they can withstand the types of extreme weather events that are typical and predicted to increase in the Caribbean. See Chapters 12, "Agriculture and food safety and security", and 16, "Smart health facilities", for further recommendations. Building on the work of PAHO/WHO and others to develop climate-smart health facilities, it is important to develop health facility and technology design standards that are forward-looking, based on climate projections for the region (Dubrow, 2021). It is also very important to explore the effectiveness of nature-based solutions, given that changes in land use and urbanisation have been found to contribute to the lethality of hurricanes and floods (Andrewin et al., 2015; Asian Development Bank, 2022; Environment Agency, 2023).

Surveillance gaps and how to address them

Calculate excess deaths and excess incidence of health conditions to measure the health impacts of severe weather events

It is important to move beyond the current methodology used to produce official death tolls from severe weather events, which tend to be restricted to deaths that occur during the event itself. As was done in Puerto Rico following Hurricane Maria, the number of deaths in the three months following a hurricane could be compared with a similar period the previous year, for example (Kishore et al., 2018). Along similar lines, the number of deaths following an extreme weather event could be compared with the average number of deaths over the same time period in previous years without extreme events, as this would enable a comparison between mortality following an extreme weather event with mortality under average conditions in the recent past.

An important contribution of Kishore et al.'s (2018) study was conducting a parallel survey in which people were asked to report on deaths in their household and disruption to medical care and to utilities such as water and electricity. This methodology can assist in explaining excess deaths that may have resulted from disruption to health systems, utilities and infrastructure (Dubrow, 2021).

Syndromic surveillance data should be closely monitored in the period immediately following severe weather events to detect outbreaks of infectious diseases. To assess whether outbreaks can be attributed to the severe weather event, incidence in the weeks following the event can be compared with the average incidence in the same weeks in previous years, or with incidence rates in countries that have not experienced the same severe weather events. These methods were used to analyse data reported to CARPHA following Hurricanes Irma and Maria, and increased rates of gastrointestinal symptoms were found (Allen et al., 2019a).

A limitation in assessing the health impact of extreme events is the lack of reporting of some disease conditions to governments, including gaps in reporting of some notifiable diseases. Disease surveillance systems require considerable strengthening so that the range of impacts of climate change on health can be properly measured and assessed. To assess impacts on vulnerable populations, morbidity data need to be disaggregated by age, gender and local area.

Strengthen monitoring of population displacement and migration resulting from severe weather events

Following hurricanes, the number of people in shelters is taken as a measure of population displacement. See Chapter 8, "Population displacement and migration", for further recommendations. This is of limited value, since many people may take shelter in other households or buildings, and some may find no shelter following damage to their accommodation. It is important that local, regional and national government bodies investigate patterns of displacement and shelter-seeking, and provide support to households and other private and public bodies providing shelter to others. In the months following severe hurricanes, it is important to monitor travel patterns to assess the extent of temporary and permanent internal and external migration.

Strengthen integrated risk management and early warning systems

Disaster preparedness reduces vulnerability in the face of climate and weather hazards. See Chapter 11, "Research and surveillance on climate change and health", for more details. Integrated risk management (IRM) and early warning systems (EWSs) are essential for providing information to guide the design of effective preparedness measures (R4ACCHC, 2023). IRM takes a society-wide approach to risk identification, analysis and evaluation, and includes a wide variety of stakeholders. Risk identification and analysis are followed by measures to address the risks, communication to ensure that these measures are implemented, and monitoring and evaluation of these measures. EWSs are intended to give advance notice of impending hazards; enable the timely activation of preparedness, prevention and mitigation activities; and ultimately reduce harm (Harewood, 2021). Most EWSs focus on weather hazards, but there is a growing body of research on EWSs for climate-sensitive diseases, such as vector-borne diseases (Lowe et al., 2020; Stewart-Ibarra, 2021). It has been suggested that EWSs be expanded to include measurement of air quality and heat-related illness risk. The views of community members and policymakers on the utility of EWSs should be sought (Harewood, 2021). Adjusting seasonal forecasting to include evidence of climate change is an important aspect of EWSs (R4ACCHC, 2023).

Research and surveillance capacity-strengthening needs

To implement the recommended extreme weather event research agenda above, some key skills areas in Caribbean countries will need to be strengthened, such as those related to:

- Evaluating communication and behavioural interventions;
- Designing climate-resilient health facilities, technologies and public utilities, to account for projected Caribbean weather conditions;
- Designing communication strategies for people with physical and mental disabilities;
- Conducting emergency response management, including management of health facilities and shelters;
- Maintaining disease surveillance and statistical capacities post disaster;
- Designing climate-smart agriculture and food distribution systems;
- Building disease surveillance capacities and infrastructure;
- Performing statistical analysis, including data analysis, presentation and modelling;
- Understanding the demography of migration;

- Communicating complex scientific information to key audiences, including policymakers and the general public.

Climate-resilient information technology and electronic communication infrastructure should also be developed and expanded.

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2. VULNERABILITY TO VECTOR-BORNE DISEASES

2.1. WHAT IS HAPPENING?

Vectors are living organisms that can transmit disease-causing microorganisms between humans or from animals to humans (WHO, 2022). Mosquitoes are the most significant vectors for transmitting diseases to humans in the Caribbean. On a global scale, mosquitoes cause more human deaths than any other animals, including humans themselves (Wilkerson et al., 2021). Higher temperatures speed up the development and maturation of larvae; therefore, global warming brings larger numbers of vectors and greater chances of infection. Mosquitoes also tend to feed more frequently in warmer weather (Hemme et al., 2010; Mavian et al., 2018; Méndez-Lázaro et al., 2014; Schnitter et al., 2019; Taylor et al., 2010; Yearwood and Polson-Edwards, 2017). Finally, changes in precipitation patterns due to climate change can affect mosquito breeding in complex ways (Dubrow, 2021; Gharbi et al., 2011; Jury, 2008; Méndez-Lázaro et al., 2014).

Mosquitoes require standing water to breed. Therefore, there tend to be more mosquito-borne disease cases in the rainy season (Douglas, 2021; Francis, 2021; Jury, 2008; PAHO, 2022a; Schnitter et al., 2019). Tropical storms and hurricanes associated with climate change increase the amount of debris and discarded items that collect water. Floods and sea level rise can increase the quantity of pools of water for breeding (CARPHA, 2017, 2018; Mavian et al., 2018; Medlock, 2021; Méndez-Lázaro et al., 2014). Unless properly monitored and covered, water storage drums and underground drains and septic tanks can provide additional sites for mosquito breeding (CARPHA, 2014; Chadee et al., 2006; Clauzel and Forbes-Robertson, 2017; Medlock, 2021; Ortiz et al., 2015). Thus, harmful behavioural practices and a lack of availability of water and sanitation services combine with climate change to create vulnerabilities throughout most of the year (Medlock, 2021; Ortiz et al., 2015).

Since at least 2008, increasing numbers of vector-borne disease (VBD) outbreaks have been registered in Small Island Developing States (SIDS), with importation of some new diseases from endemic areas. SIDS have been identified as hotspots for emerging mosquito-borne viruses, with their characteristics facilitating the emergence and dispersal of these viruses to the mainland, fuelling global epidemics. These characteristics include tropical climatic conditions that are becoming ever more suitable for vector reproduction as temperatures rise and hurricanes increase in intensity; rapid urbanisation and high population density; the high cost and poor quality of sanitation and water infrastructure and vector control systems; and the intense movement of humans and goods owing to SIDS' remoteness and size and thus strong reliance on international trade, including tourism. These conditions have set the stage for the global dispersal of dengue, chikungunya and Zika, and may promote novel, unknown and unexpected threats to public health from mosquito-borne diseases (Mavian et al., 2018).

The challenge of addressing a VBD relates not only to the disease itself but also to controlling the vector and its habitats (CARPHA, 2017; Lichtveld and Wahid, 2017; Rawlins et al., 2006a). Vector control requires community mobilisation, environmental management and tailored disaster preparedness measures. Public health measures are needed to prevent and treat imported cases.

VBDs affect vulnerable populations most severely, including people with the poorest access to health services, people with disabilities, pregnant women, impoverished people, and women and children living in remote rural areas and informal urban settlements (Diaz-Quijano and Waldman, 2012; Medlock, 2021; Sommerfeld and Kroeger, 2015). The *Aedes aegypti* mosquito is the most common disease-transmitting mosquito in the Caribbean and is well adapted to urban settings where human-inhabited buildings are close together (CARPHA, 2017; Henry and Mendonça, 2020; Heslop-Thomas and Bailey, 2006; Mavian et al., 2018; Medlock, 2021; PAHO, 2022b).

Increased contact between infected and uninfected populations occurs through international travel, tourism and migration (Mavian et al., 2018). Caribbean people are relatively mobile, and tourism is a mainstay of Caribbean economies. Migration to the Caribbean from other parts of the world is also relatively common, especially from the South American mainland. It is challenging to implement infection control measures among informal migrants. This movement of people also facilitates the spread of VBDs beyond Caribbean shores. For instance, 50–80% of the imported cases of dengue, chikungunya and Zika found in Florida in 2008–2018 were reportedly introduced from the Caribbean (Mavian et al., 2018).

In recent years, three viruses spread by the *Aedes aegypti* mosquito (and secondarily by the *Aedes albopictus* mosquito) have caused many illnesses, disabilities and deaths, and outbreaks have incurred major economic and social costs (Dubrow, 2021).

Cases of dengue have risen in the region since the 1980s, with major outbreaks and a transition to a highly endemic state and annual outbreaks in multiple locations (CARPHA, 2017; Rawlins et al., 2006a; Schnitter et al., 2019). Typical dengue symptoms include fever, headaches, nausea, vomiting, a rash and pain in the eyes, joints and muscles. The World Health Organization (WHO) has classified dengue cases according to symptoms to help patients gain access to the appropriate care according to disease severity as follows: dengue without warning signs (D-W), dengue with warning signs (D+W) and severe dengue (also known as dengue haemorrhagic fever). D-W and D+W are classified as non-severe dengue fever (Ajlan et al., 2019; WHO, 2009). In addition, there are four dengue serotypes, each of which could cause either non-severe or severe dengue (WHO, 2009). Infection with one dengue virus subtype confers immunity from that subtype but can increase vulnerability to dengue haemorrhagic fever if a person is infected with another subtype. Caribbean countries have moved from a situation where only one subtype was circulating to one where subtypes 1 to 4 are circulating. This has increased the incidence of severe health outcomes. Cardiovascular complications have also been found to arise from dengue (Araiza-Garaygordobil et al., 2021).

In the 2013–2016 period, attention shifted from dengue control to the control of two VBDs that had not existed in the region before (Mavian et al., 2018). Chikungunya can cause high fever, a rash, headaches and joint and muscle pain that can culminate in arthritic symptoms and disabilities (La Rosa et al., 2017). Although the chikungunya virus is traditionally considered nonfatal, a study in Jamaica showed that 2499 excess deaths took place in Jamaica during the epidemic in 2014 (Freitas, 2019). Zika generally causes mild symptoms or can be asymptomatic, so incidence may be underestimated (Public Health England, 2017). Concern about Zika arises mainly because of its association with neurological birth defects, including microcephaly, a condition where babies are born with a small head and incomplete brain development (CDC, 2022), and Guillain–Barré syndrome, a condition that causes nerve damage (Krauer et al., 2017; Ryan et al., 2017, 2018). When the WHO declared the Zika epidemic a Public Health Emergency of International Concern (Krauer et al., 2017), there was a decrease in tourist arrivals to the Caribbean (CARPHA, 2017; R4ACCHC, 2022a). Cases of chikungunya and Zika increased work absenteeism and decreased worker productivity in the Caribbean (Ramrattan, 2015).

Yellow fever and malaria have been kept under control in the region by vaccination and a concerted eradication campaign, respectively. However, malaria continues to be endemic in the Dominican Republic, Belize, Haiti and Guyana (CARPHA, 2018). Caribbean countries remain at risk of outbreaks of yellow fever and malaria and VBDs transmitted by other vectors, which, in the Americas, primarily affect impoverished communities in Central and South America.

Caribbean research teams have been at the forefront of research showing links between climate and VBDs for about 30 years (Amarakoon et al., 2008; Chen et al., 2006a; Chen et al., 2006b; Ortiz Bulto and Linares Vega, 2021; Rise et al., 2022). Several Caribbean studies have established positive relationships between rising temperatures and the incidence of dengue fever (Amarakoon et al., 2008; Gharbi et al., 2011; Jury, 2008; Lowe et al., 2018; Méndez-Lázaro et al., 2014). Some studies have also found a positive association between levels of precipitation and dengue incidence, with others finding no or only a weak relationship between the two (Gharbi et al., 2011; Johansson et al., 2009; Méndez-Lázaro et al., 2014). Two studies have noted higher numbers of cases in years with El Niño activity (Ferreira, 2014; Johansson et al., 2009). Higher vulnerability to dengue in urban than in rural areas has been found, along with a tendency towards an expansion of dengue's geographical range to higher altitudes (Henry and Mendonça, 2020). In Barbados, geographical hotspots of dengue and chikungunya cases were identified (Lippi et al., 2020). In Puerto Rico, a study found an association between dengue and sea level rise, which may have resulted from the perimeter of an estuary expanding and shorelines moving inland, providing pools of brackish water for mosquito breeding. However, as mean sea level rise was found to correlate with both sea surface and air surface temperatures, the authors noted that rising temperatures were likely to be the most important explanatory factor (Méndez-Lázaro et al., 2014).

The Caribbean body of research has spearheaded the development of information products and communication known as climate services for health. Climate predictors of VBD outbreaks have been identified, facilitating the development of early warning systems (EWSs) (Linares-Vega and Ortiz-Bulto, 2021; Linares-Vega et al., 2020; Lowe et al., 2018; Lowe et al., 2020; Ortiz, 2021; Ortiz et al., 2015; Stewart-Ibarra, 2021; Stewart-Ibarra et al., 2017, 2019, 2022). However, action to address VBDs is constrained by the failure in most countries to link climate and health action, and a lack of specialised human resources. In addition, some of the approaches used do not sufficiently integrate metrics from medical, environmental, climatic and epidemiological sources (Ortiz Bulto and Linares Vega, 2021), highlighting the need to strengthen collaboration between agencies (see Chapter 10, "Collaboration between agencies"). In the research field, there is a need to build the skills of local staff in statistical modelling, geographic information systems (GISs) and data analysis, to increase self-sufficiency in the conduct of studies, and in building and using EWSs (Hussain-Alkhateeb et al., 2021; Stewart-Ibarra et al., 2019). While gaps remain, VBDs are one of the only areas where a substantial body of Caribbean research exists (Allen et al., 2021a,b; CARPHA, 2018).

2.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

A major focus of individual and community action to prevent mosquito-borne diseases, especially those transmitted by *Aedes aegypti*, which spreads the most common VBDs in the Caribbean, should be reducing standing water that is accessible to mosquitoes for breeding. This highlights the importance of water management, such as covering water containers, and waste management, such as removing plastic litter and old tyres, where water can gather (R4ACCHC, 2023). For other VBDs, the reduction of breeding sites is also a major strategy. Proper waste management controls other vector populations such as rats, flies and fleas, and so can reduce the incidence of the diseases they spread. In Saint Lucia, a project was established where communities were encouraged to use old tyres and plastic to construct kitchen gardens, so that these communities had greater access to fresh food, thus contributing to a reduction in noncommunicable diseases (NCDs) (R4ACCHC, 2023). Personal protection and vector control measures complement these approaches.

At the individual citizen and community levels, these methods require small amounts of time and effort at regular intervals for environmental inspection and reducing breeding sites. Clearing drains and guttering and removing household waste are important. Small sums need to be spent on installing lids or fine netting on water containers and cistern openings so that mosquitoes cannot enter and lay their eggs.

There are also long-standing barrier methods such as installing bed nets and insect screens and wearing long-sleeved garments and insect repellent (R4ACCHC, 2022a). These can be adopted by visitors to the region as well as residents. Support for installing and using barrier methods is important given the difficulties in reducing breeding sites in the Caribbean (R4ACCHC, 2023). Individuals and communities can liaise and cooperate with environmental inspectors and implement other aspects of vector control, such as using technologies to kill adult mosquitoes or larvae. Educational institutions at all levels should be involved in sharing information on prevention and control strategies with their students. Communication should be tailored to populations at risk, such as pregnant women (R4ACCHC, 2023).

From an intervention perspective, Caribbean experience suggests that action involving communities is often more effective than communication to motivate individual behaviour change. It is difficult to change how people manage the spaces around them without involving them in some collective activity, such as clearing up items where rainwater has settled (R4ACCHC, 2023; Yearwood and Polson-Edwards, 2017). Community-based vector control interventions in several Latin American countries were tested in cluster randomised trials and found to be effective (Sommerfeld and Kroeger, 2015).

Tools and equipment are needed to facilitate individual and community action, such as bins, garbage trucks, gloves, spades, mosquito netting and specially adapted water containers. Adequate drainage and drain maintenance also facilitate prevention (R4ACCHC, 2023).

People in the Caribbean often do not take the actions necessary to protect themselves and keep vectors under control in their own households and communities. Research is needed to understand why such actions are taken or not, and to build and implement effective communication and behavioural interventions. As suggested above, it is also important to conduct studies on the efficacy of community-based interventions. Recommended research is described below.

Structural/governmental and private sector actions

Establish effective intersectoral and interagency collaboration mechanisms based on the One Health approach

Intersectoral and interagency collaboration to address climate-related health risks is addressed in detail in Chapter 10, “Collaboration between agencies”. For research and action on VBDs, relevant government ministries and environmental health, medical and climate professionals should work together. Staff on the front line of service provision in public, private and nongovernmental organisations should be involved, as well as managerial staff and academics (Dubrow, 2021; Fontes-Filho et al., 2021).

The One Health approach is particularly relevant to collaboration relating to tackling VBDs (Benjamin, 2021; Dente et al., 2018).

> One Health recognizes that the health of humans, animals and ecosystems are interconnected. It involves applying a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address potential or existing risks that originate at the animal-human-ecosystem interface.
>
> One Health Global Network (n.d.)

For instance, to prevent and address tick-borne diseases, in which wild and domestic animals infested by ticks play an integral role, it is important for veterinarians, medical and public health scientists and entomologists (specifically acarologists) to work together and provide advice to policymakers (Charles et al., 2021). This concept of interdisciplinary collaboration is fundamental to the integrated vector management (IVM) approach promoted by the WHO (2012, 2022a).

IVM uses a suite of complementary approaches involving governmental and community action across sectors, making use, based on evidence, of high and low technologies and environmental management approaches, and involving monitoring and evaluation, to ensure effectiveness and efficiency. It reduces the previous reliance on toxic chemical insecticides, which can be harmful to public health (WHO, 2012). In 2017 the WHO built on experiences with IVM with the issue of its “Global vector control response 2017–2030” strategy. Limited IVM uptake was attributed to limited human capacity to advocate, plan and implement, as well as fragmented global and national architectures unable to support a multi-disease approach. The strategy highlighted the need to increase human capacity at the national and subnational levels and to strengthen infrastructure and systems (e.g. access to potable water, adequate solid waste and excreta management), particularly in vulnerable communities. It called for strategic intersectoral and interdisciplinary action, linking efforts in environmental management and health education and reorienting relevant government programmes around proactive prevention and control strategies (WHO, 2017).

Implement vector control strategies with a special focus on poor and disadvantaged communities

The circumstances in which people live and work affect their vulnerability to VBDs, as is the case for other health conditions (Marmot, 2005). In low-income communities, vector control programmes tend to be inadequate; healthcare and sanitation infrastructure is suboptimal; and social and environmental conditions tend to promote mosquito breeding. Inequalities within and between countries affect responses to VBDs (Mavian et al., 2018).

Outreach strategies may be necessary to involve low-income and isolated communities and assist them in environmental action to clean up potential breeding sites (Sommerfeld and Kroeger, 2015). Special efforts are needed to meet the needs of geographically remote communities with weaker infrastructure, such as indigenous communities.

Poorer communities and those with an inadequate water supply can also be assisted through donations of supplies and equipment, such as insect screens, and guidance on how to store water safely by modifying storage

Figure 1: Health promotion poster in Dominica aimed at preventing the spread of mosquito-borne diseases

Source: photo of an Environmental Health Department of Dominica poster, taken by Caroline Allen.

drums (Mavian et al., 2018), such as the example in Figure 1. The distribution of products and community education should focus on women, since it is mostly women who manage water storage and harvest rainwater as part of their domestic responsibilities. Opportunities are available for the private sector to become involved in providing supplies and public education as part of corporate social responsibility.

Boost the capacity of public health departments responsible for vector control

Vector control in SIDS is constrained by a lack of dedicated personnel. Sometimes there are no specialist vector control staff; instead, vector control is one of the several environmental and public health responsibilities of small teams or individuals. Resources should be dedicated to building up the numbers and skills of staff with vector control expertise. If the cost of recruiting additional staff cannot be met, existing personnel should be selected for training and they should be allocated the responsibility of vector control. Teams should be supported with knowledge about the latest scientific developments in vector control and with equipment and supplies to pilot and implement the latest vector control strategies (Medlock, 2021). Teams should be provided with skills for vector and disease surveillance, and contribute to and be provided with information from EWSs. They should be given support to become “first responders” in addressing the environmental risks of VBD transmission (R4ACCHC, 2023).

Governments should determine the level of human resources and range of skills necessary to address vector control and compare current staffing and skills with these. Shortfalls may be addressed by recruiting additional staff or providing existing staff with new skills and revised responsibilities, and supportive supplies and infrastructure. Educational institutions should be involved in identifying the skills needed for vector control and training new cohorts of students as well as existing health sector staff (see Chapter 13, “Awareness- and skills-building”).

Vector control teams should be provided with opportunities for networking and collaboration (Ortiz Bulto and Linares Vega, 2021; Ortiz, 2021). In Barbados, Cuba and Dominica, government and international partners have enabled team members to collaborate with meteorologists and scientists to co-create VBD EWSs and determine how information from them will be used. VBD experts at the regional and international levels should actively include staff working in the field in discussions on how to translate the results of research and the development of EWSs into practical and useful action on the ground (Lowe et al., 2020; Stewart-Ibarra, 2021; Stewart-Ibarra et al., 2019, 2022).

Vector control teams should be trained in/have the following characteristics (Medlock, 2021):

- Strong links with the community and understanding of factors promoting compliance;
- Good knowledge of mosquito ecology and disease risks in the context of climate change;
- Mosquito surveillance;
- Knowledge of how to seek and destroy breeding sites and reduce infestations;
- Knowledge of how to monitor and evaluate vector control interventions;

- Appropriate use of insecticides given evidence on resistance;
- Resources and infrastructure for mobilisation;
- Strong leadership and supportive work environments.

Strengthen water, sanitation and hygiene infrastructure and services

Building climate-resilient water, sanitation and hygiene (WASH) systems is a general recommendation for addressing climate-related health risks (R4ACCHC, 2023) and is detailed in Chapter 3, "Water, sanitation and hygiene". It is critical for the elimination of vector breeding sites, especially in vulnerable communities and urban settings (Henry and Mendonça, 2020; Medlock, 2021). Guidelines on vector control should be expanded to include underground breeding sites (such as cisterns and pipes) and brackish water (Mavian et al., 2018; Méndez-Lázaro et al., 2014). Public health regulations on water storage should be revised, updated and enforced (Lowe et al., 2020).

Waste management before the wet or hurricane season is a key intervention for disaster resilience. If potential water receptacles are covered or adequately disposed of, the potential for mosquito proliferation in the event of flooding or a hurricane will be lower (Medlock, 2021). Community clean-up drives can assist with this (Sommerfeld and Kroeger, 2015). Bodies responsible for solid waste management should ensure that their equipment, such as garbage trucks, can access remote communities in the event of a landslide, flood or hurricane (Allen et al., 2019a; CARPHA, 2018).

Build skills in complementary disciplines

The training of healthcare workers and laboratory staff is also needed. Further and higher education institutions can build skills in areas such as clinical care, communication, entomology, environmental health, laboratory testing and vector control. The development of short courses and online training modules, through collaboration with regional institutions of higher learning, can assist. See also Chapter 13, "Awareness- and skills-building".

Support the tourist sector and ports of entry in preventing and controlling vector-borne diseases

Some VBDs, such as yellow fever, can be prevented through vaccination. A malaria vaccine has also been launched. Caribbean governments should continue to be vigilant in requiring visitors to be vaccinated against VBDs for which effective vaccines have been developed, depending on VBDs predicted to be of concern (CARPHA, 2017). Airlines and cruise ship companies should continue with practices such as spraying aircraft cabins prior to take-off and inspecting ships for infestations, particularly in water containers.

The Caribbean Community (CARICOM) Regional Coordinating Mechanism on Health Security was developed in 2014 partly in response to the chikungunya epidemic and focuses on measures to protect local populations from imported diseases. The Global Health Security Cooperative Agreement with the Centers for Disease Control and Prevention (CDC) included funding to address Zika starting in 2016. This has focused on enhanced surveillance using GISs and laboratory and insectary facilities, and building a Caribbean network of VBD experts (CariVecNet).

Some tourist establishments have installed barrier methods such as bed nets, conduct regular exercises to remove breeding sites and have advised their visitors to adopt prevention methods. The Caribbean Public Health Agency (CARPHA) has collaborated with tourism ministries, the Caribbean Tourism Organization and the Caribbean Hotel and Tourism Association (CHTA) to develop strategies on mosquito-borne diseases. The Caribbean Alliance for Sustainable Tourism, which was formed by two board members of the CHTA, has conducted educational sessions and webinars on Zika and other mosquito-borne diseases (R4ACCHC, 2022b). Such initiatives should be continued and promoted. Tourist premises should be subject to more regular public health inspections, with an increase in the number of inspectors if necessary.

Include vector-borne diseases in disaster preparedness and resilience strategies

Extreme weather events associated with climate change may disrupt vector control activities, highlighting the need to put systems in place to strengthen the resilience of community infrastructure (Medlock, 2021). Resilience strategies relevant to vector control in extreme events such as hurricanes and flooding should be put in place (Allen et al., 2019a; CARPHA, 2018; Medlock, 2021):

- Strengthen the climate resilience of buildings housing laboratories and vector control departments and their communications and other equipment and supplies.
- Provide air conditioning in buildings and shipping containers used for remote laboratories or equipment storage.
- Provide robust vehicles and parking spaces for vector control staff that will withstand flooding or high winds in the surrounding area.
- Prepare temporary office accommodation and establish rapid repair processes.
- Provide staff with real-time information on geographical communities at risk, through collaboration with sentinel stations and meteorological services.
- Establish rapid procurement/sourcing of vector control products and equipment.
- Establish systems for the rapid removal and proper disposal of bulky waste and debris.
- Establish systems for checking and fixing gauze on outlet pipes and screens on windows and for ensuring rainwater drums are covered.
- Ensure access to first aid for vector control staff and vulnerable communities.
- Maintain and stockpile resources such as traps with charged batteries, mesh for securing cisterns, covers for temporary water-capture receptacles, larvicide and where necessary adulticide (for fogging), and public communication material for rapid dissemination.
- Compile lists of available stocks and create procedural manuals.

Research gaps and how to address them

Improved prediction models for vector-borne diseases

Research is needed to determine how meteorological factors interact with nonclimate drivers in the spread, distribution and incidence of vector-borne infections. Nonclimate drivers include pathogen evolution, human susceptibility to infection, ecosystem change, level of economic development, water and land use (e.g. dams, deforestation), urbanisation, human behavioural factors, international travel and trade, level of public health infrastructure, vector control measures and migration. It is reasonable to hypothesise that meteorological factors interact with nonclimate drivers with a high degree of specificity, with marked variation by disease and geographical location, meaning that this research needs to be conducted on a disease-specific and SIDS-specific basis (Dubrow, 2021; Ortiz Bulto and Linares Vega, 2021). An important reason for conducting this research is to inform the development of accurate EWSs, but it should be noted that this type of activity is research, not surveillance. It can help to inform national, regional and international prevention and control policies; inform adaptation and mitigation measures; and target resources where most needed.

The development of prediction models depends on the existence of strong surveillance data from the field and from laboratories, however (R4ACCHC, 2023). See the subsection "Surveillance gaps and how to address them" below.

Communication of information from early warning systems

It is important to research the best ways to communicate information from EWSs to key stakeholders. Knowledge and communication products should be simple to use and accessible to decision-makers, especially those responsible for public health, health service management and disaster preparedness (Stewart-Ibarra, 2021). Knowledge products and communication methods designed for the general public based on EWS data may be helpful, particularly in motivating action to prevent outbreaks (Lowe et al., 2020). Simplified modelling and automation of thresholds for warnings can enhance uptake (Lowe et al., 2018; Stewart-Ibarra et al., 2022). Forecasts of disease risk could be used to inform hospitals about staffing needs and which medicines and laboratory diagnostic reagents to stock (Allen et al., 2021a; Lowe et al., 2020; Stewart-Ibarra et al., 2019).

Studies on knowledge, attitudes, beliefs and practices on vector-borne diseases

Studies on knowledge, attitudes, beliefs and practices (KABP) can reveal motivations for and constraints on individual action to control VBDs, but very few have been conducted in the Caribbean. Only one study was identified in the current review, published in 2006 (Rawlins et al., 2006b). Since the chikungunya and Zika epidemics, the CDC has provided funds to CARPHA for further KABP surveys, but conducting these surveys was challenging during the COVID-19 pandemic. Studies should be conducted to measure public knowledge about vectors, their breeding practices, how they transmit diseases and whether diseases such as dengue are believed to be spread in ways other than by vectors. Attitudes and behaviours relating to evidence-based VBD prevention and control recommendations also need to be more closely examined to inform future interventions (Allen, 2021).

KABP studies are needed to inform the development of effective communication and behavioural interventions to achieve the major objectives of vector control programmes, i.e. reducing vector breeding sites and adopting personal protection and vector control measures.

Research on effective behavioural and communications interventions

Approaches to promoting vector control in the general population should be tested using intervention studies, the outcomes of which are the adoption of behavioural recommendations and, ultimately, changes in vector numbers and disease outbreaks (Dubrow, 2021).

Research based on behavioural theory can help in the development of interventions. For example, Anderson et al. (2020) applied protection motivation theory in a study of personal protective behaviours to prevent chikungunya (appropriate clothing and repellent use) among travellers from the United States of America to the Caribbean. The perceived severity of the disease and perceived vulnerability were found to be significant predictors. This type of research can help to inform communication in the tourism sector.

The general application of research on how to strengthen community action on public health can also assist. A CARPHA evidence brief reviewed behaviour change strategies that can help to strengthen household and community action for the prevention and control of mosquito-borne diseases. Findings included the following (Yearwood and Polson-Edwards, 2017):

- Participation in environmental enhancement and conservation activities produces personal, social, physical and psychological benefits, and these foster individual change to benefit the community.
- Digital health promotion interventions, presented via electronic devices and social and other media, help to modify behaviour, especially if combined with text messaging, online support and decision support tools.
- Financial incentives, both positive and negative, have been successfully used to modify behaviour related to risks such as smoking and alcohol use and the use of vaccination services, and these incentives could be applied successfully to prevention of viral VBDs.

The implementation of recommendations from behavioural research should be monitored and evaluated to improve the effectiveness of interventions.

It is important when conducting such research to enable participants to explain in their own words the factors that may prevent them from adopting the appropriate preventive behaviour. Individuals and communities may regard other concerns as more immediate or important than VBD prevention, such as retaining employment, maintaining relationships and other health concerns.

Studies in Latin American countries looked at strategies to involve communities in removing discarded containers, cleaning backyard areas, covering large water containers, covering windows and large containers with insecticide-treated material, elementary school education and practical skills development. These interventions all led to a reduction in mosquito populations compared with control communities (Sommerfeld and Kroeger, 2015). Similar studies involving vulnerable communities in research and intervention design should be conducted in the Caribbean, while assessing the human resources and other resources available for the sustained support of these efforts.

Identification of vulnerable communities in need of vector control interventions

As highlighted in the situational analysis on VBDs and in Chapter 9, "Distribution, equity and justice in climate change and health", the risks of VBDs are unevenly distributed such that identification of vulnerable communities is critical (R4ACCHC, 2023). The starting point for this research should be identifying the key facets of communities' vulnerability to VBDs, including:

- Poor or unreliable access to water;
- Poor or inadequate access to solid waste removal;
- High prevalence of open containers;
- High risk of flooding;
- High risk of being isolated following severe weather events;
- Low income;
- History of marginalisation and discrimination.

Sentinel stations, VBD surveillance and meteorological services can help to provide real-time information on vulnerable communities and their needs.

Further vulnerabilities within communities should be identified, such as among women, children, older people, people with disabilities and people with NCDs. Research along these lines can assist in the efficient and equitable allocation of vector control and healthcare resources (Allen, 2021; R4ACCHC, 2023).

Surveillance gaps and how to address them

Strengthened field and laboratory surveillance

Field-based staff, such as vector control, environmental, public health and laboratory personnel require further skills, equipment and supplies, so that they can collect, enter and analyse data on a systematic basis. Their ability to collect data on environmental conditions, vector numbers and distribution, and disease incidence and prevalence must be improved so that data coverage and quality can be improved. Time series and location-based data are critically needed. Strengthening capacity among front-line staff is critical to the ability of researchers and policymakers to develop and use the evidence base (R4ACCHC, 2023). There is also a role for "citizen science" in providing reports on breeding sites and environmental hazards. Tools such as smart phone apps can be used to facilitate data collection (Poon, 2022; Walsh et al., 2018).

Rapid availability of relevant data on public health and weather risks

Electronic information systems should be developed to enable the establishment of EWSs and responses to evolving risks. Weather forecasting capacities should be strengthened and early warnings provided directly to healthcare providers. Public health inspectors and vector control teams should be trained in and provided with computer hardware and tailored software to record their monitoring data on environmental conditions relating to VBDs, such as drainage; solid and liquid waste management and disposal; water storage; adult and larval vector counts; and inspection of public and commercial buildings and facilities, especially hotels, ports, cargo, healthcare facilities and workplaces. Data from EWSs should be presented in bulletins to stakeholders, including policymakers, healthcare managers and the general public.

Assess current and required equipment and supplies

Inventory and procurement information systems are needed to keep track of equipment and supplies for vector control and enable a flexible response to emerging environmental threats.

Mapping the movement of vectors, vector-borne diseases and viral strains geographically and over time

Mapping and predicting the distribution of vectors, cases of disease and viral strains can sharpen the design of control strategies and optimise the use of limited public health resources. With four dengue virus serotypes circulating in the Caribbean, and given the vulnerability of individuals to severe forms of the disease if they are exposed to a serotype they have not been infected with before, it is critical to map how serotypes and strains are circulating within the region and in other areas connected through travel. Routine sequencing of dengue virus strains can identify which part of the world they came from, helping to prevent further imported cases (Douglas et al., 2020). Awareness of the spread of existing strains and the introduction of new strains is also needed. Mapping the spread of vectors, which may move into new environments and even adapt to new places and conditions, is needed as well. For instance, Yang et al. (2018) mapped the spread of the snails that cause schistosomiasis and found that a combination of human behavioural and climatic factors has led to the enlargement of their habitat from tropical to some subtropical regions. Prioritising surveillance and control efforts in high-traffic regions with highly suitable vector habitats may be the most effective approach.

Excess deaths and seroprevalence surveys as tools of epidemiological surveillance

Many cases of VBDs are not reported to healthcare practitioners or onwards to surveillance systems. This means that the true extent of illness and death from VBDs is not known. In the Jamaica Health and Lifestyle Survey 2016–17, the population prevalence of self-reported chikungunya was 48.8%, but 80.4% of the population had a positive serum (blood) test for the disease (Ministry of Health Jamaica, 2018). This highlights the importance of utilising available diagnostic tests to establish seroprevalence in the context of major outbreaks.

Freitas et al. (2019) looked at excess mortality in Jamaica in 2014, the year of a major outbreak of chikungunya. Excess deaths were estimated by calculating the difference between observed deaths and the expected number of deaths based on the average age-specific mortality rate in 2012–13. They found that there was an excess of 2499 deaths during the epidemic (91.9/100 000 population) and a strong positive correlation between the monthly incidence of chikungunya and excess deaths. Similar methods could be used in future to investigate whether outbreaks are associated with increased mortality.

Research and surveillance capacity-strengthening needs

Improved prediction models for vector-borne diseases

Collecting good longitudinal data on nonclimate drivers is needed to enable research that will lead to improved prediction models for VBDs. Researchers in several academic disciplines, including medical science, environmental science, economics, behavioural science and international relations, should contribute their expertise by strengthening their collection, analysis and communication of data on nonclimate drivers of climate change and health risks, and informing policy.

Establish links, networks, working relationships, data-sharing and methodological agreements between research and surveillance professionals in the meteorological and health fields

This is linked to the recommendation on intersectoral and interagency collaboration and is covered in more detail in Chapter 11, "Research and surveillance on climate change and health". With regard to research on VBDs, time periods for the integration of longitudinal data on weather patterns, vector densities and VBDs, and spatial boundaries for data collection should be agreed on (Linares-Vega and Ortiz-Bulto, 2021; Ortiz, 2021; Ortiz et al., 2015). There are some methodological challenges, since data on vector densities and VBD cases tend to be collected less frequently than data on weather. For instance, at the regional level, cases of dengue, chikungunya and Zika are reported in four-week blocks in communicable disease surveillance reports to CARPHA and confirmed by laboratory testing of samples (Allen et al., 2019a). The relative infrequency of aggregated regional VBD data collection means that, to get a picture of climate–VBD associations at the regional level and to compare countries, datasets may need to cover periods of years (Allen et al., 2021a; CARPHA, 2017). These types of methodological challenges will need to be discussed between agencies collecting data, to agree on ways to integrate climate/weather and health data to analyse associations.

As mentioned above, the One Health approach is particularly relevant to the prevention and treatment of VBDs; therefore, research collaborations between meteorologists, environmental health and medical professionals, veterinarians and entomologists would be fruitful.

An excellent example of integrated science for health is that of the approach taken in Cuba. In this country, research has been conducted on climate variability and change and its impact on health over the last 30 years. This was facilitated by establishing a multi-agency group on climate and health based at the Instituto de Meteorología de la República de Cuba (INSMET), resulting in research projects and publications combining climate and health data. INSMET communicates with the public when climate-related disease outbreaks and risks are predicted (Allen et al., 2021b). In the past decade, efforts in Cuba have focused on understanding and attributing the effects of climate on changing patterns of viral and bacterial agents that cause infectious diseases. Cuban research teams have examined climatic data alongside the dynamics of the vectors and pathogens affecting changes in disease transmission; ecological changes such as biodiversity loss, residential location and nutrient cycle changes; and socioeconomic changes in areas such as demographics, migration, sanitation and nutrition (Ortiz Bulto and Linares Vega, 2021).

Strengthen early warning systems and embed them in public health decision-making

The Caribbean is a global leader in the development of EWSs for VBDs (Stewart-Ibarra, 2021), and these have helped decision-makers to take targeted action to prevent and address outbreaks. However, only some Caribbean countries have established these systems and are using them to help guide decision-making.

A scoping review found that almost all EWS models for VBDs require highly skilled users with knowledge of advanced statistics (Hussain-Alkhateeb et al., 2021). One of the challenges in the local development of EWSs in SIDS has been the lack of personnel with the requisite skills to combine health and climate datasets and to conceptualise and implement the complex statistical modelling required (Mavian et al., 2018). There is therefore a need to build expertise in statistical and epidemiological modelling in the region. Other areas where strengthening skills is required are GIS and computer programming (Stewart-Ibarra, 2021; Stewart-Ibarra et al., 2022). Cuba has developed its own institutional capacity in these areas (Linares-Vega and Ortiz-Bulto, 2021; Linares-Vega et al., 2020; Ortiz, 2021; Ortiz et al., 2015). In other Caribbean countries, the requisite expertise has generally been provided through collaboration with universities outside the region (Lippi et al., 2020; Lowe et al., 2018; Lowe et al., 2020; Stewart-Ibarra et al., 2022). These universities have engaged in collaboration and capacity-building with local staff, but specific efforts are needed throughout the region to build human resources through advanced training and scholarships as well as short courses.

Electronic information systems are generally weak in the Caribbean and it is particularly important to strengthen capacity for the monitoring of environmental conditions and diseases. Investment in electronic hardware and the development of specialised software is needed.

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3. WATER, SANITATION AND HYGIENE

3.1 WHAT IS HAPPENING?

Water, sanitation and hygiene (WASH) are essential for health. They are affected by all the main consequences of climate change: increased temperatures, extreme weather events and sea level rise. Water access and quality are determined by environmental and institutional factors such as geography, land and marine use, agricultural production and infrastructure (Trotman et al., 2017). Water distribution is also associated with social stratifiers such as gender, race, age, income and education. Preexisting conditions and access to health care influence health outcomes arising from WASH (Allen, 2021; USGCRP, 2016).

Water access and quality are interrelated in several ways. If water supplies are limited, then maintaining adequate hygiene may be challenging. At the same time, if the resource from which a water supply is sourced is "low" then the quality may also be poor, depending on how much the water is treated before it enters the distribution system. Lastly, intermittent flow associated with limited water supplies can affect the water chemistry within the pipe distribution system. The impacts of water insecurity and water quality on health are discussed separately in the subsections that follow, but it is important to recognise that they are linked.

Water security

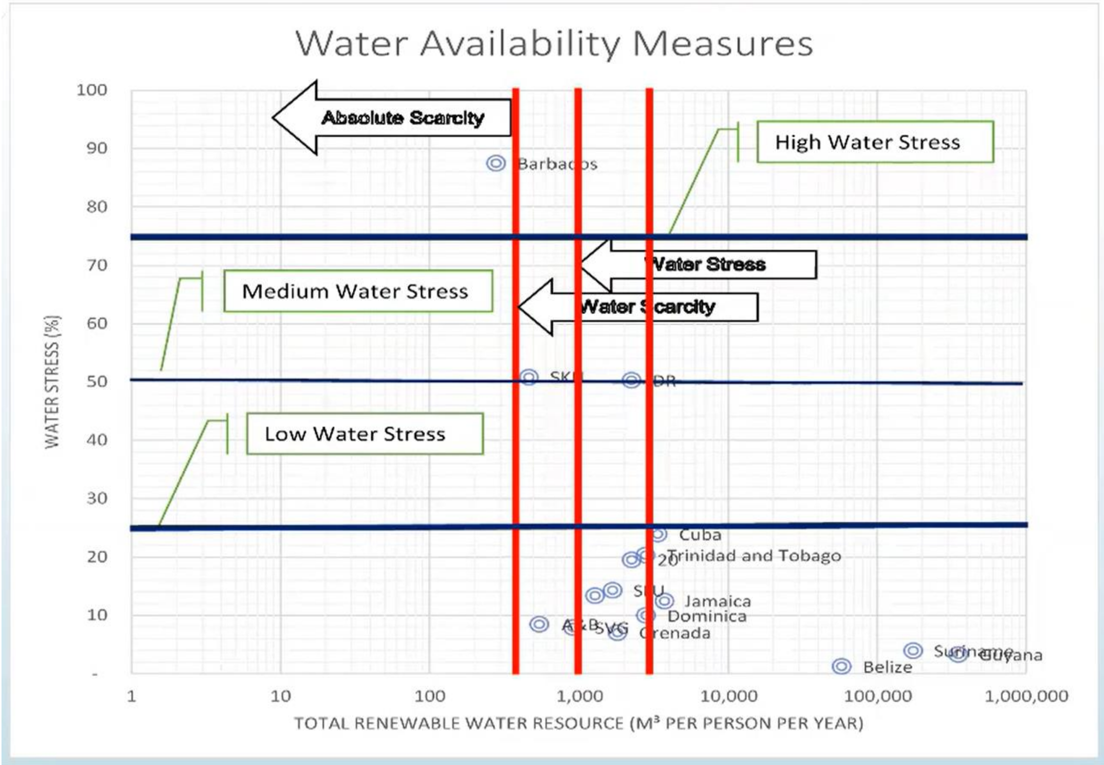
Hydration is fundamental to life. The body requires water for many essential functions, including balancing internal temperature and keeping cells alive. Survival time without water is generally estimated at under five days, depending on factors such as age, sex, weight, height, exercise patterns and external temperature. With climate change compounding hot conditions in the tropics, water needs are likely to increase in Caribbean Small Island Developing States (SIDS).

Making water available to all who need it is hindered by two main types of challenges (Cashman, 2021):

- Challenges with regard to the availability of water resource;
- Challenges in making water resources accessible for those who need them.

Having a safe, reliable and sustainable source of drinking water has always been a challenge for SIDS, with fresh water being from surface water (rivers, springs, ponds) and groundwater sources, and increasingly from desalination plants. In 2013, Antigua and Barbuda, Barbados, Dominica, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago were among the top 36 water-stressed (based on demand for water relative to supply) countries in the world (Dubrow, 2021; Reig et al., 2013). The availability of water varies from island to island and even within islands (CIMH and Land and Water Division of FAO, 2016). For instance, in Jamaica, the capital city of Kingston is located in a region of the country where water is relatively scarce, which poses health and other challenges to residents of this metropolitan area. In the Caribbean, Barbados has the lowest total water resource volume per person and the highest level of water stress (Figure 1). The challenges are likely to worsen, since climate models for the Caribbean predict an overall drying trend, with more frequent dry spells, as climate change advances this century, although with some geographical variation (Cashman, 2021; Taylor, 2021; Taylor et al., 2018).

Figure 1: Water availability by Caribbean country



Source: Cashman (2021).

Water availability varies over time, and one of the consequences of climate change is increased seasonal variability and unpredictability, posing problems for farmers (Gamble et al., 2010) and for the sustained provision of water to the population. Both slow-onset extreme weather events (such as drought) and rapid-onset conditions (such as hurricanes) affect the availability of water. Pollution with harmful microorganisms and chemicals can make existing water supplies unusable. Saline intrusion and other pollution resulting from sea level rise, over abstraction and flooding can also reduce the availability of fresh water.

Governance factors affecting the ability to make water available include uncertain finances, ageing infrastructure (resulting in burst pipes and loss from pipelines), inadequate planning, lack of data, poor service coverage and human resource constraints. Combined, these result in inadequate water services, eroding political support and finances and increasing the challenges. In some Caribbean countries, up to 75% of the water supplied by national water companies is lost through leakage. Across the Caribbean, people experience water outages and many pay for trucks to bring water to meet their water supply needs, for instance by filling their water tanks. This creates inequity, as many people cannot afford to pay for truck-borne water (R4ACCHC, 2022a). Attempts to address food insecurity by increasing local production may increase water stress because of competition for water resources (Cashman, 2021).

The impacts of these scenarios include increased competition for water resources, higher cost of provision, disruption in supply due to extreme events and deterioration in water quality. These all point to the likelihood of increasing water insecurity as climate change advances (Cashman, 2021; UNFCCC, 2008). Droughts often give rise to an increased need to store water. If water is stored in uncovered containers, this may result in increased mosquito breeding and increased incidence of vector-borne diseases (Clauzel and Forbes-Robertson, 2017; Dominica Ministry of Health and the Environment, 2016).

Water quality, sanitation and hygiene

Anthropogenic and natural threats to the quality of the water supply that are not related to climate change include poorly designed or malfunctioning sanitation infrastructure and services; contamination by human, animal and agricultural wastes; deforestation leading to greater exposure of water sources to contamination; pollution due to chemical contaminants; over abstraction; sand and gravel mining from freshwater sources; and deposition of airborne contaminants (IPCC, 2014; Itoewaki, 2021; UNEP, 2012; UN-OHRLLS, 2015). Over 80% of wastewater going into the ocean is untreated, threatening marine water quality and marine life. Humans who have direct contact with ocean water (e.g. fisher people, swimmers) can be exposed to contaminants from untreated wastewater. Human health can also be threatened via consumption of contaminated fish and other seafood (see Chapter 14, "Marine resources and health"). In water-stressed countries, wastewater should be recycled, so dumping wastewater into the ocean represents a lost opportunity for sustainable water supplies (Buenfil, 2021; Dubrow, 2021). The impacts of all of these threats to water quality on health are aggravated by climate change.

Drought can lead to the spread of disease, as people use scarce water that may be contaminated with pathogens or harmful chemicals. A reduction in rainfall reduces river flow and effluent dilution and increases pathogen loading. Health impacts are likely to include an increase in waterborne diseases with diarrhoeal and other symptoms and an increased burden on health services.

Flooding can lead to a variety of diseases, as pathogens and chemicals are spread by floodwater (Dubrow, 2021; Wells et al., 2015). Exposure to floodwater most commonly causes diarrhoeal disease, while prolonged exposure leads to skin diseases. *Leptospira*, the genus of bacteria that causes leptospirosis, is spread through the urine of infected animals, and can get into water or soil and survive there for weeks to months. The bacteria can then be carried by floodwater that humans can be exposed to. Leptospirosis can lead to kidney damage, meningitis (inflammation of the membrane around the brain and spinal cord), liver failure, respiratory distress and even death (Dubrow, 2021; CDC, 2017). Mosquitoes, the vector that spreads the most disease in the Caribbean, breed in standing water. Several other vectors also require water as part of their life cycles. Flooding tends to provide additional breeding sites for vectors that spread diseases (see Chapter 2, "Vulnerability to vector-borne diseases").

Warming oceans and freshwater lakes, combined with elevated phosphorus and nitrogen from agricultural run-off (promoted by extreme precipitation events), increase the risk of harmful algal blooms. These blooms, which represent overgrowth of microalgae in either salt or fresh water, produce an array of phycotoxins. Depending on the species, phycotoxins produced by these algae have a range of toxicities, including liver, gastrointestinal, kidney, neurological, skin and respiratory toxicities. Fish, shellfish and drinking water can become contaminated with phycotoxins, which cause a variety of human diseases (Dubrow, 2021). Further detail is provided in Chapter 14, "Marine resources and health".

The effects of flooding on water quality depend on sanitation systems and practices. Large portions of the populations of Caribbean countries are not serviced by public sewage collection systems but rather depend on individual systems such as septic tanks, soakaways and pit latrines. In times of high rainfall, run-off and floodwater may become contaminated with faecal waste from these systems and pose health risks. The practice of dumping solid waste into rivers, streams, ravines and drains is widespread. This waste can clog waterways, exacerbating the effects of flooding and leading to human exposure to pathogens (Ebi et al., 2006).

Extreme events such as hurricanes can cause major disruption to water hygiene, sanitation and distribution systems, increasing vulnerability to waterborne diseases, including schistosomiasis, cryptosporidiosis and cholera, and dehydration and malnutrition resulting from disturbance in food production or distribution (Taylor et al., 2010). Box 1 provides a case study from Dominica.

Box 1: Case study – the impact of Hurricane Maria on water, sanitation and hygiene in Dominica

Hurricane Maria caused extensive damage to the water and sewage infrastructure in Dominica (18 September 2017) as water cascaded down hills and mountains and broke pipes, some of which were built into bridges. The main sewage treatment facility in Roseau was compromised because its electrical panel flooded. Pump stations were also damaged, and a major sewage pipeline under one of the bridges in Roseau was broken. Much of Roseau was covered in mud and silt, and sewage in places, for a few days following the hurricane. Throughout the island, there were cuts in the water supply and risks of exposure to sewage.

Watersheds were also compromised. Forest coverage and shade of these bodies of water was reduced as the hurricane removed leaves and branches of trees. It was estimated that 80–90% of trees were defoliated by Hurricane Maria (Government of the Commonwealth of Dominica, 2017). This led to increased evaporation of water and risks of contamination. In some water sources, new colourful blooms of algae and traces of sulphur and iron were identified by environmental health officers. Analyses of the risks to human health were hampered by damage to the national laboratory at the Princess Margaret Hospital. Laboratory staff at the Dominica Water and Sewage Company, assisted by a senior member of staff from the national laboratory, therefore monitored water quality, conducting chemical, physical and bacterial analyses.

In the first few days after Hurricane Maria, hygiene in shelters for displaced people was poor, with no potable or stored water and very little food. Few had toilet facilities and shelters were overcrowded. This combination of factors produced a high-risk public health situation, as unsafe water and food supplies were being used by occupants in the interim, and there was high risk of transmission of disease among the shelter population.

Many of the immediate water supply needs were addressed by importing millions of plastic water bottles with assistance from aid agencies and neighbouring countries. This added to the solid waste management challenges of the country. It was also ecologically unsustainable, since plastic water bottles are petrochemical products and release greenhouse gases as they slowly break down in hot weather (World Economic Forum, 2022).

Sources: Allen et al. (2019a); CARPHA (2018); Dubrow (2021).

Pathogenic *Vibrio* species, which cause diarrhoeal disease, including *Vibrio cholerae*, grow best in warm brackish water along coastlines. Although cholera is not found in most of the Caribbean, it has become endemic in Haiti (Eisenberg et al., 2013) and remains a threat wherever and whenever sanitation systems fail in the Caribbean. With warming waters, infection by noncholera *Vibrio* species is of increasing concern (Dubrow, 2021).

Primary research on the health outcomes of changes in WASH owing to climate change is rare in the Caribbean (Rise et al., 2022). The information in Box 1 arose from key informant interviews in Dominica conducted approximately seven months after Hurricane Maria. Post-disaster needs assessments are often conducted in the immediate aftermath and identify challenges for the WASH infrastructure, but we did not identify longitudinal studies in the Caribbean that tracked the effects on health systems, the disease outcomes that emerge and the responses that arise from various sectors. A major challenge is the lack of monitoring data on the WASH systems themselves, such as the location, type, frequency and duration of leaks and damage to the infrastructure (Cashman, 2021). The impact of hurricanes in particular on WASH and associated health outcomes is an important area for further research.

A few Caribbean studies have looked at the impact of climate change on gastrointestinal (GI) illnesses. For instance, the relationship between extreme rainfall, ecosystem services offering flood protection and the occurrence of Medicare claims for GI illnesses was studied in Puerto Rico. The study found that claims for GI illnesses increased following extreme rainfall events. However, the effect was reduced for people living in areas with ecosystem services such as karst soils and increased for people living in flood-prone areas (De Jesus Crespo et al., 2019). In Haiti, where cholera has become endemic since the 2010 earthquake, increased rainfall was found to be significantly correlated with increased cholera incidence four to seven days later. The relationship between rainfall and cholera was found to be significant for all spatial scales and locations examined (Eisenberg et al., 2013). In Cuba, significant associations were found between the Oceanic Niño Index and giardiasis cases. However, in two out of three study locations the relationship was positive, while in the other study location it was negative (Escobedo et al., 2015). One study used weekly syndromic surveillance data on gastroenteritis cases collected by the Caribbean Public Health Agency to examine the impact of the 2017 hurricanes. Countries hit by Hurricanes Irma and Maria at Category 4 or 5 strength were compared with other Caribbean countries. It was found that, in the three months following the hurricanes, the numbers of gastroenteritis cases increased more rapidly in the countries that were struck by the hurricanes at Category 4 or 5 than in the countries that were not (Allen et al., 2019b; CARPHA, 2018).

This small body of Caribbean research, then, focuses mainly on water quality and waterborne disease. A few studies also examined the effect of drought and floods on Caribbean agriculture and thus on food security (see Chapter 12, "Agriculture and food safety and security"). We did not identify studies that looked at how the construction and management of utilities and infrastructure contribute to the health outcomes of climate change.

3.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Encourage water demand management, water conservation and the use of alternative water sources

While water availability is largely out of the hands of individuals and communities, they can be encouraged to moderate water demand and engage in conservation practices. Communication strategies and tools should be developed to enable consumers to reduce water wastage. Similarly to elsewhere, Caribbean governments periodically impose hosepipe bans in times of drought. More can be done to encourage turning off taps when they are not needed in the home (Cashman, 2021).

Potable drinking water is often used in situations that do not require a high level of water cleanliness (e.g. for washing the car). As water becomes scarcer, it will become increasingly necessary to recycle water and adapt to using water of the appropriate quality for a given task. Water should be used at the quality level needed (Buenfil, 2021). Desalination technologies are seeing increased application in those Caribbean islands where the demand for freshwater substantially exceeds the supply from natural sources (UNEP, 2012). Rainwater harvesting schemes are being developed across the Caribbean, and their use by the general population should be facilitated (R4ACCHC, 2022b). Rainwater harvesting should be included in building codes, policies and laws. For example, in Antigua and Barbuda, a water harvesting system is a requirement in the building code for residential buildings.

It is important to note that rainwater harvesting can increase the risk of disease if water receptacles and storage containers are uncovered and mosquitoes that transmit diseases can breed in them. Rainwater harvesting should be accompanied by measures to cover water containers and otherwise prevent mosquitoes from breeding in them. Guidance on managing water storage should be developed.

Involve communities in integrated water resource management

The Global Water Partnership defines integrated water resources management (IWRM) as "a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Hassing et al., 2009). Local communities and nongovernmental organisations (NGOs) can play a critical role in developing systems that manage water resources in tandem with land and other resources that sustain livelihoods and health in a manner that leaves no one behind. They should be involved in recommending, lobbying for, working on and developing appropriate local solutions to water shortages, making use of alternative sources and technologies as needed (Cashman, 2021). This may help make the most efficient use of scarce water resources. Communities are unlikely to achieve this alone, however. IWRM also requires a structure of policies and legislation along with an institutional framework for implementing and enforcing them. Information and monitoring and evaluation systems are also necessary (Hassing et al., 2009). These points highlight the need for structural/governmental and private sector actions, as detailed below.

Structural/governmental and private sector actions

Fulfil government responsibilities on the human right to water and sanitation for all

As it is essential for life, access to clean water has been recognised as a human right. The human right to safe drinking water was first recognised by the United Nations General Assembly and the Human Rights Council as part of binding international law in 2010 (United Nations, 2010). The human right to sanitation was explicitly recognised as a distinct right by the United Nations General Assembly in 2015 (UN-Water, n.d.; United Nations, 2016). These rights were also asserted in United Nations Sustainable Development Goal 6: "Ensure availability and sustainable management of water and sanitation for all" (see https://sdgs.un.org/goals/goal6). Thus, governments are obliged by international law to ensure that their citizens have access to water and sanitation.

They must be available to all communities, regardless of circumstances. This is becoming increasingly challenging because of climate change, with low-income and other vulnerable communities facing disproportionate challenges in accessing water and sanitation. Policymakers must listen to the concerns of vulnerable communities in different types of circumstances, so that they can address the needs of these communities. Information about water safety and access must be issued regularly, along with early warnings for floods and droughts. A multisectoral approach is needed for IWRM, which includes the private sector, to prevent risks associated with industrial processes (R4ACCHC, 2023).

Facilitate access to water from recycled and alternative sources

Since water is a public good, local and national governments must be involved in providing households with access to water from various sources, while keeping the population adequately informed about the level of safety of each source. The provision of safe drinking water to all must remain a government priority, and the general population should be kept informed of ways to sanitise water from sources other than government pipes as necessary. Recycled water can be shared between sectors to be used in production processes, with adequate safety measures in place. Technical assistance may be needed to help governments optimise their adaptation strategies. The Food and Agriculture Organization of the United Nations has developed a tool to help governments establish where to locate structures for rainwater harvesting. It is also exploring the possibility of developing urban agriculture, including vertical gardens, which will use less land and water than conventional agriculture. Aquaculture can also reduce the need for land and irrigation (Buenfil, 2021). The Pan American Health Organization (PAHO) has included water conservation and rainwater harvesting strategies in its Smart Health Facilities initiative (Hassan, 2021; PAHO, n.d., 2013).

Develop disaster preparedness strategies for droughts

Caribbean disaster risk management efforts have focused mainly on floods and storms, so drought strategies tend to lack effective governance and adequate human resources and funds, and the national coordination, policymaking and planning in place are relatively poor and unable to deal with droughts effectively (CIMH and Land and Water Division of FAO, 2016). Drought is one of the issues that should be addressed by IWRM planning and policy (Cashman, 2014; Cashman et al., 2010; UNEP, 2012).

Strengthen waste management in advance of extreme weather events

Waste management before the wet or hurricane season is a key intervention for disaster resilience (R4ACCHC, 2023). If potential water receptacles are covered or adequately disposed of (e.g. plastic bottles, tires), the potential for mosquito proliferation in the event of flooding or a hurricane will be lower (Medlock, 2021). Community clean-up drives can assist in removing waste that may become hazardous by presenting an injury or sanitation risk. Drains, rivers and other waterways should be cleaned regularly, especially given the practice of dumping major solid waste items, such as fridges, into river courses.

Develop climate-resilient water and sanitation infrastructure

Existing infrastructure is very vulnerable to hurricanes. In mountainous terrain, vital pipelines are often built into bridges, making them vulnerable to damage from raging torrents that damage the bridges themselves. Caribbean governments are facing increasing costs of using stronger materials to construct pipes and reinforce them. In Dominica, the main water pipeline for the capital city of Roseau was rebuilt underground after it was damaged during Hurricane Maria.

It is clear that much of the existing water and sanitation infrastructure is not fit for purpose, since in several Caribbean countries more than half of piped water leaks away before reaching consumers. Routine maintenance **and** breakage repair are needed at a bare minimum (R4ACCHC, 2023). Going beyond these, extra funds and technical expertise are needed to make the most of existing and new technologies. The process of upgrading

WASH infrastructure can take considerable time and is hampered by lack of adequate monitoring systems to pinpoint the problems. Development partners and the private sector can make useful contributions to efforts to strengthen WASH infrastructure and information systems. The Green Climate Fund is contributing to some water infrastructure development projects (Cashman, 2021).

Infrastructure such as roadside and pipe drainage should be expanded to accommodate greater volumes of water. There is also a need to control the sources of flooding to slow the flow of water (such as increasing the capacity of rivers to contain high discharge [heavy rainfall] events). Furthermore, nature-based solutions, such as improving soil cover with plants to reduce water pollution and run-off, and diverting high water flows into natural water storage areas, can reduce the volume of floodwater (Asian Development Bank, 2022; Environment Agency, 2023). Guidelines on nature-based solutions should be developed for the Caribbean. Guidelines on vector control should be expanded to include potential breeding sites underground (such as cisterns and pipes) and brackish water (Mavian et al., 2018). Public health regulations on water storage should be developed and reinforced (Lowe et al., 2020).

Insurance providers should subsidise the development of infrastructure to ensure that it can be repaired in the event of disaster (CARPHA, 2018; Harewood, 2021).

Decentralise sanitation services to ensure post-disaster access

As experienced in Dominica following Hurricane Maria, roads and bridges can be destroyed by hurricanes, making it impossible for garbage trucks and other vehicles and equipment to reach communities. Thus, regular refuse collection services are disrupted at a time of great need, and it is very difficult to remove the debris. It is important to station equipment, vehicles and dumps strategically in various parts of the country, while observing measures to avoid contamination of water sources and agricultural sites with waste (Allen et al., 2019a; Harewood, 2021). The Dominica Solid Waste Management Company introduced measures to station garbage trucks and establish dumps in various parts of the island, following the experience of roads and bridges being damaged by Hurricane Maria and vehicles being prevented from reaching areas outside the capital, where they were stationed at that time (Allen et al., 2019a; CARPHA, 2018). Water, solid waste and debris management plans should be integral parts of disaster preparedness and response plans (Harewood, 2021). Adaptation measures include locating vehicles and equipment in areas less prone to flooding and other sorts of damage from extreme events.

Provide water, sanitation and hygiene infrastructure and services to all populations

Efforts must be made to provide adequate water and sanitation infrastructure and services (such as refuse removal and water pipes) to all types of accommodation and surrounding roads and landscapes. Support should be provided for the maintenance of water storage and sewage systems. When developing policies and interventions, the need for these services among the following vulnerable populations should be at the forefront of considerations: poorer communities, urban populations, squatter communities, indigenous communities, and women, children and people with disabilities (Medlock, 2021).

Develop human resources and access to technologies to improve water, sanitation and hygiene

There is a need to increase expertise in the Caribbean population in areas such as plumbing, hydroengineering and water quality assessment. Members of the public could be trained in basic plumbing skills, which could assist in reducing leakage and increasing the efficiency of water systems at the household level. However, the emphasis must be on improving public works and addressing deficiencies in infrastructure and water safety (R4ACCHC, 2023).

Research gaps and how to address them

Conduct research on how climate change is affecting the biological and chemical composition of water sources

Environmental research and monitoring should be conducted to assess how climate change factors such as increased ambient temperatures and coastal and other flooding affect the biological and chemical composition of water sources. This includes assessing the microorganism profile of water and chemicals, such as antibiotics, that may enter the water supply. There is also a need for better understanding of how ingesting water that is polluted as a result of climate change can affect health via its impact on the body's microbiome, chemical balance and immunity (R4ACCHC, 2022b, 2023).

Conduct research on how floods and droughts are affecting the agriculture sector and food safety and security

Scarcity, unpredictability and safety of water supplies can have major impacts on the agriculture sector and on food safety and security. Governments should be partners in research to identify and track the impacts of water-related hazards on the local agriculture sector (R4ACCHC, 2023).

Improve prediction models for waterborne infections

Research is needed on how meteorological and climatic factors interact with nonclimate drivers in the spread, distribution and incidence of waterborne infections, including leptospirosis, a range of diarrhoeal diseases (including cholera) and noncholera *Vibrio*. Nonclimate drivers include pathogen evolution, human susceptibility to infection, ecosystem change, level of economic development, water and land use (e.g. dams, deforestation), urbanisation, human behavioural factors, level of public health infrastructure and level of WASH infrastructure. This research can inform national and regional prevention and control policies, adaptation measures, the targeting of resources and the development of early warning systems (EWSs).

Conduct research on community and industrial water and waste management practices

It is important to study water management (including wastewater management, water safety practices, use of water for produce irrigation, rainwater harvesting and desalination) and sanitation and conservation practices (Allen, 2021). Research should be conducted at the local community level and within industries, including agriculture, extraction, processing, manufacturing and tourism. Water use should be appraised to identify wasteful and polluting practices and develop solutions.

Conduct practical research projects to explore integrated water resource management solutions for local communities

Communities and NGOs should be supported in developing IWRM plans that follow good-practice guidelines, and in implementing, monitoring and evaluating them. They also should be supported in disseminating the results of their research so that other communities can learn from their experiences. Experts in IWRM and civil society organisations should collaborate in this research and establish links with government water and sewage agencies to develop and implement solutions.

Conduct research on water wastage, recycling and technologies to reduce water scarcity/insecurity

The following three topics should be researched to enable more sustainable water solutions (Dubrow, 2021):

- The impact of water wastage on water scarcity/insecurity;
- Technical and behavioural issues with rainwater harvesting and wastewater reuse;
- Technologies to address water scarcity/insecurity.

Civil society organisations and WASH experts should collaborate on the first two of these. WASH experts should collaborate with other scientists and higher education institutions in the Caribbean to address the third. Research on these topics should be supplemented by operational research, involving governments among the stakeholders and economists among the experts, to work out feasible and cost-effective ways to roll out the recommendations.

Include water, sanitation and hygiene in research to develop disaster preparedness and response strategies

Water and sanitation are critical utilities and should be included in integrated risk management research to develop strategies to bolster their resilience in the face of extreme weather events and other disasters (Harewood, 2021). Existing strategies to maintain and bolster the resilience of infrastructure must be critically examined to identify weaknesses and gaps in existing services and how they are affected during extreme events. WASH experts, including civil engineers and public health inspectors, should be involved in this research. Again, operational research is needed to identify feasible and cost-effective ways to roll out the recommendations. A useful component of disaster preparedness research would be to explore atmospheric water generation technologies for the provision of potable water at shelters.

Surveillance gaps and how to address them

Develop water and sanitation infrastructure monitoring systems and data

Caribbean governments struggle to maintain and develop water and sanitation systems that are fit for purpose, partly because they lack diagnostic and monitoring capacity (Cashman, 2021). Major investments should be made in developing an information system in each country that clearly identifies the locations and causes of leaks, contamination and other issues, and records how and when they were addressed. Records should be kept of issues raised in public complaints and how they were addressed. Resources and skills in managing information systems should be developed, so that information can be shared regularly with all stakeholders to enable evidence-based policy decisions. Electronic information systems should be developed to facilitate data-sharing.

The development of such information systems is essential for providing data that can be used in research projects that explore associations between WASH infrastructure availability and quality and health outcomes.

Monitor waterborne and vector-borne disease outbreaks and water pollution, with a focus on the outcomes of extreme events

There is a critical need to strengthen the reporting of waterborne and vector-borne diseases and to establish systems to monitor pollution of water sources, including harmful algal blooms. This need will increase as water becomes scarcer and temperatures increase further. Temporally and spatially granular data are needed to establish EWSs, pinpoint areas and communities at risk, and respond to outbreaks on a timely basis.

Research and surveillance capacity-strengthening needs

To address the profound infrastructural and societal issues surrounding WASH, a stakeholder analysis is needed at the beginning of each research project and surveillance-strengthening initiative, listing those most affected and the range of experts and government agencies that need to be involved in developing and rolling out the solutions. Technical expertise alone will not address the challenges, since cooperation and collaboration with civil society, national governments and regional agencies are essential. Regional agencies that should be involved include the Caribbean Disaster Emergency Management Agency, the Caribbean Public Health Agency, PAHO and the University of the West Indies. National universities should also be involved. Data-sharing agreements should be developed.

Caribbean expertise may be supplemented and enhanced by technical support, training and research collaboration with international agencies and universities in areas such as (Harewood, 2021):

- Information systems;
- Epidemiology;
- Gastroenterology;
- Toxicology;
- Parasitology;
- Behavioural science;
- Civil engineering;
- Land surveying;
- IWRM;
- Integrated risk management;
- Emergency management;
- Mixed methods approaches to quantify and document the extent of waterborne and vector-borne diseases.

Investment in information technology infrastructure is very important for enabling the necessary information flows and level of detail needed for epidemiological and environmental reporting.

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4. NONCOMMUNICABLE DISEASES AND RISK FACTORS

4.1. WHAT IS HAPPENING?

Since the beginning of the twenty-first century, noncommunicable diseases (NCDs) have accounted for approximately 75% of all deaths in the English- and Dutch-speaking Caribbean. The three leading causes of death are cerebrovascular disease, diabetes and ischaemic heart disease (CARPHA, 2017, 2020).

Higher temperatures associated with climate change can cause a number of NCD-related health difficulties. The human cardiopulmonary system is sensitive to changes in temperature. Viscosity of blood increases when temperatures are higher, which can lead to high blood pressure and heart rate – known risk factors for cardiovascular disease events such as heart attacks, strokes and other vascular events. Concurrent acute and chronic respiratory conditions can be aggravated by temperature changes, which can cause constriction of the bronchial tubes (Ebi et al., 2006; Kjellstrom et al., 2010; McMichael et al., 2003). Dehydration caused by exposure to high temperatures can cause kidney stones or acute kidney failure.

Higher temperatures can result in less outdoor physical activity, contributing to increased NCD incidence. Increasing minimum temperatures, which interfere with overnight recovery from heat stress in vulnerable people living with NCDs, may exacerbate NCDs. Adults who suffer from preexisting cardiovascular and pulmonary disease, the elderly, children and outdoor workers are particularly vulnerable to increased air temperatures. People living in cities are subject to the “urban heat island effect”, which further multiplies the effects of hotter weather (Campbell-Lendrum and Corvalán, 2007). Older people, among whom there is a higher prevalence of NCDs, are particularly vulnerable to higher ambient air temperatures, which can result in cognitive impairments (Yi et al., 2021).

Extreme weather events and increased ambient air temperatures have been found to increase mortality and morbidity among people with underlying heart disease or diabetes (Evans et al., 1993; Martinez-Lozano et al., 2021; R4ACCHC, 2023a; Zilbermint, 2020). It has been demonstrated that vasodilation, which allows people to adapt to high or low temperatures, is severely compromised in older populations and people with diabetes. Some medication taken by people with NCDs affect their thermoregulation capacity, thus preventing the ability to transfer heat from the body to the environment (Xu et al., 2019).

Longer term degradation of local fisheries and the agriculture sector due to climate change may result in increased dependence on imported high-calorie, high-sodium, high-sugar, low-micronutrient processed foods, contributing to increased NCD incidence and the exacerbation of existing cases. Extreme weather events can also reduce access to nutritious foods for months or even years, thus perpetuating dependence on unhealthy imported foods. For example, in 2017 Hurricane Maria caused the loss of 100% of crops in Dominica (Buenfil, 2021; CARPHA, 2018; Dubrow, 2021; Gordon-Strachan, 2021).

Increased episodes of asthma and chronic respiratory disease can be caused by degradation of air quality associated with climate change. For instance, fires and smoke are associated with hotter weather and drought, and the toxicity of emissions from vehicles is exacerbated in hot weather. Dust from damaged infrastructure and trees, the burning of debris following a hurricane and the Saharan dust that blows across the Atlantic Ocean can lead to further air pollution (Allen et al., 2019; Akpinar-Elci et al., 2015; Cadelis et al., 2014; Hambleton, 2008). See Chapter 5, “Air quality”.

Extreme weather events also put a strain on the running of, and access to, health facilities and healthcare services. High winds associated with hurricanes may lead to power outages affecting essential services, including refrigeration for the storage of medication. Other technologies, such as dialysis machines and radiotherapy treatment for cancer patients, may also be compromised. Roads are often blocked by fallen trees, landslides or flooding, thus preventing patients from reaching health facilities (CARPHA, 2018; Martinez-Lozano et al., 2021; Ryan et al., 2015). Other challenges include problems accessing remote medical advice due to telephone and internet outages, and reliance on ad hoc volunteers and external assistance (Cruz-Cano and Mead, 2019; Hassan et al., 2020; Joshipura, 2021).

Surveillance data on select health conditions, including some NCDs, are collected at the national level by health ministries. These include mortality data on diabetes, cerebrovascular disease, ischaemic heart disease, other cardiovascular diseases, hypertensive heart disease and malignant neoplasms. The Caribbean Public Health Agency (CARPHA), the Pan American Health Organization (PAHO) and the Caribbean Institute for Meteorology and Hydrology (CIMH) produce a quarterly Caribbean Health Climatic Bulletin, which includes advice for people with specific conditions. The Caribbean Institute for Health Research (CAIHR) at the University of the West Indies (UWI) in Jamaica has established a climate and health observatory to examine the linkages between weather and health. This will include examining retrospective data on hospital admissions of patients with cardiovascular diseases and other chronic diseases. Projections will also be made to provide early warnings. Chronic disease registries are currently being set up in several Caribbean countries. CAIHR is also working with the George Alleyne Chronic Disease Research Centre (GA-CDRC) to analyse associations between climate change and strokes by using data from the Barbados National Stroke Registry (Allen et al., 2021).

Limited studies of climate and health relating to NCDs have been conducted in the Caribbean. One area of study has been the relationship between asthma incidence and increased dust, including Saharan dust (Akpinar-Elci et al., 2015; Cadelis et al., 2014; Hambleton, 2008; Prospero et al., 2008). These studies are detailed in Chapter 5, “Air quality”.

The incidence of diabetes may have increased in Puerto Rico following Hurricanes Irma and Maria. People with diabetes also experienced difficulties in obtaining their medication and accessing health care after these hurricanes, but one study showed that this did not result in a significant increase in average blood glucose levels or uncontrolled diabetes (Martinez-Lozano et al., 2021). In the United States Virgin Islands, it was found that surges in the incidence of childhood type 1 diabetes occurred in 1984 and 2005, when there was unusually high rainfall with lower than normal temperatures (Tull and Yarandi, 2017). Other climatic changes such as extreme weather events and rising temperatures were also demonstrated to be risk factors for mortality and morbidity among people living with diabetes, especially those with cardiovascular complications (Zilbermint, 2020).

Institutional capacity for NCD research is strong in the Caribbean, but climate change has not been firmly integrated into NCD research programmes and projects. CAIHR at UWI has conducted substantial research on NCDs and has a dedicated research centre, the GA-CDRC. This centre has conducted research on food systems and security and the prevention of NCDs in the political and economic contexts. The Windward Islands Research and Education Foundation (WINDREF) has conducted research on the management of NCDs (Allen et al., 2021), but only a very small portion of this research has looked specifically at climatic factors affecting NCD risk.

4.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Increase knowledge of risks and their management pre- and post-disaster among people living with noncommunicable diseases

In the immediate aftermath of an extreme event such as a hurricane, access to health services, transport and refrigeration for medical supplies, and the availability of clean water and nutritious food can be substantially reduced. Therefore, it is vital that people living with NCDs, vulnerable populations such as the elderly and people with disabilities, and people at risk of developing NCDs know how to manage their condition and mitigate the risk of developing NCDs in the future. They should also be provided with information on emergency measures that are in place locally (as per the recommendations below) to enable them to access medication, medical care and nutritious food (Hassan et al., 2020; Kim and Hassan, 2021; R4ACCHC, 2023b). Tailored communication strategies should be developed, including strategies employing sign language and braille materials.

Develop climate and health information tailored to reducing risks related to noncommunicable diseases in the context of climate change

Information and health communication products on the climate-related risks specific to each NCD should be developed. For example, fact sheets can be developed for people with congestive heart failure on the risks associated with heat, air quality and extreme weather events, and how to reduce these risks.

Civil society organisations can play a critical role in developing communication products based on the lived experience of people living with NCDs and communicating the information directly to vulnerable communities such as indigenous people and people with disabilities. For instance, fact sheets on diabetes and climate change can be created, with information on the specific climate-related risks facing people living with diabetes and how to reduce them. Levels of education, age and cultural issues such as religion and language need to be taken into consideration when developing knowledge products. Dissemination can be sector specific. For example, the Caribbean Hotel and Tourism Association could disseminate NCD-specific climate and health information to its members through webinars. Different working groups could be created for different communities/sectors to lead on the development of such information. The media and other communication specialists should be involved (R4ACCHC, 2022a,b, 2023c).

These information products can be further adapted to take account of gender- and age-specific risks. The WHO STEPwise approach to NCD risk factor surveillance surveys in 14 Caribbean countries and territories[1] found major differences between genders in terms of NCD risk: men were more physically active and more likely to have high blood pressure and/or smoke, whereas women were more likely to be overweight or obese (although there were high rates of overweight and obesity among both sexes). The different physiology of men, women and older people affects their physical reactions to climate-related factors, such as extreme heat and changes in the supply of nutritious food. It is important to develop tailored health-promotion programmes based on knowledge of the susceptibilities of both sexes and older people to climate stressors, taking account of both lifestyle factors (e.g. exercise types and levels) and physiological differences (CARPHA, 2020).

[1]Countries that have conducted the WHO STEPwise survey or equivalent: Anguilla, Aruba, the Bahamas, Barbados, Bermuda, British Virgin Islands, Cayman Islands, Dominica, Grenada, Guyana, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

Structural/governmental and private sector actions

Train healthcare professionals on the links between climate change and noncommunicable diseases, and the management of health care following extreme events

Medical professionals need to be trained on the health impacts of environmental factors affected by climate change, such as air pollution and water quality, on NCDs as part of their regular learning curriculum. During training, special attention should be given to delivering medical response to people living with NCDs following extreme events and integrating NCDs into disaster preparedness. This training can be carried out in collaboration with national and regional academic institutions (R4ACCHC, 2023c).

Include management of noncommunicable diseases in national disaster preparedness and recovery plans

An island-wide survey in Puerto Rico following Hurricane Maria in 2017 found that many people had disrupted access to health care due to factors such as inability to obtain medicines, inability to use respiration equipment, damaged roads and other barriers to transportation, closed facilities and unavailability of doctors. This helped to explain why the number of deaths in Puerto Rico during the three and one-half months following the hurricane was 62% higher than during the same period in the previous year (Kishore et al., 2018). It is believed that 37% of excess deaths in the two months after Maria were due to complications from heart disease and diabetes (Cruz-Cano and Mead, 2019).

Strategies to address these challenges include the following:

- Ensure access to adequate supplies of commonly used medications through a centralised pharmacy registry; raise awareness of locations where medication will be available; increase the use of pharmacies as medication and supply distribution centres, and the availability of pharmacists to distribute them; and provide a list of alternative medications that patients could use if they are unable to get their usual prescriptions.
- Communicate with people living with NCDs before and after an extreme event to ensure that they have information on how to obtain medical care and supplies. People living with NCDs should be provided with access to and/or advice on forms of communication able to withstand extreme events, so that they are able to obtain information after an extreme event even if the electricity supply and/or internet connection have been disrupted. For instance, they can obtain radios and batteries and be advised on which channels to tune into; public health personnel may need to visit people living with NCDs in person or communicate with communities via loudhailer/loudspeaker (R4ACCHC, 2023b,c).
- Include guidance on the management of people living with NCDs and their access to medication and food in protocols for hurricane shelters (CARPHA, 2018; Hassan et al., 2020; R4ACCHC, 2022c).

It is important to use an inclusive and “all-of-society” approach when developing these plans and to include people from the government ministries responsible for the environment, local government, works and transport, communications, finance and, of course, health. People on the ground can contribute to the design of approaches that are appropriate and effective in their circumstances. Therefore, it is important to include community leaders, workers and local businesses, and also young people, older people, indigenous people, religious communities and migrants. In addition, people living with NCDs and the civil society organisations that represent them must be involved in developing those Ps of plans relating to the health and well-being of people living with NCDs, pre- and post-extreme events. It is necessary to build capacity to develop such plans, particularly at the community level (R4ACCHC, 2023c). The World Diabetes Foundation has supported the Organisation of Eastern Caribbean States (OECS) to develop a project that will address and mitigate risks from natural disasters and the subsequent disruption of health care for people with diabetes and other NCDs (see Box 1).

Box 1: Mitigating the risks from natural disasters and the subsequent disruption of health care for people living with noncommunicable diseases

In 2019, the OECS, through its health unit and the health ministries of its Member States, received funding to implement the "Diabetes in Disasters in Eastern Caribbean Island States" project. Its partners include CARPHA and WINDREF. This project aims to address and mitigate the risks from natural disasters and the post-disaster disruption of health care for people with diabetes and other NCDs. The project is ongoing. Activities have included (World Diabetes Foundation, n.d.):

- Establishing a project steering committee consisting of health authorities and other key local/regional stakeholders from all participating Member States;
- Assessing health outcomes for people with diabetes/NCDs for the two years following the 2017 Hurricanes Irma and Maria using existing records with clinical indicators;
- Using video documentation of the initial health system response and lessons learned as a regional advocacy tool;
- Training healthcare professionals in disaster preparedness and response for vulnerable people with diabetes/NCDs;
- Updating national and regional response plans and shelter management tools to include response to vulnerable people with diabetes/NCDs;
- Establishing patient registers (integrated with existing health management information systems) with clinical indicators for improved disaster preparation and response;
- Developing and piloting a new OECS electronic patient record in two selected island states to improve continuity of care for patients moving within or outside the region following a natural disaster.

Source: World Diabetes Foundation (n.d.).

Use World Health Organization noncommunicable disease kits in the aftermath of a natural disaster

The World Health Organization (WHO) has developed NCD kits (NCDKs) to be used in the aftermath of natural disasters. Each kit has sufficient supplies to support the care of up to 10 000 people living with NCDs for three months. The kit includes oral medicines, basic diagnostic equipment, restocking supplies for single use items, products requiring refrigerated transport and storage (i.e., "cold chain") such as insulin and accompanying treatment guidelines. Only medicines in the WHO Model List of Essential Medicines are included. There are five different modules within each kit. The modules can be ordered separately depending on need, available resources and logistics in the field. The modules are as follows (WHO, 2017):

- Module 1 – medicines only, not including cold-chain insulin (for 10 000 people lasting three months);
- Module 2 – cold-chain medicines only, including insulin (for 10 000 people lasting three months; requires availability of an adequate cold chain);
- Module 3 – items including plasters, gloves, cotton wool, urinary test strips, disinfectant swabs (for 10 000 people lasting three months);
- Module 4 – supplies, e.g. blood lancets, needles, blood test strips, valve mouth pieces, batteries (for the equipment in Module 5);
- Module 5 – equipment, e.g. blood glucose monitors, stethoscope, sphygmomanometer, otoscope and ophthalmoscope set, batteries, thermometer (can last longer than three months).

In 2020, key Caribbean stakeholders were interviewed about the NCDKs and indicated that they were acceptable and that it was feasible to use them to assist people with NCDs following extreme events. Stakeholders underlined the need for integrated work between disaster response agencies and agencies caring for people with NCDs, and the need to consider the logistics of training, storage, distribution, cost-sharing and redistribution of unused medication (Hassan et al., 2021).

Develop and implement communication and other tools for disaster preparedness for people living with noncommunicable diseases

Tools to facilitate disaster preparedness among people living with NCDs should be developed and implemented in the Caribbean (R4ACCHC, 2023b). The approach and checklist of the Juvenile Diabetes Research Foundation and the Diabetes Disaster Response Coalition of the United States of America can be adapted by individual countries or regionally for various NCDs. The Juvenile Diabetes Research Foundation and the Diabetes Disaster Response Coalition collaborated to form the Diabetes Disaster Relief Coalition, which ensures that people with diabetes have support, sufficient insulin and sufficient supplies before a major storm or hurricane. This coalition created a "patients' preparedness plan", which includes a disaster preparation emergency checklist, and also created information resources on how to locate a shelter, discard sharps, request diabetes care in an emergency or disaster and store insulin safely (JDRF, n.d.; Zilbermint, 2020). While this information improves individual-level preparedness, its dissemination in an organised and effective way requires national and regional reach. This approach can be either a civil-led initiative as in the United States of America or government-led as in the case of the Diabetes in Disasters in Eastern Caribbean Island States project coordinated by ministries of health in OECS Member States (World Diabetes Foundation, n.d.).

Address the main risk factors for noncommunicable diseases

Addressing the main risk factors for NCDs can reduce the burden of poorly managed NCDs and the prevalence of NCDs. This will, in turn, reduce the impact of climate change on health. Since the 2007 Declaration of Port of Spain, "Uniting to Stop the Epidemic of Chronic NCDs" (CARICOM, 2007), Caribbean governments have been involved in setting up mechanisms such as national NCD commissions and implementing strategies for prevention and control of NCDs, including addressing the main risk factors.

The main risk factors for NCDs include alcohol consumption; smoking tobacco; physical inactivity; poor nutritional habits, including diets high in salt, sugar and fat and low in fresh fruits and vegetables; and being overweight or obese. Dependency on food imports, many of which are high in sugar and fat, is one of the factors that place people in SIDS at risk of NCDs in the context of climate change (see Chapter 12, "Agriculture and food safety and security", for more information) (R4ACCHC, 2022d). Several Caribbean countries have sought to reduce diet-related risks by implementing taxes on sugar-sweetened beverages (e.g. Antigua and Barbuda, and Barbados) (R4ACCHC, 2022b), and efforts are under way to provide front-of-packaging warning labels on processed food products to notify consumers of dietary ingredients that can increase the risk of NCDs, with the Healthy Caribbean Coalition providing assistance to several Caribbean countries (HCC, 2021; R4ACCHC, 2023c). All Caribbean countries should sign up to the WHO Framework Convention on Tobacco Control, one of the world's most adopted international treaties (WHO, 2003). In the context of climate change, it is particularly important to implement these types of measures to address risk factors.

It is important to recognise that some actions to promote healthier lifestyles have co-benefits for climate change mitigation and adaptation, such as the provision of additional green spaces, more shaded pathways to promote physical activity (R4ACCHC, 2022b) and the promotion of less meat consumption. Chapters 15, "Climate-friendly health-promoting infrastructure", and 5, "Air quality", include further details of climate change mitigation measures with health co-benefits relating to NCDs.

Research gaps and how to address them

Evaluate the impact of disaster preparedness on noncommunicable disease outcomes and develop evidence-based strategies to reduce the impact of disasters on noncommunicable diseases

There are associations between hurricane preparedness and the impact of hurricanes on health. In a study in Puerto Rico following Hurricane Maria that involved people who were obese, overweight and/or had diabetes, those who were prepared to a low to medium level were twice as likely to suffer harmful health impacts than people who were highly prepared. Furthermore, people whose diet changed as a result of power outages, financial challenges and/or disruption to their drinking water supply were significantly more likely to experience detrimental health impacts (Joshipura, 2021). Similar studies with people living with NCDs could be conducted in the wake of other extreme events. Such studies should compare the cost of the health impacts in cases when there is no preparedness with cases of different levels of preparedness (Zilbermint, 2020). Results from these evaluations should be used to inform the development of evidence-based strategies at the individual, community, health system and policy levels to reduce the impact of disasters on NCDs.

Conduct studies to develop evidence-based strategies to reduce disruptions to healthcare service access in the event of a climate-induced disaster

- Document the effect of disasters on access to healthcare systems. Example research questions:
    - To what extent do people living on dialysis miss their scheduled days for dialysis?
    - What proportion of people living with diabetes or cardiovascular disease have had their medication interrupted, for how long and why (e.g. displaced from their homes without taking their medication with them; pharmacies closed; no access to physicians to get their prescriptions)?
- Understand the effectiveness of existing emergency preparedness planning and smart health facilities in improving access to healthcare services in the event of a climate-induced disaster. Example research question:
    - How does lack of emergency power and water at healthcare facilities affect access to care?
- Develop evidence-based strategies that improve access to healthcare services in the event of a disaster.
- Use outputs from the studies suggested above to inform future strategies that improve the resilience of the healthcare system.

Identify the impact of environmental determinants on people living with noncommunicable diseases

The ways we manage (or mismanage) natural resources and the built environment, and social/economic exclusion, are largely responsible for the health outcomes of climate change and how they are distributed. Further studies are needed on the impact of various environmental practices on the risk of developing NCDs and morbidity among people living with NCDs. Studies should examine exposure to NCD risks linked to practices in key sectors, including agriculture, forestry, fisheries, construction, sanitation, transport, and land ownership and use. Monitoring data on practices in these sectors is needed, including levels of organic and inorganic pollutants they release into the air, soil and water (Allen, 2021; R4ACCHC, 2023c).

After extreme events, it is particularly important to monitor the impact of disruption to essential services, including health, sanitation, water, communication, transport and electricity, on the health of people living with NCDs. Service disruption tends to coincide with further environmental stressors following extreme events, such as a subsequent extreme event (e.g. extreme heat following a hurricane), mould exposure and air pollution (CARPHA, 2018). After Hurricanes Irma and Maria struck Puerto Rico, environmental factors such as wind, water, heat, air pollution, noise pollution and mosquitoes were found to be highly challenging for women with gynaecological cancers (Méndez-Lázaro et al., 2021). Being aware of these stressors can assist with pre- and post-disaster plans, to mitigate morbidity and assist with supporting well-being, including mental recovery.

Determine the effectiveness of actions at the individual, community, structural/government and private sector levels

Actions need to be evaluated to ensure that they are effective. Evaluations may be of process, impact and/or cost-effectiveness. Determining the barriers to and the facilitators of implementing suggested actions would also be helpful in making recommendations for the way forward. Research questions could include the following:

- As a result of increased public awareness through communication strategies prior to an extreme weather event, were people living with NCDs able to access medication, medical care and nutritious food after the event?
- Are there sufficient numbers of healthcare professionals trained in emergency response and preparing people living with NCDs for disasters? Are there sufficient first responders trained in the emergency management of people living with NCDs? What are the barriers to and facilitators of responding to the needs of people living with NCDs in the disaster setting?
- Was an all-of-society approach used when including pre- and post-disaster management of NCDs in national disaster preparedness and recovery plans?
- Were the NCDKs distributed efficiently and available to the population in need, pre and post disaster?
    - Were sufficient numbers of personnel trained to assist with use of the NCDKs pre and post disaster?
    - What were the barriers to and facilitators of implementing the NCDKs?
- After a national weather event, was the shelter management tool for people living with NCDs cost-effective?

Surveillance gaps and how to address them

Create national and local noncommunicable disease registries

To provide assistance after an extreme weather event, it is necessary to be able to locate people living with NCDs. Information of the type of NCD, its burden and the distribution of the disease also needs to be captured. Known people living with NCDs and those at high risk of developing an NCD should also be documented at the local level (Hassan et al., 2020). Registries should be updated annually, especially prior to hurricane season.

Monitor the association between climate and severe weather and noncommunicable disease events

Incidence figures on new cases of NCDs (especially those that show acute manifestations such as stroke and acute myocardial infarction) and exacerbation of NCDs (e.g. emergency department visits among asthma and chronic kidney disease patients) can be monitored alongside climate and weather and air pollution data showing, for instance, precipitation, temperature and fine particulate matter levels. Tests of association between these data can help identify important climate-related risk factors for NCDs and for exacerbation of NCDs and assist in the development of early warning systems (EWSs) and other prevention and treatment interventions. EWSs assist in risk predication and generation of disease vulnerability maps, which in turn enables more efficient allocation of public health resources (Hassan, 2021).

Research and surveillance capacity-strengthening needs

Capacity needs to be strengthened in the realm of climate and NCDs, as does NCD surveillance, to successfully address the aforementioned research questions and gaps. This includes strengthening capacity in implementation science, qualitative and mixed methods research, and advanced statistical methodologies.

Capacity needs to be strengthened to form new, and strengthen existing, collaborations and partnerships across disciplines invested in climate and health (R4ACCHC, 2023c). Health information systems, and capacity to house such systems, are key to research and surveillance. CAIHR at UWI in Jamaica has initiated a climate and health observatory to examine the linkages between weather and health, including NCDs. To create such an observatory, tailored information technology systems within CAIHR and partner institutions such as the University Hospital of the West Indies and Bustamante Hospital for Children should be designed and implemented. Since this observatory is expected to operate at the regional level, such collaborations must be formalised between regional agencies that collect both health data, such as CARPHA and GA-CDRC, and meteorological data, such CIMH. Even though there are some national partnerships that feed into regional entities (e.g. national ministries of health that report certain diseases and syndromes to CARPHA), further collaborations to report climate-related health conditions, such as heat-related illnesses and conditions caused by air pollution, must be strengthened.

A surveillance system that captures climate- and health-related injuries, conditions and diseases at the level of national health facilities would provide useful information for forecasting and planning the health workforce, medication and other health system needs in general, and for people living with NCDs specifically. Again, there must be strong collaboration between national hospitals and clinics and meteorological agencies. Strengthening of electronic record systems will be crucial in this regard.

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5. AIR QUALITY

5.1. WHAT IS HAPPENING?

The burden of disease attributable to air pollution is now estimated to be on a par with other major global health risks such as unhealthy diets and tobacco-smoking. In 2015, the World Health Assembly adopted a resolution on air quality and health. The resolution recognises air pollution as a risk factor for noncommunicable diseases (NCDs) such as ischaemic heart disease, stroke, chronic obstructive pulmonary disease, asthma and cancer, as well as the economic impact of the toll air pollution takes on human health (WHO, 2021). Air pollution can also shorten survival in people with lung cancer (Eckel et al., 2016). It can contribute to the spread and aggravate the symptoms of communicable respiratory diseases such as COVID-19, as demonstrated in Latin American and Caribbean countries (Bolaño-Ortiz et al., 2020). People who are highly susceptible to illnesses resulting from air pollution include those with pre-existing respiratory or cardiovascular diseases, older people, infants and children. Outdoor workers are highly exposed (US Centers for Disease Control and Prevention, 2019). There is evidence that air pollution is a major cause of premature birth, low birthweight and stillbirth (Bekkar et al., 2020). Air pollution affects air quality, and food, water and economic security, both directly through its negative effects on public health, agriculture and ecosystems, and indirectly through its impact on the climate (Kumarsingh, 2021).

In this chapter, we mainly address toxic air pollutants. These have direct adverse effects on human health. We also touch on climate pollutants, most of which indirectly harm human health because they contribute to climate change, either as greenhouse gases (GHGs) or by absorption of solar radiation because they have low albedo.

Weather conditions influence the transportation, distribution and concentration of airborne pollutants. Climate change affects human exposure to air pollutants by:

- Changing weather patterns, which influence local and regional concentrations of pollutants;
- Changing human-made emissions, including through adaptive responses involving increased fuel combustion;
- Affecting natural sources of air pollutants;
- Changing the distribution, types and amounts of airborne allergens (Taylor et al., 2010);
- Causing wildfires (by exacerbating heat and drought), which emit particulate matter and other toxic air pollutants.

As an example of how climate change is affecting humans' exposure to air pollutants through an adaptive response, air conditioning (AC) is highly protective against heat-related mortality and morbidity, and its use is increasing as temperatures rise. This is increasing human-made GHG emissions and toxic air pollution from fossil fuels used to generate the electricity to power AC systems (unless alternative sources of energy are used). AC systems also use hydrofluorocarbons (HFCs), which are potent GHGs used for refrigeration, and which may escape into the atmosphere (Dubrow, 2021).

Anthropogenic GHG emissions are the main contributor to climate change, with the main climate pollutants being carbon dioxide, methane, nitrous oxide and fluorinated gases. Measures to reduce GHG emissions have health co-benefits because they also reduce toxic air pollutants, most notably ground-level ozone precursors and particulate matter emitted from burning fossil fuels (Kumarsingh, 2021). Such measures are detailed in Section 5.2, "What should be done?".

The main types of toxic air pollution of concern can be classified as follows:

- Particulate matter, including Saharan dust;
- Harmful chemicals and gases;
- Airborne organic matter, including pollen, mould, viruses, bacteria and small insects.

Often, more than one type of air pollution is present at the same time, and weather conditions such as extreme heat can magnify their negative impacts. Furthermore, natural phenomena can add to pollution. Examples are Saharan dust (discussed later in this subsection) and volcanic eruptions, such as the Soufrière Saint Vincent eruption of December 2020–April 2021. The ash plume from the volcanic explosion was blown eastwards and large quantities of ash fell on Barbados, causing respiratory problems among inhabitants and other challenges on this island and Saint Vincent and the Grenadines.

Particulate matter is a mixture of solid and liquid particles in the air that are small enough not to settle on the Earth's surface under the influence of gravity, and are classified according to their aerodynamic diameter (WHO, 2021). Health effects are strongly linked to particle size. Very small particles, with an aerodynamic diameter equal to or less than 2.5 µm ($PM_{2.5}$), are the most dangerous, as they can be inhaled deeply into the lungs and pass into the bloodstream. The inhalation of $PM_{2.5}$ is associated with lung and heart diseases, including heart attacks, the aggravation of chronic conditions such as asthma and bronchitis, and elevated all-cause mortality (Taylor et al., 2010; Xing et al., 2016). Long-term exposure is associated with an elevated risk of infant mortality, low birthweight, diabetes, dementia and death from lung cancer (American Lung Association, 2022; Liu et al., 2021). Large particles, with an aerodynamic diameter equal to or less than 10 µm (PM_{10}), can irritate the nose and eyes and increase rates of respiratory diseases (US Centers for Disease Control and Prevention, 2019).

In the Caribbean, key sources of particulate matter are bush and forest fires (increasing owing to rising temperatures), the burning of waste, the combustion of fossil fuels and Saharan dust. Fossil fuel use in transport is a major source of exposure in the Caribbean. The use of wood-burning stoves is a source of indoor exposure for some women on low incomes (WHO and UNFCCC, 2021). Following Hurricanes Irma and Maria in 2017, there was an increase in the incineration of waste because of the massive amount of debris resulting from damage to property and vegetation. In addition, there were delays in the removal of organic waste from homes due to damage to roadways. In Dominica, the disposal of downed trees by chopping and shredding released wood dust into the air. Dust may also increase because of construction to rebuild infrastructure damaged by severe weather events (Allen et al., 2019; CARPHA, 2018).

Saharan dust, a complex form of particulate matter containing both $PM_{2.5}$ and PM_{10}, is composed of organic and mineral matter, chemicals, and viruses and bacteria, has been blown across the Atlantic to the Caribbean for hundreds of years. It has some beneficial properties, contributing important nutrients to marine and terrestrial species (Mendez-Lazaro, 2021). It is predicted that increased atmospheric and sea surface temperatures may decrease wind speeds and the amount of Saharan dust that reaches the Caribbean, causing concern about biodiversity loss and damage to agriculture and fisheries (Kumarsingh, 2021). On the other hand, desertification in Africa, caused in part by climate change, may result in increased amounts of Saharan dust.

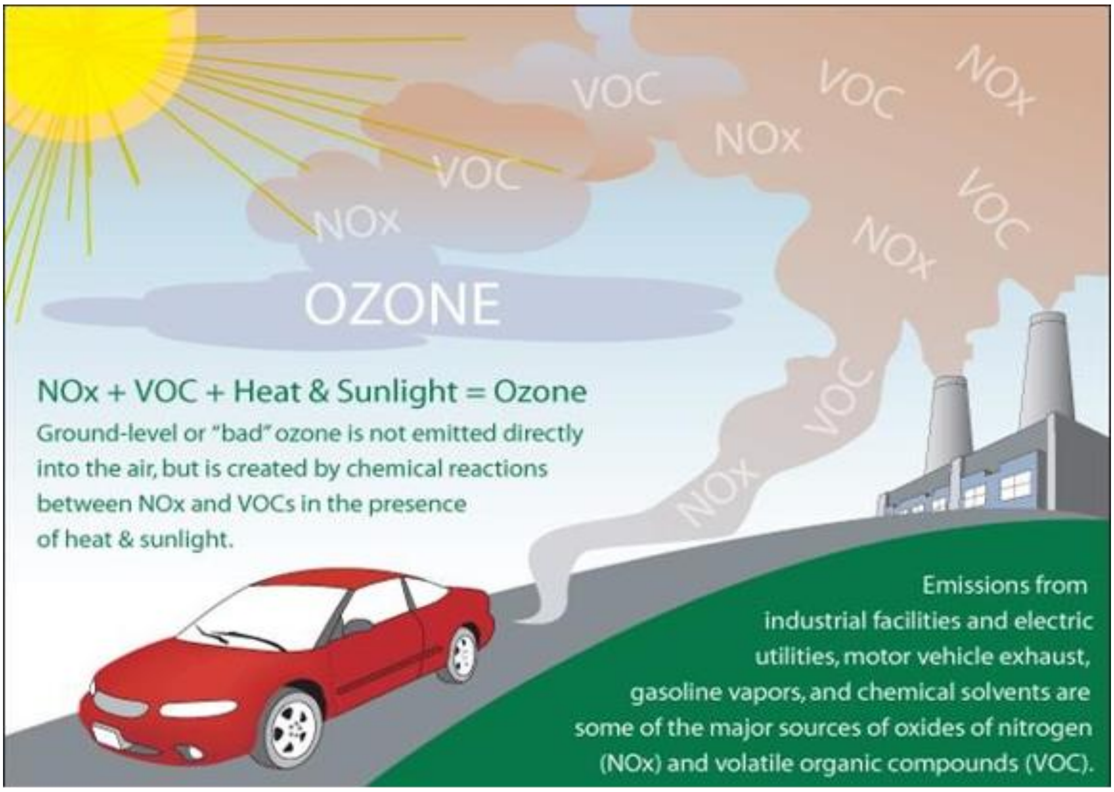
Several constituents of Saharan dust have negative health impacts, and PM_{10} concentrations have been found to exceed World Health Organization (WHO) guidelines at some times of the year (Sealy, 2021). A variety of chronic and acute conditions may result from exposure to Saharan dust (Mendez-Lazaro, 2021; Monteil and Antoine, 2009; Prospero et al., 2008, 2009, 2014). In the Caribbean, Saharan dust has been shown to be associated with seasonal allergies (with the vast majority of dust arriving between April and September), and health crises among people with asthma (Akpinar-Elci et al., 2015; Cadelis et al., 2014; Gyan et al., 2005). Furthermore, exposure to the dust may increase the risk of meningococcal meningitis because of bacteria carried in the dust (Yarber et al., 2023). The levels of dust in the air are sometimes thick enough to impair visibility, making road conditions hazardous (Bozlaker et al., 2017; Mendez-Lazaro, 2021). In an island-wide survey in Puerto Rico following the massive, so-called Godzilla Saharan dust event that took place there in June

2020, nearly 90% of respondents reported that their health had been negatively affected. However, only 12% visited a physician owing to Saharan dust complications. Asthma was the most reported condition (55%), and many reported postnasal drip, red or itchy eyes, shortness of breath and fatigue (Mendez-Lazaro, 2021).

Harmful chemicals and gases, most notably ground-level (i.e. tropospheric) ozone, may be by-products of industrial and domestic activities as well as natural processes. Natural processes may themselves be altered by climate change. For instance, climate change has altered the balance of nutrients in the ocean. This has led to the proliferation of *Sargassum* seaweed around Caribbean coastlines, gathering in piles on beaches. As the seaweed decays, it releases the toxic gas hydrogen sulphide (Dubrow, 2021).

Ground-level ozone is an important concern in the Caribbean, given the heavy use of fossil fuels in hot conditions (including in vehicular transport and industrial activities) and the high level of urbanisation (World Bank, 2021). It is formed when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants and other sources (including some natural sources) chemically react in the presence of heat and sunlight (Figure 1). Ground-level ozone, which is most likely to reach unhealthy levels on hot, sunny days in urban environments, is projected to increase with rising temperatures. Inhaling ozone can cause coughing, shortness of breath, asthma, bronchitis and other lung diseases, irritation and damage to airways, and premature death from lung diseases. In addition, it can increase the severity of asthma (United States Environmental Protection Agency, 2022). Ground-level ozone is also harmful to vegetation and can reduce agricultural production (Kumarsingh, 2021).

Figure 1: Ground-level ozone formation



Source: United States Environmental Protection Agency (2022).

Airborne organic matter can cause disease, especially when present in higher quantities than previously experienced. As mentioned, viruses and bacteria may be present in Saharan (and other) dust. It is forecast that in a climate-changed future there will be higher concentrations of airborne allergens, such as pollen and moulds. This is predicted to increase the incidences of asthma and allergies (Hambleton, 2008). High aridity caused by rising temperatures may increase the concentration of particulate-carried fungal spores in the air, increasing the potential for pulmonary and systemic fungal infections (Taylor et al., 2010). The predicted combination of more episodes of flooding and hotter conditions in the Caribbean may increase air pollution, as mould and other pathogens that grow on walls and other materials in the aftermath of floods are dried and carried in the air (Dubrow, 2021).

Finally, most **climate pollutants** do not directly affect health, but harm health because they contribute to climate change. Methane is the second most important anthropogenic GHG. Important anthropogenic sources of methane are animal agriculture (especially concentrated animal feeding operations), fossil fuel production and consumption, and the decomposition of organic waste. HFCs used in AC and refrigeration leak into the atmosphere. Black carbon $PM_{2.5}$ (i.e. soot), formed by the incomplete combustion of fossil fuels, is a climate pollutant that directly harms human health and contributes to climate change by absorbing solar radiation. Ground-level ozone is another pollutant that both directly harms human health and contributes to climate change (as it is a GHG). Carbon dioxide is, of course, the main anthropogenic climate pollutant. Measures to reduce carbon dioxide emissions, most notably transitioning from using fossil fuel energy to renewable energy, are closely linked to a reduction in the emission of toxic air pollutants from the burning of fossil fuels.

Primary research on air quality and health in the Caribbean has focused on the impacts of Saharan dust more than any other pollutant, with some exploration of other correlates of respiratory illnesses such as pollen counts and humidity (CARPHA, 2018; Rise et al., 2022). To date, research in the Caribbean has concentrated on hospital admissions for asthma during Saharan dust events, with varied results as to whether the events lead to significant increases in admissions (Akpinar-Elci et al., 2015; Cadelis et al., 2014; Gyan et al., 2005; Hambleton, 2008; Monteil and Antoine, 2009; Prospero et al., 2008, 2009). Climate change has been mentioned as an associated factor but has not taken centre stage. Toxic air pollutants are a major cause of morbidity and mortality. Climate pollutants emitted together with these pollutants are the primary cause of climate change, and climate change itself has significant effects on air pollution, all with consequences for the health of Caribbean people that extend beyond the scope of the current research.

5.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Provide knowledge and economic incentives to enable individuals and communities to reduce their air-polluting activities

Individuals and communities should be provided with information about how to reduce their own air-polluting activities along with incentives to do so. Nongovernmental organisations and community groups can play important roles in raising awareness and improving knowledge through face-to-face interactions, the media and electronic communication. Most importantly, actions that decrease fossil fuel consumption, which reduces the emission of both GHGs and toxic air pollutants, should be facilitated. These actions include, but are not limited to, installing (ideally with the use of government incentives) rooftop solar panels on homes and solar arrays in communities, promoting the use of electric vehicles, promoting active transport (i.e. walking and cycling) and instituting measures to increase energy efficiency and conservation. Governments should actively encourage the use of clean sources of energy.

In Barbados, tax breaks are available for people who install solar panels on their homes, and some charging stations for electric cars have been installed in public areas such as car parks. Demand for electric and hybrid vehicles, which are more efficient than and substantially less polluting than conventional internal combustion engine vehicles, remains low in the Caribbean owing to their relatively high prices. This is despite local governments beginning to provide fiscal incentives for the purchase and importation of such vehicles. To facilitate individual and community action, the price of clean energy and clean vehicles should be decreased to below that of fossil fuels. Other examples of individual and community actions are recycling food waste to create compost and thereby reduce methane gas at landfills; and facilitating the planting and care of plants and trees, which absorb carbon dioxide.

Alternative fossil fuel products have been developed and are now marketed in Caribbean countries. Liquid petroleum gas and compressed natural gas emit fewer hydrocarbons and particulates, and less carbon dioxide, and contribute less to ground-level ozone than conventional petroleum (Bielaczyc et al., 2016). However, the production chain for these products has been found to consume even more energy than conventional petroleum, and natural gas systems leak methane (Zhiyi and Xunmin, 2019). Therefore, these products do not provide a solution to the generation of air pollution in the production and consumption of fossil fuels.

Personal protection against air pollution

Individuals should be encouraged to adopt personal protective measures if levels of air pollution are elevated, for example because of wildfire events, particularly if they have pre-existing conditions, such as asthma, that render them vulnerable. Public agencies are responsible for releasing accurate and clear information about air quality and advice regarding health protection. Residents should keep track of air quality and adjust their behaviour and exposure accordingly. If an area is likely to be exposed to extremely high levels of toxic pollution, owing to an event such as a wildfire, the temporary relocation of residents may be necessary. This relocation requires the support of public agencies and community collaboration. A level of protection from ambient air pollution may be afforded by staying indoors and closing doors and windows, setting air conditioners to recirculation mode, using portable air cleaners, and using central air conditioners with filters. A limitation is that most air filters reduce exposure to particulate matter but not gaseous pollution. Heavy and prolonged physical activity should be avoided when air pollution levels are high. Wearing certain types of face masks (N95, PN95, KN95 and P100) can reduce exposure to particulate matter, viruses and bacteria, but not gaseous pollutants (Xu et al., 2020).

Structural/governmental and private sector actions

Develop a strong framework of government regulation and support

A strong framework of government regulation and support is needed to enable the individual and community actions required to achieve reductions in air pollution and associated diseases. The Intergovernmental Panel on Climate Change's Sixth Assessment Report notes that improving air quality through increasing the use of renewable energy sources is a highly effective measure that both reduces GHG emissions and benefits health and well-being. It also notes that there are major gaps between policy and action in addressing the interrelationships between air quality and climate risk. This indicates that, in addition to strong policies, enabling and reinforcing actions are needed from governments to improve air quality (IPCC, 2022).

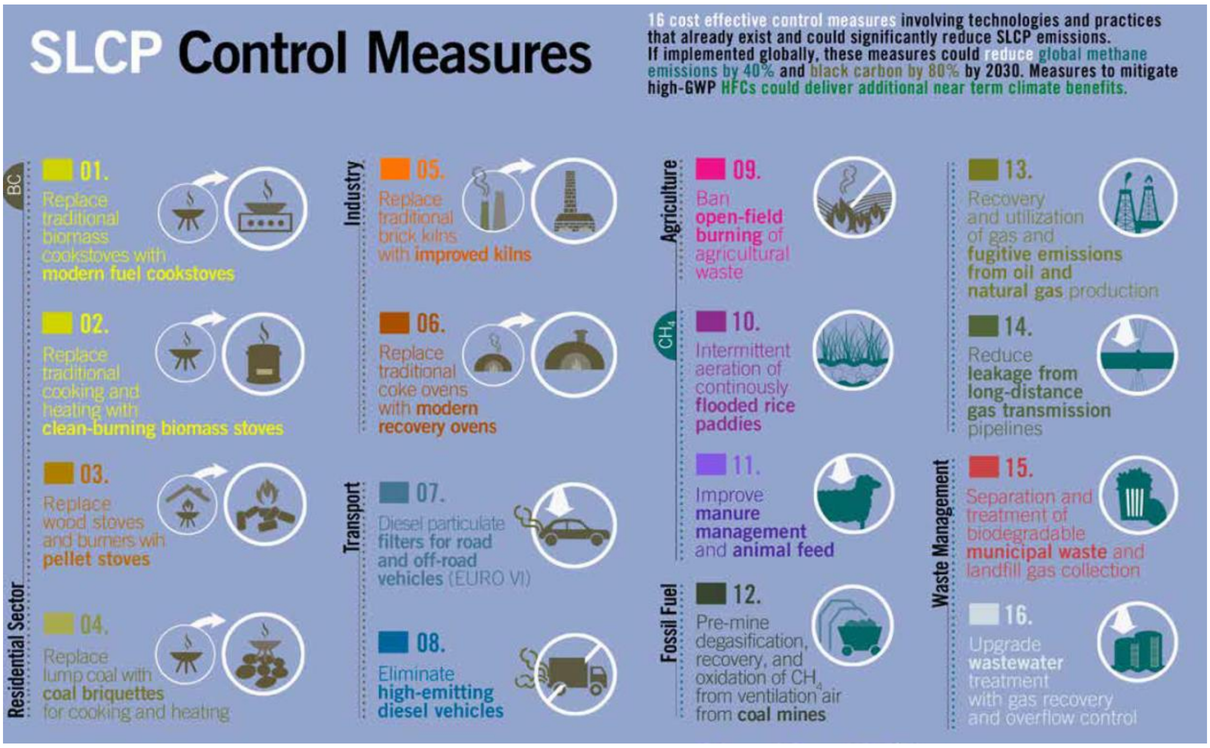
Specific recommendations are as follows:

- Develop coherent multisectoral policies and actions across the transport, industry, power generation, waste and wastewater management, agriculture, buildings and land use sectors for preventing air pollution. Most important are mandatory targets for transitioning from a fossil-based economy to a renewable energy-based economy (IPCC, 2022). Given the Caribbean's bountiful supply of free sunlight and wind, it is especially well-suited to a productive renewable energy-based economy that will substantially reduce both climate pollutants and toxic air pollutants.
- Establish and enforce air quality standards, in line with WHO air quality guidelines (WHO, 2021).
- Set a standard and example by aggressively reducing climate and air pollutants by converting to renewable energy in government facilities.
- Implement the package of control measures to reduce short-lived climate pollutants (black carbon, methane and HFCs) recommended by the World Meteorological Organization and the United Nations Environment Programme (UNEP). This package includes measures for households; industry, including the fossil fuel industry; transport; and waste management. Some of the measures are illustrated in Figure 2.

The UNEP reported in 2017 on actions taken by 12 Caribbean governments[1] to improve air quality, in the areas of industrial activities, road transport, open waste-burning, indoor air pollution and general legislative efforts. Its assessment showed that action was still required in most of these areas in most Caribbean countries. However, in six (half) of the countries, government incentives were in place to minimise industrial emissions. A couple of examples from Barbados are notable. The Renewable Energy Rider initiative allowed customers who use renewable energy to sell excess energy generated from renewable sources to the Barbados Light & Power Company Limited. Barbados has a zero value-added tax rate on all renewable energy and energy-efficient systems and products; in addition, developers, manufacturers and installers of renewable energy products are granted a 10-year income tax holiday. Puerto Rico has similar incentives.

[1]The following countries were included in the assessment: Antigua and Barbuda, the Bahamas, Barbados, Cuba, Dominica, the Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, and Trinidad and Tobago.

Figure 2: Recommendations to reduce short-lived climate pollutants



Sources: Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (2022).

In the area of transport, the UNEP reported poor progress. Only two countries had implemented initiatives to expand their public transport system and thus reduce the number of vehicles with harmful emissions. Only one country had implemented vehicle emission standards. Only two countries had established fuel quality standards that restricted sulphur content to below 500 ppm (United Nations Environment Programme, 2017). The UNEP report revealed major gaps in progress in addressing causes of air pollution with major health impacts. There is a need to update this assessment and conduct further analyses to assess progress over time.

Resources needed to support government actions include technical support to develop and implement monitoring systems (see the subsections "Research gaps and how to address them" and "Surveillance gaps and how to address them"), improved information technology systems to support the sharing and dissemination of information, and mechanisms to improve collaboration between agencies (R4ACCHC, 2023).

Support the development of green spaces and active transport to maximise the health co-benefits of climate change mitigation

Developing parks, woodlands, bicycle lanes, walkways, and linear parks along canals, rivers and streams helps reduce the risk of NCDs by providing opportunities for physical activity, while contributing to ensuring clean air and reducing GHG emissions. However, it is important to assess the extent to which active transport is a viable option for mass transportation, given that the Caribbean climate may be too hot for many to walk or cycle to workplaces and schools. Therefore, nature-based solutions and green infrastructure that provide cooling are essential. Shaded bicycle lanes and walkways should be part of urban design in the Caribbean. Integrated transport policies that reduce the use of single-occupancy vehicles and the associated air pollution should be developed, including use of renewable energy for vehicular transport and support of public transport and car-pooling (Gordon-Strachan, 2021). Further details are provided in Chapter 15, "Climate-friendly health-promoting infrastructure".

Provide resources for education, adaptation and mitigation

Private enterprises, governments, and regional and international agencies should provide expertise and financial support for the necessary measures. These include developing green spaces and providing an enabling environment for active transport, as detailed in the previous paragraph. To support individual and community action, resources are needed for public education and communication, making use of information tools such as early warning systems (EWSs). Information tools can be developed to encourage users to make choices that will lower their carbon footprint. Entrepreneurs can spearhead the development of tools, products and services that can facilitate risk communication and a reduction in air pollution. Governments should provide fiscal incentives for individuals and businesses to develop and adopt sustainable technologies. The burning of solid waste can be reduced by implementing policies to provide more recycling and waste disposal facilities (R4ACCHC, 2023).

Research gaps and how to address them

Research on patterns and trends in respiratory, cardiovascular and other illnesses in relation to air quality

The prevalence of asthma appears to be high in the Caribbean, yet there are few published data on patterns and trends in respiratory illnesses in relation to air quality. It is recommended that data are collected on topics including:

- Geographic and socioeconomic characterisation of communities that are most exposed to toxic air pollution in the Caribbean (R4ACCHC, 2022a);
- The role of natural sources of air pollution such as Saharan dust, as well as mould, pollen and spores resulting from hurricanes and floods, in the exacerbation of asthma and other respiratory diseases;
- Characterisation of the pathogens associated with Saharan dust;
- Effects of climate change on asthma incidence and exacerbation;
- Whether drought-induced increases in atmospheric concentrations of fungal spores increase the incidence of fungal infections (Dubrow, 2021);
- How above-normal heat affects ground-level ozone and particulate matter concentrations and the incidence of respiratory illnesses in the Caribbean;
- The relative contributions of climate change and human behaviour to wildfire outbreaks, determined by assessing the degree to which wildfires can be attributed to spontaneous combustion (due to increased heat and dryness resulting from climate change) compared with specific human actions (such as fire suppression or electric utility malfunctions) (R4ACCHC, 2023);
- Levels of household air pollution in different geographical locations, contributors to household air pollution and control measures that could be implemented (R4ACCHC, 2023).

Research is needed on patterns and trends in admissions to healthcare facilities, including outpatient care facilities, emergency departments and hospitals in general, related to air quality. More research is needed on admissions for a variety of air quality-related NCDs (respiratory and cardiovascular diseases, and others, such as diabetes and neurological diseases, for which there is not yet conclusive evidence of the effect of air pollution), as well as for infectious diseases (including COVID-19). Admissions and outcomes should be mapped against ambient air conditions and levels of specific pollutants (Gordon-Strachan, 2021; Mendez-Lazaro, 2022). To facilitate this research, air quality surveillance systems must be strengthened, as detailed in the subsection "Research and surveillance capacity-strengthening needs".

Research on links between climate change and Saharan dust

Research is needed to better understand whether/how climate change affects the amount and timing of the arrival of Saharan dust clouds in the Caribbean. It is also important to examine the effect of Saharan dust, if any, on Atlantic/Caribbean hurricanes. The association of Saharan dust events with respiratory disease symptoms and outcomes should be closely monitored (R4ACCHC, 2022b).

Operational research

To strengthen action to address air quality and health challenges, it is important to assess the state of play, answering questions such as the following through research (Gordon-Strachan, 2021):

- What is the current state of air quality monitoring in the Caribbean?
- What pollutants are monitored?
- Are the monitoring sites appropriately placed?
- Is the monitoring equipment up to date?
- What is the quality of the data?
- Who is responsible for collecting the data?
- How are the data used?
- What are the reporting requirements and are they being met?
- How is the information gathered incorporated into decisions made about the populations affected and the health services delivered?
- What are the legal (guidelines) and policy frameworks?
- How can we involve service providers and goods producers (not just policymakers) in actions to improve air quality?

Citizen science and action research

Individuals, communities and organisations can be engaged in research, fostering learning, knowledge exchange and public engagement on air pollution. For example, since the 2017 hurricane season in the Caribbean, community-based organisations in Puerto Rico have promoted actions to advance social transformation, sustainable development, community trust and cohesiveness, and social capital (Holladay et al., 2021). As another example, the organisation UrbanBetter works in African cities to promote sustainable urban environments for better health. UrbanBetter established the #Cityzens4CleanAir Campaign, whose members, known as Run Leaders, are mainly university students and members of running clubs. Their strategy is to use evidence collected during runs to advocate for both physical activity and clean air. Air quality is measured along running routes by attaching air quality monitors to the runners. The data they collect from routes around their cities provide evidence to advocate for improving air quality and promoting physical activity. To coincide with the youth and science-themed days at the 2022 United Nations Climate Change Conference (COP27), they carried out a social media campaign to highlight the effect of air pollution on both health and the climate, the inadequacy of air pollution measurement in most cities, the inequalities within cities in relation to air pollution and the critical role that young people can play in devising ways to reduce air pollution (UrbanBetter, 2022).

Similar strategies could be deployed in the Caribbean, especially given the popularity of running and the high level of urbanisation in the region.

Surveillance gaps and how to address them

Produce temporally and spatially granular air quality data

To ramp up research on climate change and health in the Caribbean, and to develop EWSs, it is critical to have a system that collects air quality data that enables comparisons among places and over time (Dubrow, 2021). Investments in newer technologies are needed to capture air pollution trends at a granular level (R4ACCHC, 2023). The major air pollutants listed by the WHO ($PM_{2.5}$, PM_{10}, ozone, nitrogen oxides, sulphur dioxide and carbon monoxide) should be monitored throughout the Caribbean (WHO, 2022). In addition, monitoring of Saharan dust is critical, specifically in the Caribbean. Furthermore, the antigenicity of components of dust, which carries allergens including pollen and insect parts, should be monitored (R4ACCHC, 2022a, 2023). State-of-the art air quality monitoring facilities and expertise are needed to achieve these goals. Box 1 provides examples of initiatives in various Caribbean countries.

Air quality should be mapped against climate-related drivers of ill health, such as hurricanes, heat fluctuations, droughts and flooding (R4ACCHC, 2022a). Medical doctors can act as "sentinel physicians", providing data to monitor respiratory conditions alongside climate indicators (R4ACCHC, 2022b).

Box 1: Examples of surveillance and communication activities related to air quality in the Caribbean

The Dust and Air Quality Forecasting Centre was established at the Caribbean Institute for Meteorology and Hydrology. It is based in Barbados, and covers the whole Caribbean region, parts of central and northern South America and dust source regions in North Africa. Seven-day forecasts are provided for dust, visibility associated with dust concentration, PM_{10}, $PM_{2.5}$ and ozone. The institute hosts the Regional Office for the Americas of the World Meteorological Organization's Sand and Dust Storms Advisory and Assessment System (Sealy, 2021).

In Trinidad and Tobago, the Environmental Management Authority set up the Ambient Air Quality Monitoring Network using data from five monitoring sites throughout the country. These monitor various air pollutants and meteorological parameters to generate an air quality index that provides real-time information to the public. In 2020, Trinidad and Tobago became the first Caribbean country to join the BreatheLife campaign. It pledged to reach an interim air quality target for fine particulate matter based on WHO air quality guidelines by the end of 2025, achieving this through action across the economy (Environmental Management Authority Trinidad and Tobago, 2020).

Since 2017, the University of Puerto Rico has collaborated with public health, atmospheric and meteorological scientists in a National Aeronautics and Space Administration-funded initiative to use data on Saharan dust from satellites (conducting remote sensing) and ground stations, weather information and public health data. The aim of the collaboration is to quantify the impact of Saharan dust on respiratory diseases in Puerto Rico as a proxy for the Caribbean. This has led to the co-design of a public health EWS for Saharan dust, which includes online visualisation tools (see the Caribbean Coastal Ocean Observing System's latest conditions and forecast). The University of Puerto Rico's Graduate School of Public Health develops infographics and conducts webinars to increase the population's knowledge of potential threats and protective measures and their preparedness for threats in collaboration with the weather service and a civil society organisation. Among the populations served by these information products are healthcare and emergency preparedness personnel and the general public, with a focus on populations at high risk (Mendez-Lazaro, 2021, 2022).

Monitor and strengthen the integration of air pollution into weather forecasting and early warning systems

Unlike risk factors such as diet and exercise, air quality is a risk factor over which individuals have very little control. Furthermore, individuals generally are not in a position to monitor their exposure to air pollution. This means that air quality surveillance and associated information services and EWSs are critical public health measures. Effective communication on air quality must be considered an essential component of climate information services for health. While weather forecasts on public television and radio stations in Caribbean countries now sometimes include predictions of dust concentrations alongside advice on protective measures, further information on air quality could be included. There is also a need to deploy the whole gamut of modern communication methods and media to ensure that people understand the information they receive about air quality, with a focus on vulnerable populations, such as older people and people with NCDs (especially respiratory and cardiovascular conditions) and their carers (Mendez-Lazaro, 2022). Box 1 provides examples of agencies in the Caribbean providing information about and communicating surveillance data.

Monitoring, forecasting and EWSs need to be linked with populations and agencies that can make use of the information these services provide. There should be a particular emphasis on providing information to geographical areas and populations at high risk of experiencing poor air quality. National and regional public health agencies should continue to strengthen their links with meteorological agencies engaged in the research and development of EWSs, such as the Caribbean Regional Climate Centre at the Caribbean Institute for Meteorology and Hydrology. Governments must also be engaged, including through their chief medical officers and disaster management units. Full use must be made of media, including social media. Platforms for the dissemination of information must be improved (R4ACCHC, 2023).

Research and surveillance capacity-strengthening needs

Capacity should be built in the Caribbean in the following areas (Gordon-Strachan, 2021):

- The design of air quality monitoring systems;
- Statistical disease modelling;
- Integrated surveillance systems that monitor weather, health and environmental indicators;
- The recruitment of pulmonologists and internal medicine specialists to assist with the development of direct indicators and proxy indicators (if necessary) for monitoring health impacts of air quality;
- Remote sensing;
- The communication of science related to air quality and health to the general public, vulnerable populations, policymakers and industrialists to encourage behaviour change.

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6. HEAT-RELATED ILLNESS

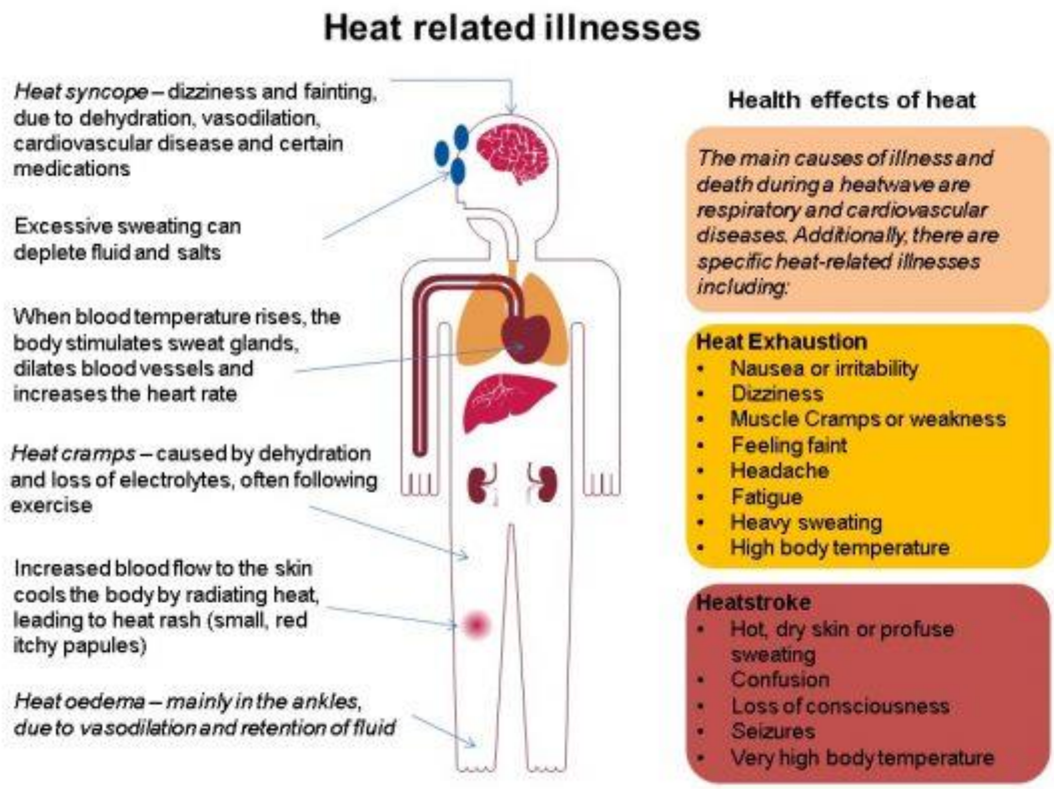
6.1. WHAT IS HAPPENING?

The Intergovernmental Panel on Climate Change states that extreme ambient air temperature is associated with elevated mortality (with "very high confidence") and morbidity (with "high confidence") (Cissé et al., 2022). In the Caribbean, there has been a steady rise in air temperature since the early 1990s. Between 1991 and 2021, the region warmed at a rate of 0.24 °C per decade. The average temperature in 2021 was 0.68 °C higher than the 1961–1990 average (WMO, 2021). The number of very warm days and nights across the Caribbean is increasing, while the number of cool days and nights is decreasing (Climate Studies Group Mona, 2020; Stephenson et al., 2014). In 2020, the Caribbean experienced record-breaking heat; new air temperature records were set in Cuba, Dominica, Grenada and Puerto Rico (WMO, 2021). In the second half of 2017, when Hurricanes Irma and Maria hit, surface temperatures were some of the highest ever recorded (Stephenson et al., 2018). Extreme heat may occur in concert with other extreme weather events that can have additional negative health impacts (Taylor, 2021).

Extreme heat exposure can compromise the body's ability to cool itself. Heat-related illnesses include heat rash, heat cramps, heat exhaustion, heat syncope (fainting or dizziness) and heat stroke. Extreme heat can also trigger acute health events, including acute kidney failure and acute myocardial infarction, and can exacerbate preexisting noncommunicable diseases (NCDs), such as heart or lung disease. Several of these illnesses (e.g. heat stroke, acute myocardial infarction), if not treated immediately, can be fatal. Activation of the body's heat defence mechanisms leads to cutaneous vasodilation, which increases blood flow to the skin, thus promoting heat transfer from the body to the skin and then to the ambient air. Extreme heat can result in reduced blood circulation in the body and, particularly if someone is in a standing position, subsequent heat syncope. Electrolyte imbalance due to sweating, the body's other major heat defence mechanism, can cause heat cramps. Symptoms of heat exhaustion, usually associated with electrolyte imbalance and dehydration, include fatigue, heavy sweating, a rapid pulse, anxiety and confusion, and elevated body temperature. Signs of heat stroke, which is considered a medical emergency, include a body temperature greater than 40 °C, loss of consciousness, hot dry skin with no sweating, severe central nervous system abnormalities (e.g. delirium, convulsions) and multi-organ dysfunction (Di Napoli et al., 2023; Székely et al., 2015; Taylor et al., 2010). See Figure 1.

In 2020, results from a global survey of over 4600 health professionals from 12 countries, including Jamaica, indicated that heat-related illnesses were already affecting local populations and that these illnesses were expected to become more frequent or severe within the next 10 years (Kotcher et al., 2021). A 2013 study in Grenada and Trinidad and Tobago used focus group discussions to explore perceptions among Caribbean healthcare providers about the health impacts of increasing temperatures. The groups included physicians and nurses, with at least one veterinarian and technician in each group. Participants in both groups perceived air temperatures as hotter than usual and as contributing to more heat-related illness and hospital admissions. Participants in Grenada described an increase in hospitalisations for dehydration and sunburn. Participants from Trinidad and Tobago talked extensively about heat stress, chronic obstructive pulmonary disease and increasing numbers of deaths of working and domestic animals. A veterinarian described putting dogs on fluids to save their lives after they had collapsed from heat stress (Macpherson and Akpinar-Elci, 2015). A knowledge, attitudes and practice survey by the Caribbean Environmental Health Institute demonstrated that 75% of hotel nurses in Barbados and Saint Lucia noticed a seasonal pattern of sunburn, peaking between April and September. However, over 80% of public health doctors and nurses and environmental health officers, in both countries, noticed no year-to-year or seasonal patterns (Taylor et al., 2010).

Figure 1: Heat-related illnesses



Source: Landeg and Extreme Events and Health Protection team (2020);
licensed under the Open Government Licence v3.0.

The relationship between heat exposure and mental health is an additional area of concern, as there is evidence from other regions of the world that heat exposure may be associated with performing violent acts, general irritability, higher levels of anxiety and stress, and increased accident and emergency admissions for mental disorders (Cissé et al., 2022; R4ACCHC, 2022a; WMO, 2021). The impacts of heat exposure on cognition add to concerns. In the Eastern Caribbean states, excessive heat exposure has the potential to reduce children's learning ability at school, indicating the need to make school environments cooler (R4ACCHC, 2022b; Van Meerbeeck, 2020). Furthermore, older people are particularly vulnerable to higher ambient air temperatures, which can result in cognitive impairments (Yi et al., 2021).

The "urban heat island" effect causes temperatures to be higher in urban areas than in rural areas, as dense concentrations of pavement, buildings and other surfaces absorb and retain heat. Night-time radiant energy from heat that builds up and is stored in built structures reduces the extent to which buildings cool down at night (Campbell-Lendrum and Corvalán, 2007; Taylor et al., 2010), depriving people of night-time relief from the heat. This is an important concern, as 52% of Caribbean people live in urban areas (World Bank, 2021). Air pollution episodes are also frequently associated with heatwaves. In addition, extreme heat affects health through its impact on air and water quality, food and water availability, infectious agents and ecosystems, and through population displacement (CARPHA, 2018; Walsh et al., 2018).

Vulnerability to extreme heat is determined by demographic factors associated with social disadvantage and biological difference (e.g. age, gender and race/ethnicity) and social factors (e.g. poverty, usual place of residence [which affects the levels of heat that individuals are accustomed to], housing and infrastructure, occupation, discrimination, access to health care and preexisting conditions). Specific vulnerable groups include the elderly, pregnant women, children, people with preexisting NCDs, people experiencing homelessness, outdoor workers, people living in poverty in urban areas and tourists not accustomed to warm weather. The likelihood of ill health is, of course, compounded for people who belong to more than one of these groups (Allen, 2021; USGCRP, 2016).

Extreme temperatures put a strain on the operation of, and access to, healthcare facilities and services. Ambulance call-outs and hospitalisations for acute heat-related illnesses tend to increase on hot days. Air-conditioning systems work harder to maintain a comfortable indoor temperature and may therefore break down more often. Storing medicines at a safe temperature may also be challenging (Macpherson and Akpinar-Elci, 2015; Méndez-Lázaro, 2021; WHO, 2018). High outdoor temperatures may lead to low attendance at health facilities, even in the Caribbean. Many smaller and rural health clinics have seating areas that are not air-conditioned, making attendance uncomfortable on particularly hot days. More modern health facilities generally have air conditioning but lack windows; this can be challenging during power outages, which often happen in the immediate aftermath of a hurricane (R4ACCHC, 2022c).

Although the adverse health effects of heat exposure have been increasingly studied globally, studies on heat-related illnesses in the Caribbean are limited. Given the high prevalence of NCDs in the Caribbean, it is reasonable to hypothesise that heat-related illness in the region might be an underappreciated problem that is being made worse by increasing temperatures due to climate change. See Chapter 4, "Noncommunicable diseases and risk factors".

Di Napoli et al. (2023) demonstrated a positive correlation between increased air temperature and heat stress in the Caribbean between 1980 and 2019, using a measure called the Universal Thermal Climate Index.[1] Therefore, the risk of heat-related illness and death is expected to increase with increasing ambient air temperatures, especially among vulnerable groups (Allen et al.,2021; Ebi et al., 2006; Pascal et al., 2021; Taylor et al., 2010). Pascal et al. (2021), using a non-linear generalised model linking temperature and mortality, demonstrated an association between higher temperatures and increased risk of mortality between 2000 and 2015 in French Guiana, Guadeloupe, Martinique and the French overseas territories in the Indian Ocean.

Mendéz-Lazaro et al. (2021) examined the environmental stressors experienced by women with gynaecological cancers from Puerto Rico and the United States Virgin Islands who received care in the aftermath of Hurricanes Irma and Maria in Puerto Rico. Focus groups with patients and healthcare providers ranked heat as the number one environmental stressor, followed by air and noise pollution. Cancer patients are known to suffer more in the heat because they experience hot flashes. It was also noted that temperatures were "above normal" (greater than 38 °C) for five consecutive days after the hurricane.

> Remember that patients who are undergoing chemotherapy suffer a lot from heats and hot flashes; they sweat more (often), and they are sick. Some of them vomit, and not even having (electricity) a fan to cool off when you feel sick is not comfortable. Not having ice to cool your organism inside, that's what patients complained the most.
>
> Méndez-Lázaro et al. (2021)

[1]Di Napoli et al. (2023) reanalysed 1980–2019 data to explore the correlation between climate change and heat stress in the Caribbean. They used a multivariate thermophysiological-relevant parameter – the Universal Thermal Climate Index (UTCI) – to represent thermal conditions and its variability. The UTCI reflects the bodily temperature felt under the combined environmental variables of temperature, relative humidity, wind speed and solar radiation; it is used as a reference to measure human thermal discomfort and therefore the environmental conditions that cause strain. This study found a regional increase in the UTCI of more than 0.2 °C per decade, with the Lesser Antilles having a UTCI increase of 0.45 °C per decade. Another biometeorological index – the heat index – which combines air temperature and relative humidity as an index of perceived temperature, has risen by 1.2 °C in the Caribbean since 1980.

The Caribbean Institute for Meteorology and Hydrology (CIMH) is working on collecting data, starting in Grenada, that can be used to study the link between climate change and heat-related illnesses (Allen et al., 2021). This will be important in bolstering early warning systems, for not only the health sector but also the agriculture, construction and tourism sectors (R4ACCHC, 2022c). The Caribbean Institute for Health Research at the University of the West Indies in Jamaica is hoping to develop a surveillance system that links temperature data with data on NCDs (Allen et al., 2021).

6.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Increase knowledge of the risks of heat-related illness and their management among the general population and vulnerable people

Given the increasing ambient temperatures and increasing duration, intensity and frequency of heatwaves in the Caribbean, behaviour change to mitigate the risk of heat-related illnesses must be promoted. Individuals need to keep themselves and their immediate environment cool. Particular attention needs to be paid to health-promotion strategies for vulnerable people such as the elderly, pregnant women, infants and people with NCDs. Recommendations for staying healthy in high temperatures include the following (PAHO, 2018; UKSHA, 2018; WHO, 2018):

- Keep your living space as cool as possible, ideally below 32 °C during the day and below 24 °C at night. This is particularly important for the elderly, infants and people living with NCDs:
    - Use natural air to cool down your house. Open windows in shaded or breezy areas. Install ventilator blocks and windows that allow a breeze to flow through indoor spaces where no air conditioning is installed.
    - Reduce heat load during the day. Close windows and/or curtains facing direct sunlight to prevent excess heat entering the house. Turn off as many electrical devices as possible.
    - When using air conditioning, keep all windows and doors closed.
    - Use fans to improve air flow.
- Keep out of the heat by staying in the coolest part of the house, avoid going outside and avoid strenuous exercise, especially during the hottest times of the day. Stay in the shade.
- Do not leave animals or small children in parked vehicles.
- Keep your body cool by taking cool showers often; wearing light, loose-fitting clothes; using light bed sheets at night; drinking fluids regularly, but avoiding caffeine, sugary drinks and alcohol; and eating small meals and eating more often. Avoid excessive consumption of foods that are high in protein.
- Get help if you do not feel well.
- Help others who are vulnerable. Check in regularly with vulnerable people in your community such as older people and people with disabilities.
- Store medications as per the storage guidelines, but, as a general rule of thumb, keep them below 25 °C or in the refrigerator.

This information needs to be disseminated to the general public and vulnerable groups before, during and after heatwaves. Social media and more traditional communication methods, such as radio, television and megaphone announcements in local neighbourhoods, can be used. Collaboration between the ministries responsible for health, education, social services and sport is important, to ensure that the appropriate information reaches the correct audience. As increased information does not always lead to behaviour change, health-promotion strategies must be designed in ways that respond to community experiences and include evidence-based behaviour-modification strategies. Skilled communication and health-promotion specialists are needed to develop such programmes (R4ACCHC, 2023a).

Structural/governmental and private sector actions

Develop national and local response plans for extreme heat

National response plans for extreme heat should be developed, including disaster preparedness measures. Saint Lucia has such a response plan (Government of Saint Lucia, 2006; NOAA NWS, 2016). These plans should include early warning systems to alert the public of impending heatwaves, provide emergency shelters for vulnerable people that are equipped with high-powered fans or are air-conditioned, and allocate responsibilities to government agencies such as the ministries responsible for health and agriculture. In addition, local (e.g. municipal) response plans should be developed in the larger Caribbean countries/territories and for specific events such as outdoor sports and cultural events when the temperature is expected to be above normal (R4ACCHC, 2023a).

Train healthcare professionals and first responders in special medical needs associated with heat-related illness

This training can be a collaboration between national and regional academic institutions. Medical professionals can be trained as part of their learning curriculum. Special attention should be given to the delivery of medical care in emergency situations involving heatwaves and prolonged high temperatures (R4ACCHC, 2022b).

Improve health facility design to optimise cooling, including by having energy-efficient temperature control systems

It is important to improve the design of health facilities so that cooling can be optimised. This is particularly important for patients, both in hospitals and in outpatient care. Cool temperatures are also critical for the functioning of medical instruments and technology, such as diagnostic equipment; operating theatres; and medicine storage. If air conditioning is unaffordable at some facilities, fans and the optimisation of air flow, shading (e.g. verandas, trees), high-albedo roofs or green roofs, and building materials with high thermal mass should be built into design. Even when air conditioning is available, these building design features can reduce the energy needed for air conditioning. The Smart Health Initiative of the Pan American Health Organization (PAHO) provides blueprints for improving the structural safety of health facilities themselves, reducing energy consumption, water conservation and using environmentally friendly appliances and fixtures. This includes replacing older air-conditioning units with more energy-efficient models (CARPHA, 2018; PAHO, 2013). This will be discussed in more detail in Chapter 16, “Smart health facilities”.

Provide support for the installation of energy-efficient air conditioning and other cooling solutions that reduce demand for air conditioning

As the climate gets progressively hotter in the Caribbean, more people are likely to require air conditioning in at least one room in their home and in indoor work settings. A combination of fiscal measures and grants may be used to ensure that everyone has access to sustainable cooling solutions. In Barbados, tax breaks are available for the installation of solar power and other renewable energy systems that can be used for air conditioning. It is important to provide support for other cooling solutions, such as high-albedo roofs and insulation, which may be more affordable than air conditioning.

Develop national occupational heat standards

Some workers are exposed to high temperatures owing to the conditions of their work. It is evident that outdoor workers such as farmers and construction workers are at high risk of extreme heat exposure, but indoor workers in workplaces without air conditioning or other cooling solutions can be at high risk as well. Governments should develop standards to protect workers, such as mandatory rules on the provision of water, rest and shade for outdoor workers, according to the ambient temperature and physical demands of the work; on appropriate clothing and personal protective equipment; on the adjustment of work schedules to avoid working in the hottest part of the day; on the acclimatisation of new workers; and on an indoor temperature threshold above which workers are automatically dismissed from work (NIOSH, 2016).

Research gaps and how to address them

Identify how increases in ambient temperature affect the healthcare system

It is important to identify how heatwaves and increased ambient temperatures affect health systems in the Caribbean. This can improve the effectiveness of emergency preparedness planning and other adaptation measures. For example, are high ambient temperature and heatwaves associated with increased accident and emergency visits or hospitalisations due to specific heat-related illnesses? How do they affect the storage of medicines and the performance of medical equipment (Dubrow, 2021; WHO, 2018)? Answering these questions will enable the better alignment of resources for critical and emergency health service delivery.

More broadly, extreme heat can affect infrastructure, which in turn can affect health. For example, the integrity of water pipes, building materials and roads can be affected, and there will be costs associated with adapting vehicles, homes, workplaces and outdoor facilities as the Caribbean gets hotter (R4ACCHC, 2023a).

Citizen science and research

Individuals, communities and nongovernmental organisations should be included in research at the community level on experiences and impacts of rising temperatures and heatwaves (R4ACCHC, 2023b). For example, since 2017, the National Oceanic and Atmospheric Administration (NOAA) has been collaborating with volunteers and community groups in mapping the urban heat island effect in 60 cities across the United States of America. In Brooklyn, New York, in 2022, approximately 800 people with sensors attached to their cars or bikes followed set routes, measuring air temperatures and humidity levels while also collecting location data. Thanks to the assistance of citizen scientists, over 1 million measurements were gathered over 16 days, covering 6000 square kilometres (Poon, 2022; R4ACCHC, 2023c). In 2023, NOAA plans to collect data in Freetown, Sierra Leone, and in Rio de Janeiro, Brazil. Caribbean regional climate and health organisations can collaborate with volunteers and community groups to conduct similar mapping exercises.

Explore the relationship between increased ambient temperature and morbidity and mortality

The precise threshold at which temperature becomes a hazard to human health varies by region and depends on factors such as humidity, wind, local acclimatisation and preparedness for increased heat conditions (WHO, 2018). The impact of heat on health and the relationship between increased ambient air temperatures and heat-related illnesses in the Caribbean should be researched, with emphasis on vulnerable groups, including people living with NCDs; tourists; outdoor workers; the elderly; women, including pregnant and menopausal women; young children; people without access to indoor cooling; and people on certain medications (Allen et al., 2021; Dubrow, 2021). It is important to develop information that is specific to the Caribbean, to ensure that any interventions at the individual, community and structural levels are appropriate for the Caribbean region and its populations (R4ACCHC, 2023a).

CIMH is working on identifying temperature thresholds that can trigger morbidity and mortality outcomes, such as accident and emergency visits, hospitalisations and cause-specific or all-cause mortality (Allen et al., 2021). Such information is valuable for the development of early warning systems. Similarly, a project in Grenada is seeking to identify heat impact thresholds (see Box 1).

Box 1: Case study – pilot project to establish a heat threshold in Grenada: a model for the Caribbean region

In 2021, PAHO funded and facilitated a pilot project to analyse the relationship between extreme heat and other climate drivers and health in Grenada. Instead of using just one proxy outcome to determine heat impact on health thresholds, the pilot used hospital admissions, visits to accident and emergency and all-cause mortality. It is hoped that this methodology can be used in other Caribbean countries to assist with evidence-based policy development.

Source: Glasgow (2021).

Using biometeorological indices such as the Universal Thermal Climate Index (Di Napoli et al., 2023), research priorities may include exploring (Dubrow, 2021):

- The health effects of both short- and long-term heat exposure;
- The differences between men and women in terms of the health effects of heat exposure;
- The role of acclimatisation to heat in the Caribbean;
- How increased ambient temperatures affect new (e.g. COVID-19) and reemerging diseases in the Caribbean context.

Determine the effectiveness of actions at the individual, community, structural/governmental and private sector levels

Actions need to be evaluated to ensure that they are effective. Evaluations may be of process, impact and/or cost-effectiveness. Determining the barriers to and facilitators of implementing suggested actions would also be helpful in making recommendations for the way forward. Research questions could include the following:

- Following health-promotion interventions, are people, especially vulnerable populations, more knowledgeable about ways of keeping their living space and their bodies cool during the hottest periods of the day?
- Is the public aware of what needs to be done before and after an extreme weather event to mitigate heat-related illnesses?
- Are there sufficient numbers of healthcare professionals and first responders trained in the medical needs associated with heat-related illnesses?
- Are diagnostic equipment and supplies and medicines consistently being stored at the correct temperatures, even during periods of abnormally high temperatures?
- What proportion of the population has taken up offers of government tax breaks for the installation of efficient air-conditioning units or renewable energy systems for cooling?

Surveillance gaps and how to address them

Monitor and evaluate changes in ecosystems due to extreme heatwaves

It is important to preserve ecosystems, as climate change, including increased temperatures, can cause disruptions, especially in the food chain. An example from Alaska (Box 2) may provide pointers on how a similar monitoring system could be implemented in the Caribbean, involving local communities.

Box 2: Case study: Community-based surveillance led by the Alaska Native Tribal Health Consortium

In Alaska, several eco-system and health consequences of warming and of the heatwave that occurred in 2016 were identified using a community-based surveillance system (the Local Environmental Observer [LEO] Network) established by the Alaska Native Tribal Health Consortium. This system used cell phones to record incidents of environmental change via photos and text, validated through expert investigation and commentary. The warming conditions favoured some phytoplankton species, and one of the largest harmful algal blooms on record reached the Alaska coast in 2015. There were uncommon paralytic shellfish poisoning events and oyster farm closures in 2015 and 2016. Dramatic mortality events in seabird species such as common murres in 2015/16 (tens of thousands of dead birds were counted) were attributed to starvation and presumed to be a result of warming-induced effects on the birds' food supply. Increased occurrences of animal diseases were also observed, including sea star wasting disease. Human communities, especially native communities, were affected by changes in the acquisition, preservation, quality, and quantity of wild foods (Walsh et al., 2018). The LEO Network community-based surveillance system has potential for adaptation to the Caribbean, to utilise local observations and knowledge to enhance responses and adaptation to climate change.

Source: LEO Network (2021).

Include alerts for above-normal temperatures in climate change and health impact early warning systems

Early warning systems (see Chapter 11, "Research and surveillance on climate change and health", for further details) are intended to give notice of impending hazards in a timely manner to allow for preparation, prevention and mitigation activities that will reduce harm (Harewood, 2021). For this to happen, meteorological monitoring (ambient air temperature and humidity), health monitoring (heat-related illnesses and mortality) and systems to link the two types of monitoring are needed. It is important that such information is distributed effectively to healthcare workers as well as the general population, including visitors to the country (R4ACCHC, 2022c). Communication methods such as social media and traditional methods such as radio and television need to be employed.

Monitor and map the incidence of heat-related illnesses

Data on heat-related illnesses are not usually reported on a routine basis and thus the linkages between increases in heat-related illnesses and extreme weather events are usually examined only as part of a research project, such as Méndez-Lázaro et al.'s (2021) examination of the adverse health effects of the heatwave that occurred post Hurricane Maria.

Heat-related illnesses need to be routinely reported, with data collated and analysed at the national and regional levels. Sociodemographic differences in incidence should be identified so that adaptation measures tailored to specific groups can be developed. Population data should be collected according to age, sex and occupation, and climate data should include information on both temperature and humidity (R4ACCHC, 2023a).

Illnesses should also be geographically mapped against temperature data to identify localities where interventions to prevent and treat illnesses should be concentrated (R4ACCHC, 2023a).

Research and surveillance capacity-strengthening needs

In the Caribbean, CIMH collects national climate and environmental data, including on temperature, humidity and rainfall, while the Caribbean Public Health Agency collects national surveillance data for noncommunicable and communicable diseases, emerging diseases and injuries. The two agencies should strengthen their collaboration to link climate and health surveillance data. This includes the electronic integration of datasets and incorporating heat thresholds into analyses of health data. High-quality national and regional data are needed to downscale reanalysis of global data (R4ACCHC, 2023a). It is likely that both agencies will need financial and technical resources to boost such collaboration.

National surveillance data need to be collected to capture heat-related illnesses, and research capacity needs to be increased to analyse both climate and environmental data in the context of heat-related illnesses. As part of this research, equipment should be widely deployed to quantify ambient air temperature and humidity (R4ACCHC, 2023a). Furthermore, heat-related illnesses and mortality are underreported around the world generally, so improved training of health professionals in the Caribbean to recognise and document heat-related illnesses and mortality is essential.

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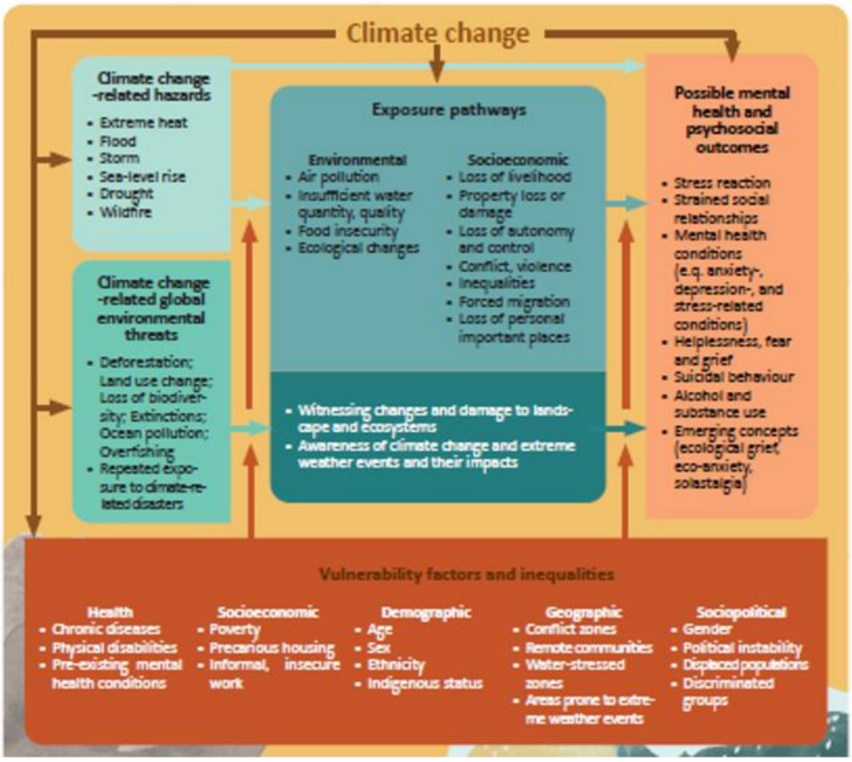
7. MENTAL HEALTH

7.1. WHAT IS HAPPENING?

The ways in which climate change-related hazards (referred to hereafter as climatic events, which include extreme heat, floods, storms, sea-level rise, drought and wildfires) can affect mental health and emotional well-being[1] are varied, complex and interconnected with other nonclimatic factors (health, socioeconomic, demographic, geographic, cultural and sociopolitical) that increase vulnerability. Climatic events could affect mental health either directly, such as experiencing a hurricane or heatwave, or indirectly, through exposure pathways such as poverty; loss of employment, crops or housing; or displacement and forced migration (Cissé et al., 2022; Dubrow, 2021; Herrán, 2021; R4ACCHC, 2022a,b,c, 2023a; WHO, 2022) (see Figure 1 and Chapter 8, "Population displacement and migration").

Figure 1: Main interlinkages between climate change and mental health



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Extreme weather events are associated with mental health and psychosocial outcomes such as anxiety, grief, depression, acute traumatic stress, posttraumatic stress disorder (PTSD) and aggression/violence. These can be associated with strained relationships, suicidal ideation, sleep problems, sexual dysfunction and drug or alcohol abuse, with the severity of the conditions ranging from mild to requiring hospitalisation to death by suicide (CARPHA, 2018, 2021; Charlson et al., 2021; Cianconi et al., 2020; Cissé et al., 2022; Comtesse et al., 2021; Dube et al., 2018; Gibson et al., 2020; Gordon et al., 2019; Hassan et al., 2020; Michael et al., 2021; Portier et al., 2010; PAHO, 2012; R4ACCHC, 2022b,c; Ramphal, 2018; Ravaliere and Murphy, 2017; Sharma et al., 2018; WHO, 2022).

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[1] In this document, "mental health" refers to mental health and emotional well-being.

Chronic stress has also been known to aggravate negative health outcomes among people living with noncommunicable diseases (Portier et al., 2010). Well-being is affected by various consequences of climate-related destruction, including the deterioration of one's surroundings, damage to one's property and disruptions to one's normal everyday behavioural patterns (Cissé et al., 2022). New phrases and concepts have been coined to describe some of these common conditions:

- Climate-related psychological distress can arise from observing changes to one's environment over time and experiencing a sense of loss. This loss can be felt especially keenly by individuals and communities with strong identity ties and attachment to their environment, which are important to their mental health. Indigenous populations are examples of such communities (Gibson et al., 2020).
- Climate change anxiety, or eco-anxiety, is related to the perception of the slow-moving impacts of climate change, such as rising sea levels and desertification, and changes such as the increasing frequency of flooding and hurricanes. Feelings of worry, fear, anger, grief, despair, guilt, shame, helplessness, hopelessness and uncertainty can arise, although the contributing factors may not be acknowledged by the individual experiencing these feelings. Sometimes these feelings can lead people to reassess their behaviour and make changes to minimise their contribution to climate change (Cianconi et al., 2020; Comtesse et al., 2021; Hickman et al., 2021; R4ACCHC, 2022d).
- Solastalgia refers to a sense of desolation, detachment and grieving in response to losing an important place. Solastalgia can be triggered by climate change-induced transformations of specific places, regions or territories greater than the home location, meaning a physical ecological loss of landscape, even if it is a gradual slow-moving process (Albrecht et al., 2007; Comtesse et al., 2021; R4ACCHC, 2022c).
- Ecological grief may be regarded as an extension of solastalgia. Solastalgia refers to loss of place, whereas ecological grief can come about due to all types of ecological loss (e.g. of species, ecosystems and ways of life). Ecological grief can be regarded as a response to past or future situations that may trigger loss, for example not being able to teach one's children to swim in the ocean that they, themselves, learned to swim in (Cianconi et al., 2020; Comtesse et al., 2021).

In a global study conducted to understand the feelings, thoughts and impacts associated with climate change among young people (aged 16–25 years), data were collected from over 10 000 young people in Australia, Brazil, Finland, France, India, Nigeria, the Philippines, Portugal, the United Kingdom and the United States of America. More than 50% of young people reported feeling sad, anxious, angry, powerless, helpless or guilty with respect to climate change. Over 45% said that their feelings about climate change have negatively affected their daily lives. In another study, climate anxiety and distress were positively correlated with perceived inadequate government response and associated feelings of betrayal (Hickman et al., 2021). Studies conducted in the Solomon Islands and Tuvalu have demonstrated that climate change is associated with worry about the future, especially regarding rising sea levels, and exerts negative impacts on well-being (Asugeni et al., 2015; Gibson et al., 2020). No similar studies have been identified for the Caribbean, and it is highly recommended that they are carried out (R4ACCHC, 2023b).

However, there have been some observations on the impacts of climate change on mental health in the Caribbean. In Saint Vincent and Dominica, psychologists have reported instances of rain showers triggering posttraumatic stress responses following experiences of floods and hurricanes. The Caribbean Alliance of National Psychological Associations (CANPA) reported that young adults (under the age of 25 years) have been feeling anxious about the future; social media has increased their awareness of the impacts of climate change; and they feel "impotent/desperate/hopeless due to perceived inaction of adults" (R4ACCHC, 2022c). The CANPA reported that young people are discussing their fears, older people are nostalgic for the past and middle-aged people are trying to understand the economic and health impacts of climate change (R4ACCHC, 2022c).

Neurological health can also be affected by climate-related factors such as extreme heat; exposure to hazardous chemicals, biotoxins and metals in air, food and water; and changes in pest management. Some harmful algal blooms, fuelled in part by warming waters, contain neurotoxins that affect foetal, postnatal and adult development (Portier et al., 2010). Air pollution can affect the cognitive ability of older people and exacerbate behavioural problems in children (Cissé et al., 2022). Polluted air causes neuroinflammation that is linked to neurodegenerative disorders such as Alzheimer's disease, Parkinson's disease and amyotrophic lateral sclerosis, and also some psychiatric disorders (Van Susteren, 2018). Malnutrition caused by food insecurity (to which climate change can contribute) can affect cognitive function and reduce educational achievement (Cissé et al., 2022). In addition, heat stress affects reaction time and ability to pay attention to tasks (Di Napoli et al., 2021; Mazloumi et al., 2014; Székely et al., 2015; Taylor et al., 2010).

Preexisting mental health conditions, such as anxiety disorders, increase the risk of individuals' physical (as well as mental) health being adversely affected by climatic events. People with conditions such as psychosis, dementia and substance abuse have a two to three times higher risk of death during heatwaves than people without such conditions, for example because of their not having the awareness to move to a cooler location. In addition, the side effects of some medications for mental illness can impair the body's ability to regulate its temperature, thus making people taking these medications especially vulnerable to heat stress, particularly older people (Lawrance et al., 2021; Nurse et al., 2010; PAHO, 2012).

Hotter temperatures have been found to be associated with increased psychiatric hospital visits, with both heat and drought amplifying the risk of suicide, particularly among people living in poverty (Brody, 2021). Furthermore, higher temperatures have been noted to be associated with decreased happiness and well-being, in addition to aggression and increases in the number of violent crimes committed (R4ACCHC, 2022e). A study conducted in the United States of America demonstrated that temperatures between 21 and 27 °C were associated with a reduction in well-being of 1.6% and temperatures above 32 °C with a reduction in well-being of 4.4%, compared to temperatures between 10 and 16 °C. These reductions were probably related to the adverse impacts on health, economic costs, social interactions or quality and quantity of sleep associated with hotter temperatures (Noelke et al., 2016). Excessive heat can restrict outdoor labour and limit one's capacity to fulfil one's potential in society, which can in turn have a devastating effect on one's mental health.

It is important to consider vulnerable populations and the inequalities associated with the mental health-related consequences of climate change (WHO, 2022). In the Caribbean, it is typically the most vulnerable populations (e.g. women, homeless people, indigenous people, older people and children) who are negatively affected by climate change and therefore suffer disproportionate mental health burdens (Dubrow, 2021). Perceived inequality and injustice can have greater negative impacts on mental health and the prevalence of violence than absolute, measurable levels of inequality (UNDP, 2012). Resentment and negative feelings, and the "acting out" of these feelings, may persist unless the health consequences of climate change on vulnerable populations, and on Small Island Developing States in particular, are addressed to the satisfaction of the Caribbean people, especially those who are poor and belong to one or more marginalised groups (Reckien et al., 2016).

Indigenous communities, and other communities, may define well-being in terms of being in harmony with nature and often form strong cultural and social ties with the environment. Extreme weather events and gradual environmental changes leading to long-term social, economic and cultural changes can undermine mental health because they bring about increased competition for resources, disruption of communities, displacement and loss of land or wildlife (Gibson et al., 2020; WHO, 2022). In the indigenous Wayana territory of Suriname there has been substantial deforestation due to gold mining. Deforestation, which contributes to climate change, has resulted in increased numbers of fires and floods, leading to concerns about food security and the availability of clean drinking water. Owing to food insecurity and the illegal redistribution of land for mining, young people in the Wayana territory do not feel secure in their own territory. This has led to experiencing feelings of hopelessness and uncertainty about their future, which has in turn resulted in high rates of suicide among 15- to 25-year-olds (Itoewaki, 2021; Vreedzaam, 2021).

The psychological effects of disasters often manifest in phases (which vary depending on the scenario and at the levels of the individual and the community), from a predisaster period to a honeymoon period through disillusionment to reconstruction and eventual recovery (Benjamin, 2015). Disillusionment may include feelings of despair, grief and abandonment. The full process can take over one year and be gradual, with possible relapses (CARPHA, 2018; Commonwealth of Dominica, Princess Margaret Hospital, Community Mental Health Team, 2017). However, there is evidence that, among some people, disasters can inspire hope, altruism, compassion and optimism, and instil a sense of purpose and promote personal growth. These positive psychological changes are known as posttraumatic growth and usually occur as people band together to console one another and rebuild their lives among the chaos and devastation (Augustinavicius et al., 2021; Hayes et al., 2018).

In the Caribbean, mental health services usually fall under the purview of the ministries responsible for health. There appears to be limited documentation of mental health services in the aftermath of extreme weather events, suggesting that the provision of such services is of low priority (Benjamin, 2015).

Antigua and Barbuda, the Bahamas and Jamaica have a mental health and well-being monitoring system in place to serve as an early warning system to trigger preventive action. The systems do not, however, include meteorological information (WHO and UNFCCC, 2020a, 2021a,b) (Table 1).

Table 1: Integrated mental health and wellbeing risk monitoring and early warning in Caribbean countries

Country	Monitoring systems in place	Monitoring system includes meteorological information	Early warning and prevention strategies in place to reach affected population
Antigua and Barbuda	yes	no	yes
The Bahamas	yes	no	yes
Dominica	no	no	no
The Dominican Republic	no	no	no
Grenada	no	no	no
Guyana	no	no	no
Jamaica	yes	no	no
Saint Lucia	no	no	no

Source: WHO and UNFCCC (2020a,b,c,d,e, 2021a,b,c).

In recent years, there has been increasing recognition globally of the importance of studying the impacts of climate change on mental health, but a limited amount of such research has been conducted in the Caribbean. Such research has focused on impacts post hurricanes/tropical storms (Michael et al., 2021; Ramphal, 2018; Sharma et al., 2018; Shultz et al., 2020). Increased diagnoses of PTSD and depression and incidents of suicide in the aftermath of hurricanes were found to have occurred after Hurricanes Dorian (2019), Irma (2017) and Maria (2017). It was found that 57.5% of adults receiving primary care from one specific health centre in the United States Virgin Islands demonstrated symptoms of PTSD (Michael et al., 2021). A low prevalence of PTSD among medical students in Dominica following Hurricane Maria was attributed to protective factors such as a comprehensive evacuation plan; safe shelter with adequate supplies of water, food and electricity; and the quick resumption of studies (Sharma et al., 2018). The reasons given for anxiety and depression in the aftermath of the hurricanes included possible future disaster events, housing, transportation, food insecurity, unemployment, homelessness and overall loss (Ramphal, 2018; Shultz et al., 2020). Schultz et al. discussed the "psychologically distressing experiences [of the initial medical] providers on the frontline. They were tired, overworked, deprived of sleep due to long hours, and worried about their own families and friends" (Shultz et al., 2020). Additional studies on the mental health impacts of nonclimatic disasters include studies of the 2010 Haitian earthquake (Dube et al., 2018; Hassan et al., 2020) and 1995 Montserrat volcanic eruptions (Brown et al., 2016). There has also been research conducted on the impacts of climate change-related environmental disruption on the mental health of vulnerable groups such as indigenous people and children (Itoewaki, 2021; Shultz et al., 2020; Vreedzaam, 2021).

After Hurricane Maria, the community of Mayaguez in Puerto Rico was provided psychological first aid (PFA) by four graduate students and six faculty supervisors from the Psychology Department at the Universidad Carlos Albizu, Centro Universitario Mayaguez (UCA-Mayaguez), as part of the initial response. The main services they offered included providing resources for basic needs, offering empathy and support and making referrals into the UCA-Mayaguez mental health clinic. Research was conducted to determine how the UCA-Mayaguez faculty and students supported the mental health of Puerto Rican people immediately following the hurricane. The results indicated that communication was a major issue and students and faculty used radio communication as an important vehicle to relay information about resources and available services. The students and faculty also used the radio as an access point and treated people as they waited in line at the radio station to send messages to family and friends. Once someone was identified as "being in crisis" (e.g. they needed to vent about a particular issue), a radio booth was provided to afford them privacy. Other access points included emergency shelters and UCA-Mayaguez itself, together with community outreach. It was noted that some individuals required more intensive mental health treatment; these individuals were triaged into the UCA-Mayaguez university mental health clinic, which opened three weeks after the hurricane hit (Alto et al., 2021).

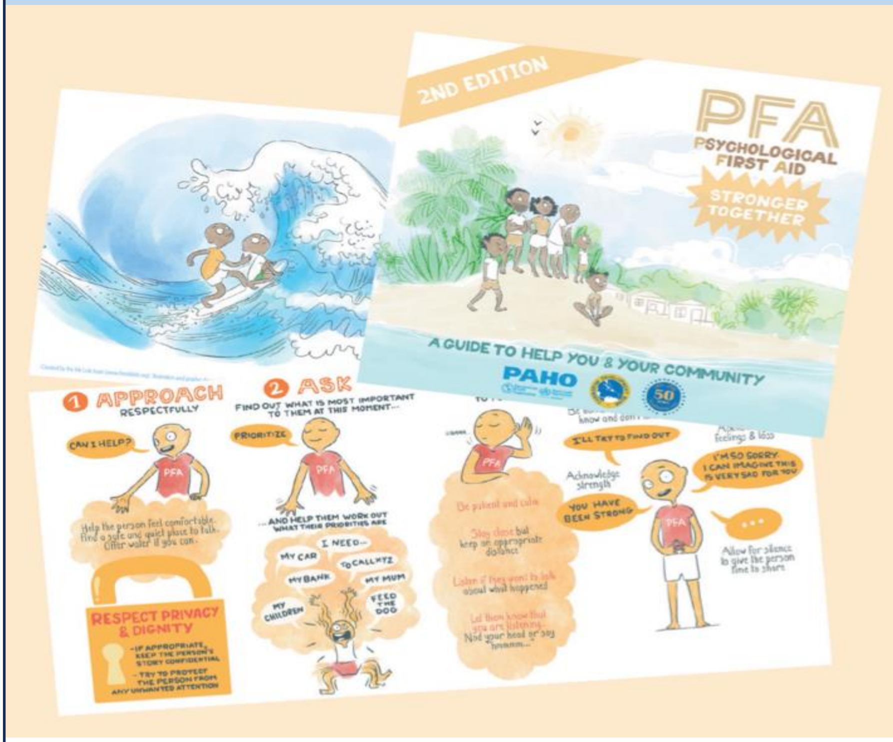
7.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Increase knowledge of mental health and emotional well-being and their management among the general and vulnerable populations pre, during and post extreme weather events

Box 1: Raising awareness and reducing stigma in the Caribbean

In the aftermath of the devastating 2017 hurricanes Irma and Maria, the Caribbean Development Bank and the Pan American Health Organization (PAHO) implemented an 18-month-long mental health project in the Caribbean. The project's capacity-building component included a PFA and Mental Health Gap Action Program Humanitarian Intervention Guide. The project also entailed awareness-raising, monitoring and evaluation, and country-specific development of realistic planning. The awareness campaign "Stronger Together" disseminated information on being able to cope and to raise awareness to reduce stigma around help-seeking.



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A study conducted in the Caribbean concerning public perceptions of climate and health among 3000 participants demonstrated that 75% of the respondents recognised that there was a connection between the effects of climate change and physical health, but only 61% made the same connection with mental health. This demonstrates the need to increase awareness of the relationship between the effects of climate change and mental health (Drewry, 2021). The general public should also be made aware of the signs and symptoms of mental health impacts and how to obtain the necessary help for themselves, friends and families. This awareness can also assist in reducing the stigma surrounding mental health (see Box 1). Healthcare providers in Grenada and Trinidad and Tobago perceived that there were more cases of mental illness due to the impacts of climate change, and expressed concerns that the stigma associated with mental illness was a barrier to seeking treatment (Macpherson and Akpinar-Elci, 2015). It is also important to teach the community how to discuss and practice culturally relevant coping strategies that can assist in providing comfort, building psychological resilience and reducing stigma attached to mental health conditions (R4ACCHC, 2023c).

Engage communities in climate change mitigation and adaptation interventions

Oftentimes people, particularly vulnerable populations such as young people and indigenous people, can become overwhelmed with feelings of anxiety, grief, uncertainty, hopelessness and a sense of impending doom about their future (Hickman et al., 2021). Including people in climate change adaptation interventions (R4ACCHC, 2023c), such as is being done by the [Mulokot Foundation of Suriname](), can be good for their mental health. To provide the indigenous Wayana population with agency, the foundation teaches them elements of sustainable farming, such as fish farming in nonpolluted, mercury-free waters (Itoewaki, 2021).

Young people can gain a sense of agency by taking part in advocacy and developing their own organisations and forms of activism, which may contribute to their feelings of accomplishment in the face of climate change challenges. Researchers and policymakers should actively seek community perspectives on climate change challenges and solutions (R4ACCHC, 2022c, 2023c), as was done in the Youth Forum at the 2021 Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean.

It is important to identify community members and organisations that can be involved in these interventions (R4ACCHC, 2023c).

Structural/governmental and private sector actions

Strengthen the capacity of national, local and regional mental health services

Mental health services are already overstretched. It is estimated that up to 50% of people with mental illnesses in high-resource settings and 90% in low-resource settings receive no treatment at all (Lawrance et al., 2021). The Caribbean overall, being a middle-income region (though with wide variation), probably falls between these two estimates. National, regional and local mental health services must be strengthened, and they should be integrated into disaster preparedness plans (PAHO, 2012; R4ACCHC, 2023c). The suggested ways to do this include (WHO, 2022):

- Ensuring that mental health services are included in health services at the primary care and local levels;
- Building referral pathways among mental health providers, general healthcare providers, community-based support and other services;
- Ensuring that every health facility has at least one trained person in place to identify and provide care for people with mental health conditions;
- Ensuring that medical pharmaceuticals and other technologies are integrated into the relevant treatment protocols and are on the disaster preparedness list of emergency supplies.

Creating a decentralised, community-based mental health system is one of the better options for immediate and appropriate response to the affected population in the aftermath of a disaster (PAHO, 2012). Creating a regional list of mental health providers is also recommended.

In the Caribbean, a multiplicity of state, nongovernmental and faith-based organisations provide mental health and psychological support services. In addition, other national, regional and international entities provide support and funding. Although decentralisation can facilitate flexible responses to needs, the coordination of services is critical for their efficiency and effectiveness (Weller and Boland, 2018). Central and local government entities should establish registers of providers, processes of referral and protocols for emergency response.

The Caribbean has a long history of collaboration among countries/territories, especially in the aftermath of disasters. After Tropical Storm Erika in 2015, it was recommended that the Government of Dominica accept the offer of psychiatrists and mental health workers from neighbouring countries (Benjamin, 2015). This spirit of cooperation should continue to increase collaboration among countries though agencies such as the CANPA (R4ACCHC, 2022c).

Include pre- and post-disaster management of mental health in national disaster preparedness and recovery plans

Mental health must be included in national disaster preparedness and recovery plans to reduce suffering and facilitate recovery. When mental health is included in such plans, both those affected and those who manage the risks are more likely to be resilient; actively engaged in prevention, preparedness, response and recovery; and working to reestablish normal living (IASC, 2021). Strategies need to address the issues of medication supply, communication before and after the weather event, and access to safe and secure shelter and nutritious food (CARPHA, 2018; Hassan et al., 2020). National and regional disaster and emergency response actors should be involved in coordinating mental health service delivery. This should supplement the work of mental health services, ensuring that basic needs such as food and shelter are met (Weller and Boland, 2018).

Given the association of mental health with a range of social and climate-change related factors, a whole-of-government, whole-of-society approach to developing disaster preparedness and recovery strategies is necessary. In addition, people with mental health conditions should be actively involved in planning and implementation to the extent that their conditions allow.

Develop and implement a comprehensive public communication strategy related to emergency management

Mental health conditions such as anxiety can be alleviated by the provision of information on how risks can be managed. If the public and vulnerable groups are provided with early warning of an impending extreme climatic event, their mental health will be less adversely affected. Communication should be continued, where possible, throughout the event and immediately after it, and, where necessary, into the future for as long as required. Social media, television, radio, mobile loudspeakers and flyers can be used. Information about where one can shelter and access food, water, health services and medicines, especially for vulnerable and sick people, can be communicated through these means (Alto et al., 2021). A media campaign can also be used to rebuild the morale of the population. Following Tropical Storm Erika in 2015, the Dominica Community Mental Health Team allowed the “heroic phase”, immediately after the storm struck, to pass before launching a two-month public media campaign using radio and TV. Members of the media also need training on psychosocial responses to enable them to respond better to disasters (Benjamin, 2015).

Train healthcare professionals and emergency first responders in the special medical and psychological needs associated with mental health related to disasters, including gender-based violence

It is necessary to ensure that there are sufficient numbers of health workers (e.g. psychologists and psychiatrists) and social workers to assist with the psychological recovery of people affected by disaster (PAHO, 2012; R4ACCHC, 2023c,d). Areas for training include survivor-centred support, case management, self-care and PFA (Weller and Boland, 2018).

As time goes on after an extreme weather event, personal, one-on-one care might be needed on a continual basis. One strategy, implemented after Tropical Storm Erika in Dominica, was to establish specialist mental health clinics within the affected communities to reach the victims and survivors (Benjamin, 2015). Another strategy, suggested after the 2017 Hurricane Maria in Dominica by the Dominica Community Mental Health Team, was to provide training to increase the number of people, including laypeople, with PFA and longer-term mental health training (Commonwealth of Dominica, Princess Margaret Hospital, Community Mental Health Team, 2017). The University of the West Indies and PAHO have collaborated to provide disaster-related psychological trauma and mental health training for emergency professionals in the Caribbean (Ocho et al., 2023).

The training of health professionals on mental healthcare responses to disasters should include approaches that destigmatise mental health, promoting concepts such as the following (Weller and Boland, 2018):

- Psychosocial support is about wellness, normal responses to abnormal circumstances and stressors and coping with these stressors, and not just about pathology and disorders.
- Stressors affect everybody and everyone may be vulnerable at one point or another, not just marginalised or “vulnerable” groups.
- Providers need psychosocial support too.
- Multiple factors influence behaviour and so interventions must be strategic, collaborative, coordinated and multidimensional.
- Gender is one of the important social constructs influencing behaviour and must be considered in the design of behaviour change interventions.
- Strongly held cultural attitudes, especially those based on religious beliefs, must be factored into design of interventions to maximise the positive impact of interventions on wellness.
- Barriers to the uptake of services may mean a reevaluation of roles and strategies (e.g. meeting the target group “where they are” rather than expecting them to come to a facility).

After Hurricane Maria, as part of the initial response the community of Mayaguez in Puerto Rico was provided with PFA by four graduate students and six faculty supervisors from the Psychology Department at the UCA-Mayaguez. The main services offered by the students and supervisors included the provision of resources for basic needs, offering empathy and support and making referrals to the UCA-Mayaguez mental health clinic which opened three weeks after the hurricane hit (Alto et al., 2021).

Each community/town should have a cohort of first responders who are trained not only in general first aid but also in PFA, to assist both the general public and vulnerable populations. To assist in community climate change adaptation, such training can be targeted to community members and conducted through partnership among community-based and other organisations using a train-the-trainer approach. PAHO values align with the essence of delivering PFA and could be a collaborator in the training of Caribbean PFA providers (PAHO, 2012). Collaborative arrangements between countries can boost the human resources available for post-disaster mental health response (Benjamin, 2015; Commonwealth of Dominica, Princess Margaret Hospital, Community Mental Health Team, 2017; R4ACCHC, 2022c, 2023c).

Other measures to increase the capacity of a mental health workforce include (WHO, 2022):

- Training healthcare managers on the effective integration of mental health into their climate and health plans and strategies;
- Ensuring that staff and volunteers are trained to manage their own mental health, and that they are provided with any necessary support when needed.

Research gaps and how to address them

Explore the relationship between extreme weather events and mental health

There is limited literature on mental health in the face of an extreme weather event in the Caribbean and such research should be prioritised (R4ACCHC, 2022d). Research using prospective and longitudinal research designs is needed to assess the short- and long-term impacts of events such as hurricanes, heat, drought, earthquakes and floods in the Caribbean (R4ACCHC, 2022c, 2023d). One longitudinal study outside the Caribbean examined the impacts of Hurricane Katrina. This study followed a cohort of young women that was established in 2004, one year before the hurricane struck, until 2020; at the end of the study, 30% of the women still showed signs of PTSD (R4ACCHC, 2022c). This study demonstrated the need to examine specific mental health diagnoses, disaggregated by gender, age and race, along with other diagnostic determinants, and their impact on the general public versus vulnerable populations. CANPA is an ideal organisation with which to collaborate for such research (R4ACCHC, 2022c, 2023d). Research questions could include, but are not limited to, the following:

- Do people with disabilities suffer greater mental health impacts?
- What are the mental health impacts on children, adolescents and young people?
- For how long after an extreme weather event do members of various vulnerable groups need mental health support?
- How do the mental health impacts of extreme weather events differ between people who evacuate and people who shelter in place?
- How do the mental health impacts of extreme weather events differ between people who are internally displaced and people who are externally displaced?
- How is the mental health of the general health workforce and the mental health workforce affected by extreme weather events?
- How do indigenous populations withstand the climate change impacts on their mental health? Even though natural disasters have always existed, what is their capacity to understand, cope with and recover from such extreme events (R4ACCHC, 2022c)?
- What are the psychological impacts of earthquakes (R4ACCHC, 2022c)?

Such research can assist with the development of prevention and treatment options (Dubrow, 2021).

Identify the challenges faced by the healthcare system with respect to mental health during and after extreme weather events

There is likely to be an increased need for mental health services as a consequence of extreme weather events (Brody, 2021; Cissé et al., 2022; Dubrow, 2021; Herrán, 2021; WHO, 2022). The areas in which research should be conducted and improvements could be made in responding to mental health needs include planning and preparedness; expanding the mental health workforce and training of existing staff; access to, and cognisance of, the cold-chain supply for medications for treating mental disorders; and addressing shortages of ambulances and hospital beds.

Conduct research on mental health concerns specifically associated with climate change

Surveys to examine how the general population feel about climate change and its associated risks have been conducted in various countries, but not in the Caribbean. To inform communication campaigns and support mechanisms in the Caribbean, therefore, surveys should be conducted in Caribbean countries.

Feelings of intense grief and hopelessness can be brought on by climate change, particularly among young people. People may experience climate change anxiety or eco-anxiety, solastalgia, ecological grief or climate-related psychological distress, which are new and emerging mental health concepts. Individuals experiencing such despair may be unable to express it, and medical providers are often unaware that their patients are experiencing these feelings (R4ACCHC, 2022c). There needs to be further exploration so that these concepts, the risk factors that cause these reactions, attitudes towards self-care, and the vulnerable populations that may experience these emotions can be understood. This will assist in identifying specific prevention and response actions (R4ACCHC, 2022c; WHO, 2022; R4ACCHC, 2023d).

Explore changes in cognition of vulnerable populations due to climate-related events

The cognitive abilities and neurological health of vulnerable populations such as children, people with disabilities and older people are known to be affected by climate hazards. It is important to better understand how adaptation measures (such as the use of air conditioning to reduce ambient temperatures in, for example, child day care centres, schools and homes for older people) can improve cognition and neurological health. This will assist in the planning and effective distribution of limited resources (R4ACCHC, 2023d).

Determine the effectiveness of actions at the individual, community, structural/governmental and private sector levels

To ensure that any actions are effective, it is necessary to monitor and assess them. Such assessments may take the form of process, impact and/or cost-effectiveness evaluations. Determining the barriers to and facilitators of the implementation of suggested actions would also be helpful in determining the limitations, challenges and recommendations associated with them. Research questions could include, but are not limited to, the following:

- After a health promotion intervention, was there an increase in awareness, especially among vulnerable populations, of the relationship between climate change and mental health? Was there an increase in knowledge of the signs and symptoms of mental illness, and where to get help?
- What have been the barriers to and facilitators of PFA training?
- Have mental health services been successfully incorporated into primary health care?
- Were public communication strategies successful in making the public, especially members of vulnerable populations, aware of where to access food, water, health services and medicines?
- Are there sufficient numbers of healthcare professionals and emergency first responders trained in the needs associated with mental health related to climate disasters?
- Did mental health preparation increase well-being after an extreme weather event?
- How did the media influence mental health after an extreme weather event?

Surveillance gaps and how to address them

Establish surveillance of mental health conditions

The lack of surveillance data on mental health and the distribution of psychological conditions across places, populations and time is a severe hindrance to research and action to address climate-change related mental disorders. Alliances with mental healthcare providers need to be formed to enable reporting and development of centralised national databases along the lines of the NCD registries currently being established. Because mental health conditions tend to be underreported to medical services, the limitations of such registries would need to be taken into account when designing research and interpreting surveillance. Nevertheless, administrative data from mental health services can help monitor reporting patterns and care and support services provided, offering guidance for service management and policy (R4ACCHC, 2023b).

Establish emergency response plans for the needs of people with mental health conditions

People living with NCDs, including mental health conditions, are among those who will be most adversely affected by extreme weather events or other natural disasters (Hassan et al., 2020). Community watch teams can help monitor the health status of people with preexisting conditions, including mental health challenges, and help ensure they have access to care (PAHO, 2018). To protect people with mental health challenges from stigma, local registries need to adhere to strict confidentiality standards.

Establish a surveillance system that integrates mental health outcomes and climate and weather information

Once the surveillance of mental health conditions and service provision is established, analyses of the impacts of climate change on mental health can be conducted, and early warning systems developed. For example, links between increases in ambient air temperature and heatwaves and mental health outcomes can be further established and early warning systems implemented accordingly (Cissé et al., 2022; Dubrow, 2021; WHO, 2022).

Monitoring increases in ambient air temperature could enable medical services to be alerted when there is likely to be increased use of health care due to mental health challenges caused by extreme weather events (WHO, 2022).

Establish surveillance systems to monitor long-term impacts of mental health post extreme weather events

Immediately following an extreme weather event, medical and psychological care may be made available, but specialised mental health care is frequently discontinued as things get back to normal. Oftentimes mental health disorders, such as PTSD, and their potential outcomes, such as suicide and attempted suicide, do not manifest until months after the event. It is therefore recommended that systems be created for the active and intense monitoring and surveillance of mental health disorders and their potential outcomes, in addition to proxy indicators such as gender-based violence, for at least 12 months after an extreme weather event.

Research and surveillance capacity-strengthening needed

Technical assistance may be necessary to build surveillance expertise and systems on mental health. Without this, research and action on links between climate change and mental health in the region will be hampered. National ministries responsible for health, along with regional agencies, such as the Caribbean Public Health Agency (CARPHA), need to strengthen mental health surveillance to capture and monitor cases of mental disorders, including psychosis, PTSD, depression, anxiety and dementia. Collaboration between mental health surveillance systems and national and regional meteorological and environmental agencies and ministries will facilitate examination of the effect of sudden-impact, extreme weather events (e.g. hurricanes) and slow-moving environmental changes, such as deforestation and sea level rise, on mental health (R4ACCHC, 2023d).

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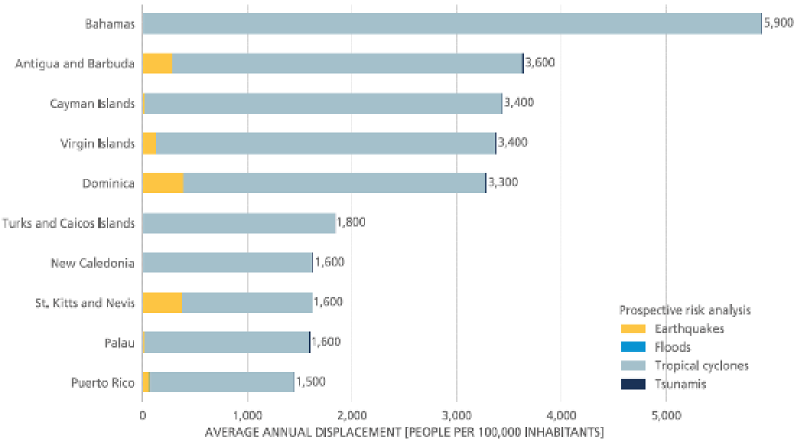
8. POPULATION DISPLACEMENT AND MIGRATION

8.1. WHAT IS HAPPENING?

Migration is a strategy that individuals and households may undertake to improve health, well-being and livelihoods in response to economic uncertainty, political instability, persecution or environmental change. Voluntary migration can be used when adapting to the impacts of climate change, whereas involuntary forms of migration and displacement occur when other forms of adaptation are inadequate and migration as a response to climate change is the only choice (Cissé et al., 2022).

The Internal Displacement Monitoring Centre (www.internaldisplacement.org/aboutus) has developed a measure based on estimates of the average number of people expected to be displaced each year by sudden-onset hazards, including flooding, tropical cyclones, tsunamis and earthquakes: the average annual displacement (AAD) measure. Relative to population size, the 10 countries with the greatest AAD are Small Island Developing States (SIDS), of which 8 are in the Caribbean (see Figure 1). The Bahamas, for example, is at risk of an annual average of 5900 people per 100 000 inhabitants, or 5.9% of its population, being displaced by tropical cyclones (Anzellini et al., 2017). Extreme storms and floods are the most significant weather-related drivers of population displacement globally (Desai et al., 2021). Hurricanes have caused major displacement and migration from Barbuda, the Bahamas, Dominica, Puerto Rico and the United States Virgin Islands internally, and also externally to neighbouring islands and outside the region (Blocher et al., 2021; Brown et al., 2016; Campbell and Emmanuel, 2019; Desai et al., 2021; Dubrow, 2021; Hill, 2014; R4ACCHC, 2022a; Thomas and Benjamin, 2020). Displacement can be temporary or permanent, and can be caused by the need to seek housing, medical care, education, food security, employment and/or a sense of security. Some temporary migration occurred after Hurricane Maria (2017) in Dominica, where many people left in the immediate aftermath and then returned home within a year to rebuild and reestablish themselves (CARPHA, 2018). Displacement can also occur when one's livelihood is affected by climate change, as is happening to farmers, fisher folk and people working in the tourist sector. Water and food insecurity and coastal erosion associated with climate change can also lead to migration (CARPHA, 2017; Kelman et al., 2021; Ravaliere and Murphy, 2017).

Figure 1: Average annual displacement relative to population size (Number of people displaced per 100,000 inhabitants)



Source: Internal Displacement Monitoring Centre, with United Nations Population Division data (Anzellini et al. [2017]), licensed under CC BY-NC-SA 3.0 IGO.

National systems that are sensitive to climate change, such as food, education and health systems, and national economies can be placed under strain due to an influx of migrants. Migrants can move toward, as well as away from, areas heavily affected by climate change, since their migration may be motivated by a variety of factors. In the Caribbean, rural to urban migration presents environmental challenges as cities and towns are often overcrowded and lack capacity for expansion due to surrounding hills and their proximity to the coast. Existing climate change-related urban problems may be aggravated, such as the urban heat island effect, air pollution and flooding (Campbell-Lendrum and Corvalán, 2007). Migration from the Caribbean to developed countries presents similar challenges, although limitations in the capacity of destination countries to cope with the influx may be exaggerated by politicians who encourage xenophobia for their own political ends (Parenti, 2011). Informal settlements, often occupied by migrants, are especially vulnerable to health impacts of climate change (Heslop-Thomas and Bailey, 2006).

It is believed that climate change has interacted with economic and political pressures to cause the migration of over 7 million people from Venezuela to other countries globally. As of November 2022, over 200 000 Venezuelans had migrated to the Caribbean, specifically to the Dominican Republic (115 300), Trinidad and Tobago (35 300), Guyana (19 600), Aruba (17 000) and Curacao (14 000) (R4V Inter-Agency Coordination Platform for Refugees and Migrants from Venezuela, 2022a). Global warming and drought have caused most of Venezuela's glaciers to disappear. Without adequate rain or glacial supplies, Venezuela's hydroelectric power production, which supplies most of the country's electricity, has diminished. Venezuela has also been affected by water and food insecurity. Trinidad and Tobago has been the largest recipient of Venezuelan migrants per capita. This rapid and huge influx as a proportion of the total population has placed a burden on Trinidad and Tobago's systems and resources, including health care, especially during the COVID-19 pandemic (Chemnick, 2019; Dubrow, 2021; Lindo, 2021).

Climate displacement has gendered dimensions. In some cultures (e.g. Maasai in Tanzania), it is often able-bodied men who migrate first, leaving behind women as primary caregivers to children and the elderly (Cissé et al., 2022). However, among Venezuelan migrants into the Caribbean, there are more women than men (R4V Inter-Agency Coordination Platform for Refugees and Migrants from Venezuela, 2022b). Women, children and lesbian, gay, bisexual, transgender and intersex people may be at particular risk of sexual and physical abuse in migrant shelters, affecting their mental health and well-being (Brody, 2021).

Health outcomes of migration vary according to geographical context, country of origin and circumstances of migration. The "healthy migrant effect" refers to the observation that migrants tend to be healthier than non-migrants remaining in their communities of origin (Hunter and Simon, 2017). This may be because migrants, before the start of their journey, tend to be in good health and financially better off than non-migrants. However, the "healthy migrant effect" does not always hold. People involuntarily displaced because of severe weather events are less likely to be in good health and the trauma of migration may worsen their health status (Cissé et al., 2022; Ravaliere and Murphy, 2017). During the migration process and after they reach their destination, involuntarily displaced people may face a lack of adequate shelter, food, water and health care; the loss of social networks; economic hardship; crowded living conditions; and even prolonged detention. These factors can lead to the exacerbation of noncommunicable diseases, the spread of infectious diseases, sexual and gender-based violence, injuries, poor pregnancy outcomes and mental disorders.

Involuntary displacement and migration can lead to or exacerbate mental illness. This can be aggravated by the interruption of health care, sleep deprivation, unhygienic accommodation, heightened exposure to vector- and water-borne diseases, and vulnerability to sexual abuse, substance misuse and violence (Cissé et al., 2022; Herrán, 2021; R4ACCHC, 2022a). For example, changes in physical environment can cause emotional distress and disorientation and the loss of one's home can create feelings of loss of permanence, belonging and personal identity. For both those migrating and those remaining, there can be feelings of loneliness and insecurity (WHO, 2022). After Tropical Storm Erika in Dominica in 2015, the primary perceived healthcare need identified by healthcare providers and displaced survivors was mental health services for adults and children (Ravaliere and Murphy, 2017). Displacement can be particularly traumatic for indigenous populations with a deep attachment to their land. On the other hand, migration from SIDS can improve mental health and well-being. Such was the case for migrants from Tonga, particularly women, to New Zealand, where their improved mental health and well-being was attributed to greater income and social opportunities, and also better public services (Kelman et al., 2021).

Migrants may be exposed to new infectious diseases in the host country, with insecure access to health services, housing and jobs aggravating their vulnerability. Care must be taken to develop culturally sensitive health systems and services to protect both the migrants and the host communities (Cissé et al., 2022; R4ACCHC, 2022a). For example, the vaccination of migrants against infectious diseases not only protects migrants, but also helps to provide herd immunity to the entire host community.

Climate change may aggravate existing inequalities and patterns of marginalisation (Foresight, 2011). Wealthier households and those with higher levels of educational attainment have a greater capacity to adapt to a climate hazard and remain *in situ*. However, they also have greater resources to migrate and may do so. Lower-income households have fewer resources to enable them to adapt *in situ* or to migrate. Thus, the migration of lower-income households is often as a reaction to the loss of livelihoods, and the move often intensifies their poverty status and their exposure to future climatic and other hazards in their new location (Cissé et al., 2022; Natarajan et al., 2019). Some people are not capable of migrating for reasons such as health and mobility challenges and a lack of financial resources; others, for a variety of reasons, do not wish to leave their homes. These circumstances can cause increasing poverty and exposure to climate drivers of ill health.

In the Caribbean there has been limited research on the effects of climate change-induced displacement (internal or external) on health and health systems. Research has tended to focus on migration resulting directly from extreme events such as hurricanes and the impacts on mental health (CARPHA, 2018; Herrán, 2021; Mezdour et al., 2016; Ravaliere and Murphy, 2017). There are some studies from the Pacific Islands that have examined climate and nonclimate drivers of migration and effects on health (Blocher et al., 2021; Mycoo et al., 2022).

8.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Include communities at risk of displacement and displaced people and migrants in developing response plans for population displacement and migration

Within countries, local and national government agencies and communities at risk of displacement should collaborate to identify the geographically defined communities most at risk of displacement through climate drivers such as sea level rise, flooding, landslides, bush fires and tropical storms (Mycoo et al., 2022). Contingency arrangements such as temporary accommodation, evacuation plans and permanent resettlement plans should be put in place. Strategies of "managed retreat" from coastlines and other areas threatened by climate change should be operationalised. Given that the hurricane season remains somewhat predictable, plans for relocation should be accelerated in the run up to and during hurricane season (R4ACCHC, 2023).

If external migration becomes necessary, communities of migrants now resident in the destination country (diaspora communities) can assist with developing contingency plans regarding how displaced people will be relocated and how families can be kept together. Individuals and organisations from the home country and in the diaspora can provide important sources of support. For instance, Caribbean people and organisations based in high-income countries often provide remittances to support people who have been affected by disasters within the region. They also sometimes assist in facilitating temporary or permanent relocation to other countries and in providing support in those countries.

Structural/governmental actions and private sector actions

Ensure a coordinated governmental and community response

Government agencies, in collaboration with faith-based and nongovernmental organisations, especially migrant organisations, should consider the needs of displaced people in planning for the hurricane season. Plans for shelter, food, clothing and housing can be made in advance. Schools, churches and community centres can be checked for suitability as temporary housing, and a list of households able to house displaced people can be drawn up (R4ACCHC, 2023).

Develop strategies for managed retreat: orderly, planned migration away from areas at extremely high risk of adverse climate impacts

There are areas at such high risk of adverse climate change impacts that movement of people away from these areas is virtually inevitable – the question is whether this retreat will be orderly and planned versus chaotic and unplanned. Very low-lying coastal areas threatened by sea level rise are a primary example of these high-risk areas. Managed retreat, which can involve movement of both people and infrastructure, has obvious advantages over unplanned retreat, which can involve substantial destruction and hardship. However, it is crucial that strategies for managed retreat involve full input from and the consent of affected communities (R4ACCHC, 2023). Dominica has developed a strategy for relocating people away from hazard-exposed areas. This can be adapted to other Caribbean countries/territories (Blocher et al., 2021).

Develop strategies that improve access to health care for climate migrants

From a public health perspective, it is important to provide migrants with full access to healthcare services (R4ACCHC, 2023). Without such access, health problems among migrants may be aggravated. These potential problems include health conditions caused by the trauma of the move and encounters with new sources of disease in the host country, as well as preexisting health conditions and infections. Health conditions brought by migrants may also affect the host population. A leading concern in host countries is that migrants may bring infectious diseases against which the host population has limited or no immunity. For instance, it has been noted that the Caribbean was a “hotspot” for the spread of chikungunya and Zika to North and South America through the travel and migration patterns of Caribbean people and through tourism (Mavian et al., 2018).

Develop strategies that afford climate-related migrants the same status as refugees

Climate-related migrants are not afforded the same status as refugees. There are no legally binding agreements obliging countries to support climate migrants (Lindo, 2021). Caribbean policymakers need to develop agreements on how climate migrants within the region will be accommodated (and to ensure their access to health care). There is also a need for advocacy to increase responsiveness to climate migrants’ needs in countries outside the region. Caribbean governments’ work on climate adaptation can help prevent the need for migration to countries outside the region.

Include climate migration and population displacement in regional and national disaster preparedness and recovery plans

The needs of people displaced by climate change within and between countries should be integrated into regional and national disaster preparedness and recovery plans, based on assessments of the needs of each country/territory and the capacity to support migrants from other countries/territories (R4ACCHC, 2023). Planning must consider:

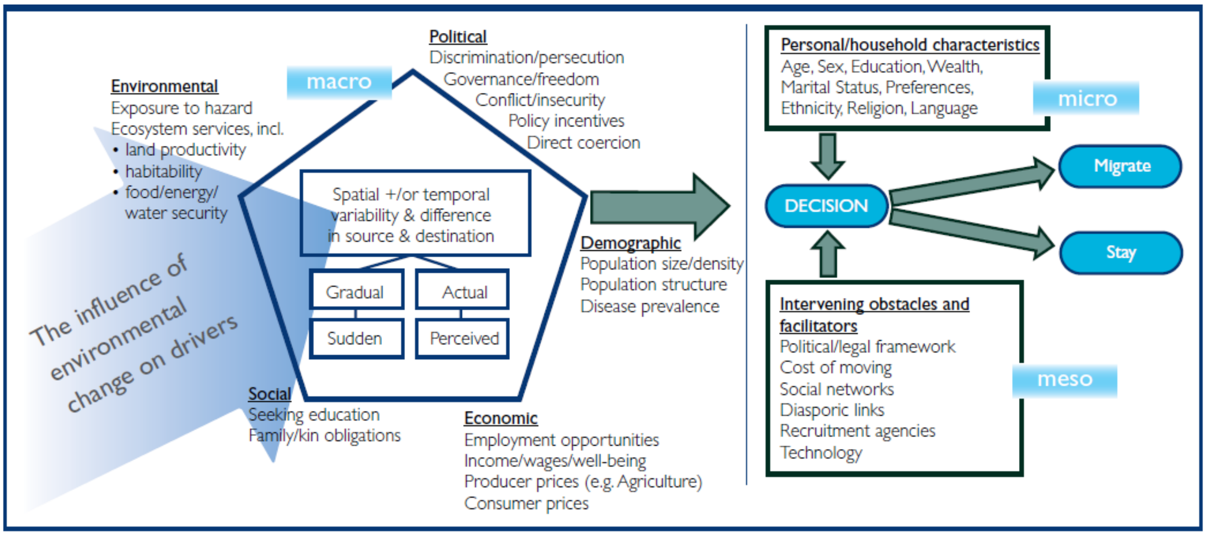
- Internal migration within one country/territory, e.g. rural to urban mobility;
- Migration between Caribbean SIDS or from other geographical areas into the Caribbean (e.g. Venezuela);
- Temporary versus permanent migration;
- The impact on national systems of receiving countries, notably health care (including mental health), social services, education, housing, education and security;
- Vulnerable groups such as women and children, people with disabilities and those who remain in the affected area.

Research gaps and how to address them

Identify the push factors for Caribbean migration

The Foresight framework demonstrates that the decision to stay or to migrate is contextual. It is influenced by multiple complex and interrelated social, economic, environmental, political, personal and household factors (Foresight: Migration and Global Environmental Change, 2011; Figure 2). The combination of factors driving Caribbean migration needs to be identified to better prepare for, adapt to and recover from climate-related hazards. Using this framework, research can be conducted with people who have migrated to identify the combination of factors that pushed them to migrate, including the role of climate change.

Figure 2: Foresight migration decision framework



Source: Foresight: Migration and Global Environmental Change (2011);
licensed under the Open Government Licence v1.0.

For policymakers to understand the context in which displacement risk occurs, the INFORM Risk Index can be used. This is "a composite indicator that identifies countries at risk of humanitarian crisis and disaster that would overwhelm national response capacity" (INFORM Risk Index, 2022; R4ACCHC, 2023). There are three main components (Anzellini et al., 2017):

1. Natural hazards and exposure: events that might occur and exposure to them. Hazards include tropical cyclones, seismic events (earthquakes and volcanic eruptions), floods, droughts and tsunamis.
2. Socioeconomic stability: this quantifies what makes a population vulnerable when faced with a hazard. It is calculated using development, deprivation, inequality and aid dependency components. It uses country-level indicators such as the United Nations Development Programme Human Development Index, a measure of inequality (the Gini coefficient) and the total official development assistance per capita in the last two years.
3. Institutional capacity: this evaluates governments' priorities and institutional readiness in implementing disaster risk reduction activities.

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is studying displacement and migration and may prove a useful international collaborator and funder for such research (R4ACCHC, 2022b).

Determine the cost of displacement and migration to inform humanitarian responses and national disaster planning and coordination

The cost of population displacement and migration is not only at the individual and family levels. There is also a cost to the community and national economies of both the country/area that has lost part of its population and to receiving countries/areas. Some questions include the following (R4ACCHC, 2023):

- For the migrants and receiving country/area:
  - What are the costs of housing, education, health and security for a displaced person?
  - What is the loss of income to the individual/family while trying to rebuild their home in a new country? What is this loss of income at the community and national levels?
- For those who remain and do not migrate:

- What are the costs of long-term consequences of not migrating? Costs to the individual could include loss of health, housing or land, and employment costs to the economy could include the costs of rebuilding and providing economic and social support to those who remain, or the eventual cost of future relocation.

Examine the connections between climate-related migration and health

There has been limited exploration of the effects on health of climate-related migration in the Caribbean. There is some evidence of mental health and well-being impacts on migrants (R4ACCHC, 2023). Some questions that can be examined include:

- What are the mental health challenges among climate migrants, and what are their specific causes?
- How does the incidence of infectious or chronic diseases compare among migrants versus the general population in places of origin and destination?
- What are the implications for healthcare provision? How can healthcare systems respond to promote health-seeking behaviour and access to health care among displaced people and among those left behind?

To answer these questions, data on health conditions need to be collected from both migrants and the general population. Collection of data from migrant communities can be challenging as they may not be in contact with services, especially if they are undocumented. Outreach services for migrants based on human rights principles need to be developed to increase access to services and enable the collection of the necessary data based on ethical research practices. The health of climate-related migrants should be disaggregated by sex, gender, race, ethnicity and age.

Identify the challenges faced by the healthcare system with respect to providing high-quality health care to migrants

One of the greatest challenges to migrants is access to health care. Migrants may have chronic conditions, such as noncommunicable diseases and HIV, that require ongoing treatment and medication. They may be exposed to new infectious diseases in the host country, and they may transmit diseases in the receiving community. Host healthcare systems must be equipped with information from research and surveillance. This will enable them to develop an efficient and competent administrative and medical workforce and appropriate medicines and technologies to respond effectively to care for migrants, especially when there is a sudden influx. Care must also be taken to develop culturally sensitive health systems and services (Cissé et al., 2022).

Conduct a review of national policies and regional (e.g. Caribbean Community and Organisation of Eastern Caribbean States) policies, treaties and agreements regarding immigration and refugees

It is important to identify which countries have migrant and refugee policies and how these relate to health and safety. Regional policies, treaties and agreements on migrants and refugees should be reviewed to assess their suitability in the context of climate-related migration and displacement. Policies on access to health care by migrants should receive special attention. This review should inform new agreements between Caribbean countries and with other countries on how the health and safety needs of migrants and refugees will be met, with a special focus on diseases associated with climate change as identified in the current report.

Determine the effectiveness of the individual, community, structural/governmental and private sector actions suggested above

Research questions for evaluation could include, but are not limited to, the following:

- What community preparations have been put in place to address the needs of displaced people in planning for the hurricane season? Did these preparations effectively meet their needs?
- What are the barriers to and facilitators of implementing policies that assist Caribbean governments with internal and external migration?
- Have national governments and regional entities such as Caribbean Community (CARICOM) and the Caribbean Public Health Agency put policies in place to ensure the health, safety and human rights of migrants?
- Have climate-related migration issues been included in national disaster preparedness and recovery plans?
- What is the economic impact of migration on the receiving country's health system?

Surveillance gaps and how to address them

Conduct disaster displacement risk assessments for both immediate climate-related disasters and long-term, slow-onset climate-related events

Climate-related displacement and migration can be addressed by a range of measures such as planned relocation that is voluntary (to a certain extent) with accompanying finances, or by building up the resilience of at-risk populations that may refuse to move from potentially high-risk disaster zones. Disaster risk assessments, including an estimation of the size of at-risk populations and available resources, will help communities and local and national governments to plan for displacement caused by short-term climate-related disasters such as hurricanes and floods or longer-term impacts such as sea level rise, drought and land erosion (Desai et al., 2021; R4ACCHC, 2023).

Monitor reasons for migration and the health concerns of migrants

There are challenges in monitoring climate-related migration. It is not always ethical or practical to monitor the movements of individuals or to enquire as to why they moved. Given national restrictions on immigration, there are risks in divulging reasons for migration, and undocumented migrants by definition do not appear in official records. For these reasons, it may only be possible to query documented migrants about the reasons they migrated. Censuses may present opportunities to record reasons for migration to a country, but questions on reasons for migration may be subject to reporting bias given the sensitivities around migration. Health surveys should be conducted periodically among migrants, comparing their health status and the environmental conditions they face with those of non-migrants. Following extreme events, monitoring of population movements should be undertaken, and samples of mobile populations may be involved in studies to record the circumstances that caused them to move, their health concerns and their access to essential services.

Strengthen monitoring of population displacement and migration resulting from severe weather events

Following hurricanes, the number of people in shelters is taken as a measure of population displacement. This approach is limited, since many people may take shelter in other households or buildings, and some may find no shelter and become homeless. It is important that local government entities conduct inquiries as to the local patterns of displacement and shelter-seeking in their communities and provide support to households and other private and public entities providing shelter. In the months following severe hurricanes, it is important to monitor travel patterns to assess the extent of temporary and permanent migration to other countries.

Research and surveillance capacity-strengthening needs

Climate-induced population displacement and migration can be voluntary or involuntary. It is very contextual and multidimensional. Researchers or research teams need to be proficient in many different technical areas such as economics, sociology, psychology and urban planning. They also need to be competent in both qualitative methodologies, to ask the “why” and the “how” questions, and quantitative methodologies, to ask the “how much” and “how many” questions.

Information technology databases need to be created to link the health impacts of population displacement, such as on mental health, to environmental hazards such as hurricanes. Demographic data on migrants experiencing these health issues need to be captured and monitored over time to enable better health outcomes.

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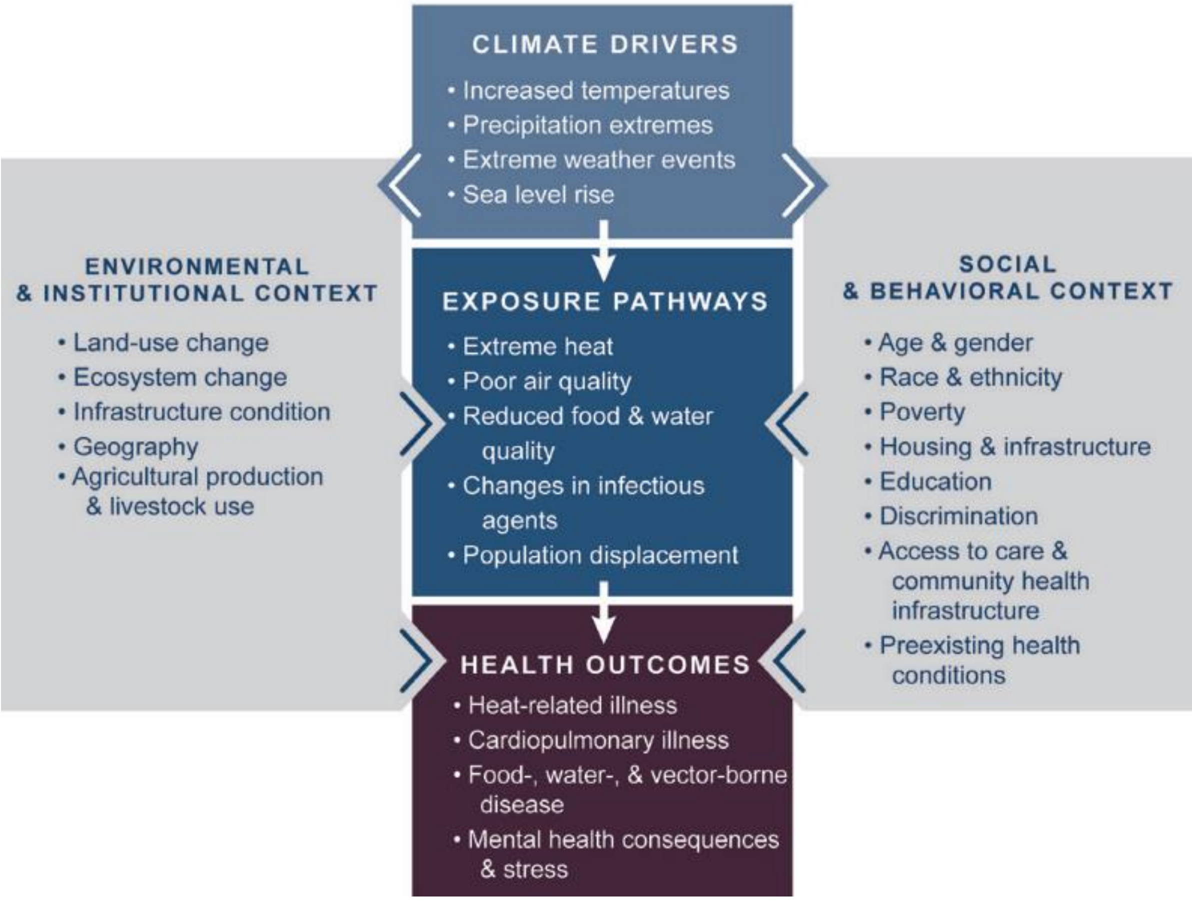
9. DISTRIBUTION, EQUITY AND JUSTICE IN CLIMATE CHANGE AND HEALTH

9.1. WHAT IS HAPPENING?

The question of whose health is more affected by climate change is of critical concern. How we manage natural and built resources and the distribution of social and economic resources are determinants of the impacts on health of climate change and their variation among population groups. Variation in preexisting biological and health conditions also determines health outcomes (Allen, 2021; USGCRP, 2016). We consider issues of resource management in Chapters 3, “Water, sanitation and hygiene”, 12, “Agriculture, food safety and security”, 14, “Marine resources and health”, 15, “Climate-friendly health-promoting infrastructure”, and 16, “Smart health facilities”. Resource management is part of the environmental and institutional context depicted on the left of Figure 1, which influences the exposure pathways of climate drivers, thereby moderating health outcomes. In this chapter we consider the social and behavioural context, depicted on the right of Figure 1. This context affects the distribution of health outcomes among populations and thus raises issues of equity and climate justice.

Figure 1: Primary exposure pathways by which climate change affects health



Source: USGCRP (2016).

Social determinants of health and climate change

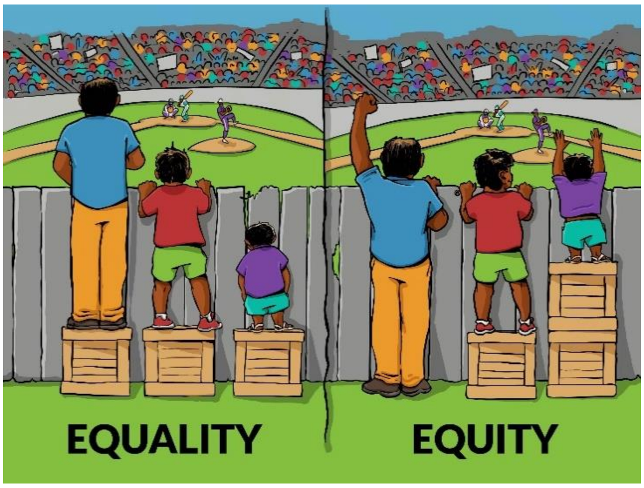
The social determinants of health approach (Marmot, 2005; WHO, 2023a) asserts that the circumstances in which people are born, work, live and age are critical determinants of health. These circumstances are shaped by the distribution of power and resources. To understand health outcomes from a public health perspective, it is important to look beyond immediate symptoms and medical diagnoses to "upstream" factors such as income, education and poverty, which can make a huge difference to an individual's ability to prevent illness and attain health and well-being. People need access to tangible and intangible resources such as energy, gainful employment, health services, education, water and food in order to survive and thrive. All of these affect health and all are affected by climate change (R4ACCHC, 2022a). The impact of climate change on essential resources (described in Chapters 3, "Water, sanitation and hygiene", 12, "Agriculture and food safety and security", 14, "Marine resources and health ", 15, "Climate-friendly health-promoting infrastructure", and 16, "Smart health facilities") compounds existing inequalities, such that approximately half of the population of the world does not have access to an acceptable quality of environmental services such as water and sanitation (Galvão et al., 2009).

Economic policies and systems, development agendas, social norms, social policies and political systems favour some individuals and populations more than others and compound inequalities in access to resources. Some social constructs, such as gender and race, are hierarchical, producing inequalities. Discrimination on the basis of gender or race intersects with other factors of discrimination, such as socioeconomic status, disability, age, migrant status and sexual orientation. This is referred to as intersectionality (World Health Organization, 2023b). These "structural factors" create "social gradients" in health outcomes, with health being positively related to control over resources and higher social status (Marmot, 2005).

Genetic factors and preexisting medical conditions also affect health outcomes. Climate change adds to the number of people in vulnerable populations (Drewry, 2021), given its effects on the incidence of long-term illness, noncommunicable diseases (NCDs) (see Chapters 2, "Vulnerability to vector-borne diseases', 4, "Noncommunicable diseases and risk factors", 5, "Air quality", and 7, "Mental health"), displacement, migration (see Chapter 8, "Population displacement and migration") and access to basic utilities and health care (see Chapters 3, "Water, sanitation and hygiene", 15, "Climate-friendly health-promoting infrastructure", and 16, "Smart health facilities").

Ethical concerns about equality and equity underlie the social determinants of health approach and inform strategies to address them. To achieve equality in outcomes, it is often not enough to treat people equally. This is because preexisting social and economic conditions and hierarchical social norms handicap the abilities of groups to compete on equal terms. Affirmative action may be necessary to achieve equity, which is a key factor in enabling disadvantaged populations to elevate their health status to the level of already advantaged populations. This applies on the global scale, to achieve climate justice among countries, and on the national or local scale, to achieve climate justice among populations. The diagram in Figure 2 is often used to illustrate the difference between equality and equity, showing that redistribution to the person who is in a position of disadvantage is necessary to achieve equal access to opportunities.

Figure 2: Equality vs. equity



Source: Interaction Institute for Social Change (interactioninstitute.org) | Artist: Angus Maguire (madewithangus.com).

Equity and climate justice: health considerations for Caribbean Small Island Developing States

Inequality is a fundamental issue in global, regional and national debates on the impacts of climate change. Caribbean Small Island Developing States (SIDS) and territories emit a minute proportion of global greenhouse gases but suffer some of the most serious consequences of climate change (Gillman and Kersting, 2021; Hamilton, 2021; Lalla, 2021; Nunez-Smith, 2021; Skerrit, 2017). The export by multinational companies to less developed countries of technologies that exacerbate environmental damage and climate change is of further concern (Galvão et al., 2009).

SIDS' geographical vulnerabilities to climate change include geographical remoteness, lack of transport links, small human and natural resource bases and high concentrations of their populations along coastlines. These contribute to climate change-related migration, which, it has been argued, has played a major role in the political transition towards more restrictive border policies in many of the richer countries of the world (Parenti, 2011). In the Caribbean, these inherent vulnerabilities have been exacerbated by the history of colonial exploitation and continued exploitation by former colonial powers. These combined vulnerabilities have been asserted by Caribbean politicians in calls for increased resources for adaptation and mitigation (Skerrit, 2017). For instance, at the 27th Conference of the Parties of the United Nations Framework Convention on Climate Change in 2022, COP27, Barbados's Prime Minister Mia Mottley referred to the history of imperialism while calling for concessional funding to reduce the inequalities between developed and developing countries in access to green energy and other technologies for mitigation and adaptation.

> This world still looks too much like it did when it was part of an imperialistic empire … Our ability to access electric cars, or our ability to access batteries or photovoltaic panels are constrained by those countries that have the dominant presence and can produce for themselves, while the Global South remains at the mercy of the Global North on these issues.

Mia Mottley, Prime Minister of Barbados, at the Opening of the COP27 World Leaders Summit (2022)

Source: www.youtube.com/watch?v=5J0egwAfO0w.

Caribbean policymakers are often unaware of the linkages between climate change and health, and thus the health dimensions of the inequalities are not often highlighted (Allen et al., 2021a) and rarely factored into Caribbean advocacy on the global stage. This to some extent reflects a lack of attention being given to the social impacts of and vulnerable populations affected by climate change (Galvão et al., 2009).

However, Caribbean policymakers are giving increasing attention to health issues in their national climate change strategies. For example, a study for the *Lancet* Countdown on Health and Climate Change found that all nine Caribbean SIDS studied mentioned one or more of the following health topics in their first and/or second submissions of nationally determined contributions: mental health, psychosocial health and social well-being; NCDs; heat-related illness; airborne and respiratory illness; vector-borne diseases; malnutrition (food security) and foodborne diseases; infrastructure to withstand extreme weather events; and waterborne diseases, water security and sanitation (Parker et al., 2022). The extent of coverage of equity issues under these headings is unclear.

Vulnerable populations and inequalities: considerations for the Caribbean context

Vulnerability is dependent on the degree of exposure to a threat, the population's sensitivity to the risk and the capacity of the population to cope with the threat – its adaptive capacity (Nurse, 2011; USGCRP, 2016). Globally, the following populations have been identified as especially vulnerable as a result of biological sensitivity, socioeconomic factors and geography: children, pregnant women, older adults, impoverished populations, people with chronic conditions and mobility and cognitive constraints, outdoor workers, and those living in coastal and low-lying riverine zones (Balbus and Malina, 2009; Cissé et al., 2022; USGCRP, 2016). To date, there have been few studies of vulnerable populations or inequalities in the health impacts of climate change in the Caribbean, so some studies from outside the region are cited below to highlight some key issues for consideration.

Low-income populations

Populations with low incomes often live in the areas most affected by climate change and its associated health impacts, such as densely populated urban areas (Diaz-Quijano and Waldman, 2012; Medlock, 2021). For instance, a study in three low-income communities in Jamaica found that 23% of households had no piped water and were more at risk of dengue fever, as storing water was necessary, creating potential mosquito breeding sites (Heslop-Thomas and Bailey, 2006). Outbreaks of cholera, dysentery and diarrhoeal diseases, acute respiratory infections, dengue and malaria are all reported to occur largely in cities with densely populated low-income neighbourhoods following intense and excessive rainfall (Reckien et al., 2017).

Low-income and squatter communities are more likely to live on land subject to environmental hazards such as landslides, torrential flooding and bush fires, which are becoming more frequent because of climate change (Jaramogi, 2021). For instance, in Trinidad and Tobago, low-income and squatter housing is often on riverbanks, in low-lying coastal areas, on steep hills or in floodplains. When extreme weather events occur in these communities, loss of life, health and property accompany them.

People employed in sectors such as street vending and farming are financially dependent on the environment for their livelihoods. Low-income populations have less access to health care than others and are often unable to buy goods and services necessary for their health (e.g. vegetables, potable water, air conditioning) (Hall and Patrinos, 2010; Portier et al., 2010; USGCRP, 2016). In the Caribbean, poverty is more prevalent among female- than male-headed households (Allen, 2018), and thus members of female-headed households are especially susceptible to the impacts of climate change. The large informal sector in the Caribbean is of concern, as most people employed in that sector lack any form of social protection or occupational health services (Galvão et al., 2009).

Rural–urban differences

Rural and urban populations face different sorts of climate-related vulnerabilities, some of which have been described in Chapters 12, "Agriculture, food safety and security", and 15, "Climate-friendly health-promoting infrastructure". In rural areas, access to health facilities and utilities may be lower, and health and livelihoods may be especially affected by the increasing unpredictability and severity of the weather. For instance, a study in Jamaica showed that farmers were especially concerned about their ability to manage seasonal weather unpredictability (Gamble et al., 2010). In urban centres, health concerns include the urban heat island effect, poor air quality and sanitation, and vulnerability to mosquito-borne diseases; these especially affect people on low incomes, those living in poor housing and outdoor workers (Campbell-Lendrum and Corvalán, 2007; CARPHA, 2018; Medlock, 2021; Mycoo, 2021; Sarjent, 2021).

Gender differences

Women, because of inherent physiological differences, are more intolerant of high air temperatures than men (Druyan et al., 2012). In addition, women generally spend more time than men at home, exposing them to greater risk of vector-borne diseases. This is especially true if they live in poor neighbourhoods with inadequate water supply and sanitation and uncovered water collection containers, and where mosquitoes can easily fly through open, unscreened windows and other openings such as cracks in walls. Women living in the tropics may experience additional heat exposure because of the time they spend in hot, indoor spaces performing tasks traditionally undertaken by women, such as cooking (Reckien et al., 2017).

After disasters, there are usually increases in domestic violence towards and sexual harassment of women and adolescent girls (UNEP, 2014; WHO, 2014). A lack of privacy in hurricane shelters contributes to the increased risk of sexual violence (WHO, 2014).

The gender division of labour can also affect vulnerabilities. Men and boys tend to spend more time working outside, especially in male-dominated sectors such as construction. They also engage in outdoor sports more than women. This exposes them to poor air quality and increased risk of heat stress. However, women are usually primary caregivers in their families and in professions such as nursing. Women may see their care responsibilities increase as climate change increases ill health (CIDA, n.d.; Reckien et al., 2017).

Gender issues have been examined in research on NCDs in the Caribbean (Cunningham-Myrie et al., 2013; Dubois et al., 2011), but the impact of climate change does not appear to have been considered in this body of research.

Children

The most climate-sensitive health impacts on children are diarrhoea, malaria and malnutrition (Cook and Frank, 2008; Michon et al., 2007). The rapid metabolisms and immature organs and nervous systems of young children are not equipped to deal with food and water shortages. Malnutrition and dehydration can have long-term consequences for child development. In the event of heavy rainfall and hurricanes, children are at a higher risk of death and injury than adults. They are more vulnerable to waterborne, foodborne and vector-borne diseases. During times of disaster, there are limited options for children to play and socialise, resulting in a lack of exercise and increased frustration and boredom. Children may be out of school and forced to work to increase the family's income, resulting in long-term risks to their future development. There may also be a higher risk of neglect, as their caregivers are busy, trying to find food and clean water and stabilise infrastructure, for example. As adults worry about the future and become stressed, the risk of them abusing and maltreating their children may increase (Bartlett, 2008).

Young people and adolescents

The importance of young people and adolescents for the future of climate change and health in SIDS is highlighted by the fact that more than 60% of the Caribbean Community (CARICOM) population is under 30 (Barnett, 2021). Young people are at the global forefront of climate activism, and the number of youth organisations and individuals campaigning on climate change is growing. Young Caribbean activists have pointed out that children and young people contribute the least to climate change but suffer the most. While adolescents and young people tend to have greater physical resilience than other age groups, climate change tends to exacerbate existing diseases, stifles their social and economic prospects and causes mental ill health (Itoewaki, 2021) (see Chapter 7, “Mental health”). Young people and adolescents want the opportunity to fulfil their dreams and contribute meaningfully to the planet. For this to happen, young people recommend developing peer-led organisations, promoting intergenerational cooperation and government accountability, including climate change and health in the school curriculum, public education on climate change and health, strengthening the resilience of health systems, protecting vital oceanic ecosystems and cultural traditions, and making data and science accessible to young people (Lalla, 2021; Lashley, 2021; Nurse-Allen, 2021).

Older people and people with preexisting medical conditions

Older people, who are often less mobile and have preexisting medical conditions such as cardiovascular disease, are also more vulnerable to extreme weather impacts such as injury and heat-related illness. Those with chronic diseases are vulnerable to interruptions in medical supplies and utility outages during extreme weather events. Those with cognitive impairment and mental illness may become further disoriented during such events. This can result in crises such as wandering outdoors and getting lost or forgetting to take their medication (CARPHA, 2019; USGCRP, 2016; WHO, 2009).

Indigenous people

Indigenous populations make up a disproportionate share of the world’s poor people (Hall and Patrinos, 2010). The indigenous people of the Caribbean are the earliest known inhabitants, predating colonisation of the territories by Europeans. They are among the poorest in society and tend to live in areas most remote from urban centres where healthcare and other facilities are concentrated. Their vulnerability is often aggravated by lack of recognition of their land rights (Itoewaki, 2021).

Among the Wayana indigenous population, who live in parts of Suriname, Brazil and French Guiana, vulnerabilities result not only from climate change but also from illegal gold mining and logging, mercury poisoning (arising from mining practices affecting the edibility of fish and plants), lack of schools and poor food security arising from lack of land rights. Gold mining and logging cause deforestation, contributing to climate change, floods, droughts and forest fires and damaging the quality of the water available to indigenous people (Itoewaki, 2021).

The indigenous people of the Caribbean and Central America generally rely heavily on natural resources directly for food security and health and also for their livelihood and well-being. For instance, the indigenous Kalinago people of Dominica rely on subsistence farming and fishing as their primary occupations (Tandon, 2012). The cultural institutions, knowledge and practices of indigenous people in the Caribbean and Central America have evolved around the use and conservation of particular natural resources of the region they live in (Kronik and Verner, 2010).

Indigenous people therefore tend to suffer the effects of climate change deeply. The loss of crops, fish, and forest and water resources affects their health more directly than people who rely on the market economy (Vreezdam, 2021). Loss of biodiversity and increased seasonal unpredictability pose threats to traditional knowledge, spirituality and cultural cohesion. These threats, along with the loss of control over land, can contribute to mental health challenges, including suicide in young people. Young indigenous people see very little prospects of good futures for themselves (Itoewaki, 2021; Kronik and Verner, 2010; UN, 2009).

The threat to indigenous people from climate change was recognised in the Paris Agreement at COP21 in 2015. The inclusion of “the rights of Indigenous Peoples” in the preamble of the Agreement, achieved despite the consistent opposition of some states throughout the process, was a significant and unprecedented step forward.

This was the first time this phrase has appeared unqualified in a legally binding United Nations treaty, environmental or otherwise (Caribbean Organization of Indigenous Peoples, 2015).

The vulnerability of indigenous people can be seen in their generally poorer health, and poorer access to health services, compared with people of European descent in Latin America and the Caribbean.

Afro-descendant groups

Afro-descendant groups have poorer-health and poorer access to health services. The health disparities that affect these groups are the result of complex dynamics between social exclusion, poverty and adverse environmental factors, and also cultural and behavioural factors (Giuffrida, 2010).

Descendants of enslaved people from Africa make up the majority of the Caribbean population. Notable exceptions are Trinidad and Tobago and Guyana, where the majority are descended from indentured labourers from India, but where people of African descent also form a large proportion. Differences in health between ethnic groups have been documented in the Caribbean. The focus of much of this Caribbean research has been on ethnicity as a predictor of NCDs, with socioeconomic circumstances increasingly being examined as an additional predictor. This more recent focus on socioeconomic circumstances represents progress from earlier studies that looked mostly at cultural (e.g. diet) and biological differences between ethnic groups as predictors of NCDs (Elia et al., 2021; Ferguson et al., 2015; Giuffrida, 2010; Gopaul et al., 2023; Miller et al., 1989; Nayak et al., 2011; Schutte et al., 2020). However, climate drivers do not appear to have been factored into this body of research.

The history of colonial exploitation continues to affect ethnic relations in the Caribbean, with people with lighter complexions still enjoying higher status and greater control of resources than those with darker complexions (Reddock, 2014). This means that ethnicity is associated with access to resources – an intersection between colonially defined racial categories and other forms of disadvantage, notably low income and lack of access to health care. It is important to bear in mind that racism may be a cause of impoverishment and poor service access – a cause of the causes (Marmot, 2005) of health inequalities arising from climate change. This intersectionality is increasingly being studied in epidemiological research in the Caribbean.

People with disabilities

People with disabilities are especially vulnerable to climate change impacts because infrastructure and interventions have not been adapted to their needs. For example, some of the challenges faced by people with disabilities during disasters such as hurricanes include (Carby, 2021):

- Lack of elevators, ramps, grab bars and space for special equipment in emergency shelters;
- Lack of information in Braille and the only intermittent availability of signing for deaf people;
- Attitudinal barriers, in that people with disabilities tend to be cast in the role of victims and there is little recognition of their potential contribution to disaster risk management planning and operations.

Migrants

Chapter 8, "Population displacement and migration", presents information on climate-related migration and associated health risks. Migrants tend to have more limited access to health care than people from the countries to which they migrate, and sometimes this discrimination is enshrined in laws (in the Caribbean and elsewhere) that state that only certain sorts of care can be provided to non-nationals. The circumstances of migration may affect migrants' mental and physical health (Herrán and Biehler, 2021).

Differences by sector of employment

There have been studies on, and activists have expressed concern about, the impact of climate change on economic sectors that make major contributions to national income and employment or that are important to food security, namely tourism, agriculture and fisheries (see Chapters 12, “Agriculture and food safety and security”, and 14, “Marine resources and health”) (R4ACCHC, 2022b; UN-OHRLLS, 2015). Part of the concern is about the people employed in these sectors and how their livelihoods may be devastated by climate change. For example, the Caribbean Fisheries Early Warning and Emergency Response system has been developed, which includes information for fisherfolk that can be accessed via a mobile phone and is also presented in posters and a documentary video (Headley, 2021). To date, there has not been major focus on the health of people employed in these sectors or on measures to protect their health.

Residents in coastal areas

Caribbean people living the closest to coastlines are especially affected by climate drivers such as sea level rise, heavy precipitation events, hurricanes and storm surges. Changes in wave climate (largely attributable to damage to coral reefs, which provide a buffer) superimposed on sea level rise are predicted to increase coastal flooding and erosion of low-lying coastal areas. The frequency, extent, duration and consequences of coastal flooding are predicted to increase significantly from 2050. However, in the Caribbean, tropical cyclones are predicted to be a more frequent cause of flooding than sea level rise, in contrast to some Pacific atolls, where sea level rise is expected to cause annual wave-driven flooding over their entire surface from around the 2070s (Mycoo et al., 2022).

Climate change also especially affects the infrastructure, water and food security, and economies and culture of coastal settlements, especially through compound events. Many coastal dwellers work in tourism and fisheries, which are highly vulnerable to climate change. Some coastal areas are likely to become less habitable because of a combination of loss of marine and coastal biodiversity and ecosystem services; submergence; destruction of settlements and infrastructure; degradation of health and well-being; economic decline and livelihood failure; and loss of cultural resources and heritage. Enabling people to continue living in these areas is likely to require adaptation, ranging from nature-based solutions, such as growing seagrass and mangroves, to expensive infrastructure projects, such as higher sea walls, elevating the land and adapting buildings. Major government or donor expenditure will be needed to ensure that infrastructural adaptation benefits population groups equitably. Relocation and resettlement may also be needed for some, which again must be managed and funded to ensure equity and that vulnerable populations are not left behind in at-risk coastal areas (Mycoo et al., 2022). See Chapters 14, “Marine resources and health”, 15, “Climate-friendly health promoting infrastructure”, and 8, “Population displacement and migration”.

Limitations of the Caribbean research

There has been little research on mediating social and behavioural factors influencing climate change-related exposure pathways to ill health in the Caribbean region. Questions about distribution of the risks and health co-benefits of climate change have also been little explored in the Caribbean context (Allen, 2021). In addition, a review found that there are few peer-reviewed publications focusing on climate change-related adaptation for health in SIDS compared with “developed” member countries of the Organisation for Economic Cooperation and Development. This limits the scope for using local research to inform policy action locally and to assert Caribbean interests on the global stage (Hamilton, 2021).

The Institute of Gender and Development Studies of the University of the West Indies has worked on mainstreaming gender in a number of climate change-related projects and initiatives in collaboration with other departments of the university and Caribbean agencies, such as the Caribbean Disaster and Emergency

Management Agency. Some of these projects focus on vulnerable communities such as small farmers. However, health has not been a major focus of this work (Allen et al., 2021a,b).

The *Lancet* Countdown on Health and Climate Change conducted a study with climate and health experts in SIDS, including the Caribbean, to identify priority topics for the development of indicators to measure climate change and health impacts and action. Study interviewees called for disaggregated data and measures of difference between populations to enable identification of vulnerabilities and equitable allocation of resources, both within SIDS and at the global level. Measures of gender differences and gender responsiveness were requested, tracking issues such as the impact of climate change on different economic sectors where men or women predominate and responsiveness to domestic violence and other issues predominantly affecting either women or men (Allen et al., 2021a).

9.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Advocate the right to health of populations vulnerable to climate change

Civil society organisations representing vulnerable populations in the Caribbean should increase their involvement in climate and health issues that affect the populations they represent (Gillman and Kersting, 2021; Itoewaki, 2021; Lashley, 2021). They can serve as watchdogs and caretakers of the environment, holding governments and powerful people to account. Civil society organisations are often first responders to emergencies and community needs and can thus play a critical and immediate role in addressing climate-related ill health. Networking with other nongovernmental organisations (NGOs) and state, pan-Caribbean, multilateral, private, academic and education agencies helps NGOs gain support for their communities and meet their resource needs (Jaramogi, 2021).

For civil society action to fulfil its potential, tailored climate and health literacy programmes should be implemented among groups such as people with chronic illnesses and NCDs, people with disabilities, women, children, young people, older people, impoverished people, disadvantaged ethnic groups, migrants, rural populations, urban populations, coastal populations, and lesbian, gay, bisexual, transgender and intersex people. Campaigns for climate justice by the region's politicians on the global stage should also assert the right to health, incorporating messages about health impacts. They should call for interventions and funding to address and prevent ill health in SIDS caused by climate change, especially among those disadvantaged by social determinants of health. Governments should also reduce red tape and improve access to funding to civil society organisations concerned with climate change and health (Jaramogi, 2021).

The inclusion of "the rights of Indigenous Peoples" in the preamble of the Paris Agreement should be used to assert land rights, prevent land grabbing by prospectors and loggers and protect agricultural and other environmental resources essential for indigenous people's health in the context of climate change (Caribbean Organization of Indigenous Peoples, 2015; Itoewaki, 2021; Vreezdam, 2021)

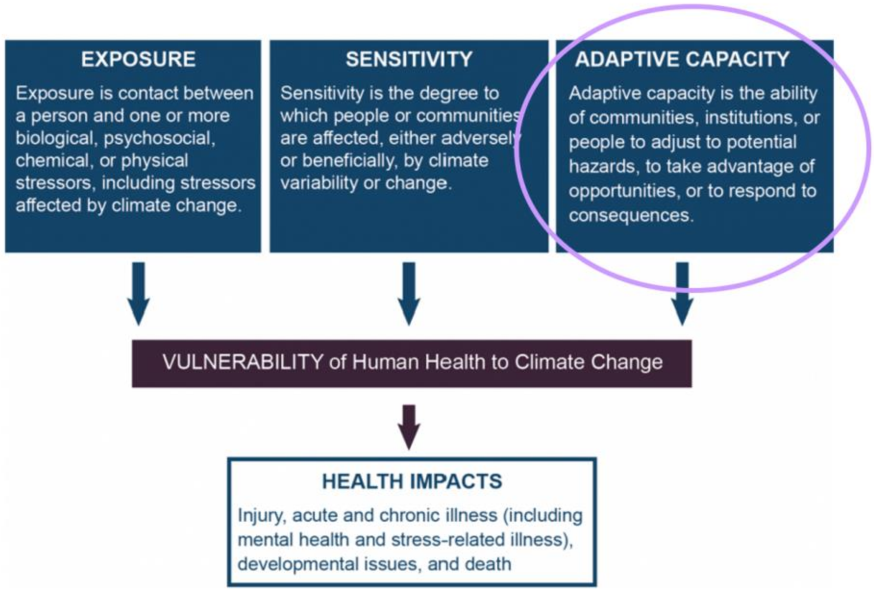
Involve young people in all their diversity in climate change and health action and decision-making

For a sustainable, healthy future, it is especially critical to listen to and involve young people. To support this, climate change and health should be a part of the school curriculum from infant school (Lalla, 2021; Lashley, 2021; Martin, 2021; Nurse-Allen, 2021; Sood, 2021). Climate and health education go hand in hand with health equity and environmental justice (Sood, 2021). Young people should represent populations in all their diversity in advocating equity and justice. A wide range of civil society organisations should be supported, and initiatives such as the Caribbean Community (CARICOM) Youth Ambassadors programme should continue and increase their focus on climate change and health issues (Barnett, 2021).

Build resilience in vulnerable communities and populations

Communities and populations identified as vulnerable to climate change should be the special focus of efforts to build community resilience (Radix, 2021). Six types of community capital have been identified as critical to community resilience: natural, built, financial, human, social and political (National Academies of Sciences, Engineering, and Medicine et al., 2019). Increasing community capital is key to adaptive capacity and thus to reducing vulnerability to health outcomes of climate change, as shown in Figure 3.

Figure 3: Determinants of vulnerability



Source: USGCRP (2016).

Community participation and engagement should take place at the outset of resilience building (Scobie et al., 2021). Representatives of each vulnerable population should be consulted on the existing strengths and weaknesses of each type of capital in their community and asked for recommendations on how each could be strengthened or supplemented by technical advice and donations (National Academies of Sciences, Engineering, and Medicine et al., 2019). Development of tailored approaches is key to agility in the face of threats, which has been defined as a key component of a community's resilience. Agility means being (Radix, 2021):

- Precise – targeting clearly defined issues;
- Comprehensive – being clear about the range of things you want to accomplish;
- Cost-efficient – if the cost of change is too high, it will not be sustainable.

It is critical that the process of consultation is built on a foundation of knowledge in the communities concerned. They should be empowered with education on the climate and health challenges they may be facing and how they can be addressed. Training and tools should be provided. Education on how climate and health challenges can be addressed should include both how communities themselves can be involved (e.g. clearing and minor maintenance of drains and stormwater systems) and how they can engage with institutions at multiple levels, including local and central government, the private sector, and disaster management and technical/development agencies. Networks of support between agencies and communities should be actively built. Demonstrations and simulations should be provided to show how communities can sustain themselves in the face of climate change challenges. Early warning systems should be adapted to facilitate understanding among vulnerable populations, including people with disabilities and low levels of literacy and education (R4ACCHC, 2023).

Structural/governmental and private sector actions

Advocate climate justice for Caribbean Small Island Developing States at the global level

If we are to significantly reduce health vulnerabilities to climate change in Caribbean SIDS, there must be a reduction in greenhouse gas emissions globally. This must be accompanied by robust adaptation measures. Given the historical responsibility of the developed countries and multinational corporations for climate change, justice will require the developed world to lead and finance global mitigation and adaptation efforts, including massive reallocation of resources to the adaptation and mitigation needs of SIDS. While developed countries should take the lead on this, continued lobbying by Caribbean politicians and civil society will be needed to achieve substantial gains (R4ACCHC, 2023). Corporations, as well as governments, should be the targets of advocacy.

The general diplomatic efforts of Caribbean states in the international arena on trade and other matters should include negotiations on matters pertaining to climate change and health. For example, the impact of climate change on NCDs in the Caribbean should be highlighted as part of negotiations to address the contents and labelling of imported processed foods (Healthy Caribbean Coalition, 2016; R4ACCHC, 2023). See Chapter 18, "Government engagement in health and climate change", for further details on governmental strategies.

Through advocacy from SIDS (Benjamin and Thomas, 2016), some progress has already been made in drawing the attention of the world to the plight of SIDS and their need for access to climate change-related finance. Chapter 17, "Funding streams for climate and health action", provides details of some of the financial resources currently available at global and regional levels.

Conduct and enforce the findings of environmental and social impact assessments in geographically defined communities at risk

Low-income, squatter and indigenous communities without land rights are extremely vulnerable to the environmental determinants of health. These also affect other vulnerable communities as outlined above. Infrastructural projects and unplanned or illegal environmental ventures such as gold mining in Guyana and Suriname can have devastating consequences for these communities (Itoewaki, 2021). Governments are responsible for requiring environmental and social impact assessments that involve local communities in commenting on the consequences of economic projects and ventures. Laws should be strictly enforced.

Integrate equity considerations into health strategies

> We need to ensure that economic and social policy responses to climate changes and other [forms of] environmental degradation take into account health equity.
>
> Galvão et al. (2009)

Significant health disparities among populations support the argument that conventional health policies have failed to improve equity in health and that there is a need for affirmative action to promote equity more effectively (Giuffrida, 2010). Disaggregated data on health outcomes are needed to support interventions and to guide donor support. Since climate change is leading to greater health disparities, it is especially important to integrate equity considerations into health strategies.

For example, two positive discrimination approaches have been proposed to achieve health equity among racial and ethnic groups in Latin America. One applies the principle of vertical equity, allocating more health resources to those populations, such as Afro-descendant and indigenous communities, that have greater health needs. The other focuses on the use of quotas to facilitate the entry of indigenous and Afro-descendant individuals into the health professions, recognising that those who are admitted to the health professions through affirmative action have been found to be more likely than others to address the health needs of those indigenous and Afro-descendant communities (Giuffrida, 2010).

The social determinants of health approach encourages those concerned with public health to address the upstream, structural factors: "the causes of the causes" (Marmot, 2005). It emphasises social justice and redressing the balance of power relations so that no one is left behind. Hierarchical power relations such as racism, sexism and ageism must be addressed and resources redistributed to compensate for disadvantage. Equitable public health policy entails a multisectoral approach that includes development of equal opportunities legislation that encompasses all forms of vulnerability to discrimination and effective enforcement of this legislation (Hassan, 2021). This will help in dismantling hierarchical normative constructs such as race and gender and thus their power to determine conditions such as poverty that affect health outcomes.

Communicate effectively with vulnerable populations about the climate change and health challenges they face

Government, private sector, philanthropic and advocacy organisations should support the necessary educational and behavioural interventions referred to in the subsection on individual and community action above. They should collaborate with vulnerable populations to design interventions to ensure that they are appropriate, clear and well understood. Scientists should also ensure that their findings are presented accessibly to vulnerable populations and should design education and outreach initiatives accordingly. It is especially important to design communication in ways appropriate for people with various disabilities (Carby, 2021). Key messages should be translated into forms that are easily understood by each affected population, which should be engaged in dialogue to ensure understanding and to foster action (R4ACCHC, 2022c, 2023).

Attending to communication with young people is essential to ensure the sustainability of climate change and health action:

> All the data and science is useless unless it gets into the hands of those who need to act on the information, including the youth.
>
> Lalla (2021)

Address socioeconomic determinants of health such as education, skill accumulation, employment and poverty

Differences between populations in educational achievement and skill accumulation, some of which persist over many generations, should be urgently addressed. Labour market discrimination and market segmentation should be combated so that all are able to thrive economically and be more resilient to climate change (Giuffrida, 2010). Education for vulnerable populations should include information on how to access climate change adaptation resources and build resilience to climate change (R4ACCHC, 2023). When employment and project-related opportunities arise in climate change and health mitigation and adaptation, people from vulnerable populations should be encouraged to apply and workplaces adapted accordingly. Some positive discrimination in employment and higher education enrolment practices is likely to be necessary to address social determinants of health.

Adapt health settings and disaster preparedness and response to the needs of vulnerable communities

This entails the development of strategies according to the needs of specific communities (Hassan, 2021). For instance, the following may be needed: mobile clinics for geographically remote communities; wheelchair ramps and health education materials in Braille or audio format for people with disabilities; and bilingual staff for migrants. The need for such strategies is heightened in the context of disasters, such as hurricanes, that curtail access to services (Carby, 2021). In addition, disaster preparedness must include safe storage and resilient transport systems for the medical supplies, food and water needed by vulnerable populations (Harewood, 2021; Radix, 2021; Riley, 2021).

Adopt gender-responsive approaches

Gender equity considerations should guide interventions to address the health consequences of climate change. Strategies include (Allen et al., 2021a,b; CIDA, n.d.):

- Developing gender-responsive disaster preparedness and response strategies, including protecting women and girls from violence following severe weather events;

- Incorporating women's views on how to improve access to and the quality of resources affecting their domestic labour in the context of climate change, such as water quality, sanitation, food security and housing;
- Incorporating both women and men into the decision-making framework on climate change mitigation and adaptation initiatives (UNDP, 2009);
- Supporting vulnerability reduction measures that target women's needs;
- Making use of technologies that are accessible, beneficial, and acceptable to both male and female stakeholders;
- Providing climate change and health education accessibly and at times and in places appropriate for men and women;
- Supporting the provision of tools, including vulnerability assessments, that build on local and indigenous knowledge, held by women and men, of measures for adapting to, or mitigating the impacts of, climate change.

Research gaps and how to address them

Conduct research to identify populations vulnerable to health impacts of climate change in the Caribbean

To achieve greater equity, it is critical to have information that identifies vulnerable populations geographically and according to socioeconomic, demographic and epidemiological characteristics. This research should be informed by a social determinants of health approach, including indicators of key social determinants that mediate the impact of climate change on health, such as level of education, housing and access to water and other utilities.

Population-level surveys are needed to map climate-sensitive health conditions and environmental factors that can place communities at risk, e.g. housing in flood-prone areas. The information generated through research must be made available to local and central authorities and disaster preparedness agencies.

Produce data disaggregated by key dimensions of social and economic inequality

Data relating to individuals, whether in studies or as part of surveillance, must include key stratification variables such as sex, race, ethnicity, age group, education level and employment status. Some of these pose challenges of definition, given that self-identified gender and ethnic status may not conform to conventional categories (Nazroo, 2003). Personal income is sensitive data, so education, employment and other proxy measures are often used to assess differences in access to resources. Some flexibility in definitions is needed, which may be informed by consultation with the vulnerable populations themselves.

Disaggregated data are a fundamental need for informing equity-oriented climate change and health action (Allen, 2021). Once adequately collected, datasets on climate-sensitive health conditions should be analysed to identify significant differences in prevalence, incidence and risk factors among populations. To be able to use data effectively, it is also important that data sharing agreements are developed between countries and regional organisations (Allen et al., 2021a).

More research is needed to develop adequate measures of socioeconomic status at various points in the life course, so that interventions can be targeted to areas of greater need and be responsive to age group differences (Nazroo, 2003; Patterson-Waterston, 2021).

In interviews with Caribbean stakeholders for an assessment of climate change and health in SIDS by the *Lancet* Countdown on Health and Climate Change, participants called for measures of difference between populations to enable identification of vulnerabilities and equitable allocation of resources. Measures of gender differences and gender responsiveness were specifically requested, tracking issues such as the impact of climate change on various economic sectors where men or women predominate and the gender responsiveness of strategies on domestic violence and other issues predominantly affecting women or men (Allen et al., 2021a).

The advent of new data technologies involving geographic information systems and artificial intelligence offer new possibilities for pinpointing vulnerable geographical areas/populations and offering assistance. Ethical considerations must precede any use of personal data generated from mobile phone and internet use to prevent further abuse of vulnerable populations.

Study relationships between social determinants of health, climate change and health inequities

Much more analysis of the relationship between the social determinants of health, climate change and health inequities is needed to inform policy and practice (Galvão et al., 2009; R4ACCHC, 2023). Retrospective studies should examine differences in immediate health outcomes and access to health care among populations following a severe weather event, with a focus on hierarchical social stratifiers and commitment to taking action to redress any inequities in access found. Elements of community resilience – natural, built, financial, human, social and political – should be measured and compared between geographically defined communities selected on the basis of stratifiers such as mean levels of education and employment. Tools to measure community resilience should be adapted to the local context through community consultation and used in action research (National Academies of Sciences, Engineering, and Medicine et al., 2019).

The impact of climate change on poor people in urban and rural areas should receive special attention, along with the survival and economic strategies they have developed, which may have positive and negative environmental consequences. The geographical distribution of vulnerable populations in areas of risk such as coastal and flood plains, and the quality and climate resilience of their housing and basic utilities should also be studied (Richards, 2008).

Conduct longitudinal studies of the impact of climate drivers on health of people with preexisting genetic and medical conditions in the Caribbean

The Caribbean relies mainly on international research on genetic or medical predisposition to climate change exposure pathways such as extreme heat and poor air quality. More research with Caribbean populations is needed to tailor solutions to local characteristics. For instance, does sensitivity to heat stress differ between men and women, and between ethnic groups, in the Caribbean context? How are older Caribbean people affected by heat stress? What are the adaptive measures adopted by these populations to avoid heat stress and how effective are they?

Longitudinal research with people with conditions predisposing them to NCDs should also be conducted, monitoring their health status alongside climate information. The impact of severe weather events on their health, access to care and other social determinants of health, such as education and level of income, should be studied.

For example, researchers at the University of Puerto Rico were monitoring the incidence of NCDs in a cohort of overweight and obese people when Hurricanes Irma and Maria struck in 2017. Study participants were aged 40–65 years and free of diabetes at baseline. Among the participants, 6.5% developed diabetes in the pre-hurricane period compared with 12.9% post hurricane. After adjusting for age and body mass index, diabetes incidence was significantly higher after the hurricanes than before (incidence rate ratio = 2.1; 95% confidence interval 1.4–3.1). Blood glucose levels were also significantly higher at the post-hurricane visit compared with those recorded during pre-hurricane monitoring. Participants (15.2%) reported having trouble getting medical care for diabetes or related complications, and 12.8% reported encountering problems getting or storing insulin (Joshipura, 2021; Martinez-Lozano et al.,2021).

Involve vulnerable populations in research on and development of adaptation and mitigation solutions suitable for their needs

People in positions of disadvantage are very aware of the challenges they face and may have good ideas for overcoming them, with technical and financial assistance. With adequate support and investment in research, they can develop innovative solutions to adapt their environments and adopt sustainable energy and technology solutions. Traditional knowledge can supplement that of conventional science in developing locally appropriate technologies (Carby, 2021).

Conduct qualitative research with vulnerable populations to identify the climate change and health challenges they face and develop solutions

Exploratory qualitative research with vulnerable populations can enable them to speak about the forms of discrimination and obstacles they face in protecting their health from the impacts of climate change. Participants should be encouraged to identify cultural, physical and other barriers that limit access to health and health services. This type of information is key to developing the most effective policies to reduce health inequalities (Giuffrida, 2010; Nazroo, 2003; R4ACCHC, 2023).

Qualitative and quantitative research should also be conducted in geographically defined communities and specific communities of interest (e.g. people with disabilities, people with low levels of education) so that members can identify their own vulnerabilities and needs. Special efforts should be made to facilitate the inclusion of people with disabilities in this research, such as by employing researchers who can use sign language and through outreach programmes for people with mobility challenges (R4ACCHC, 2023).

Conduct research on the vulnerabilities and adaptation strategies of specific populations

Examples of suitable research questions include:

- What is the understanding and capacity for adoption of emergency management procedures among people with disabilities? What measures can be taken to enhance their understanding and capacity? What are the attitudes to people with disabilities among government officials concerned with emergency management? (Carby, 2021).
- What are the impacts of coastal erosion, coral bleaching and ocean acidification on food security in impoverished populations and on livelihoods and health in key sectors (fisheries and tourism)? (Nurse-Allen, 2021).
- What are the sanitation and waste management conditions and practices in impoverished communities and their gender dimensions?
- What are the health vulnerabilities to climate change of the indigenous people of the Caribbean? (Kronik and Verner, 2010).
- What are the roles of women and men in the management of food- and waterborne diseases? The management of such diseases should be examined by considering the differences in the culturally defined responsibilities of men and women for food preparation and hygiene in domestic and professional settings (Allen, 2021).
- What is the exposure to and control of insect and other animal vectors in impoverished communities? (Medlock, 2021).
- In what ways do exposure pathways (e.g. heat, sea level rise) affect women and men according to their occupational and mobility patterns?

Surveillance gaps and how to address them

Include disaggregated data in routine administrative and surveillance data collection

As emphasised above, disaggregated data are essential in assessing the impacts of climate change on health in various populations. Routine administrative data collected by service providers and health surveillance data must include social stratification variables and geographical indicators to help pinpoint needs and monitor progress in reaching equity goals.

Environmental monitoring should focus on communities at risk because of their geographical location and inadequate level of adaptation, such as communities living in floodplains with low drainage capacity. Health data should be collected from sentinel sites in these communities.

Include gender indicators in monitoring and evaluation of projects

Data disaggregated by sex would be necessary to develop gender indicators, such as the proportions of male- and female-headed households storing water in uncovered containers and thus vulnerable to mosquito-borne diseases. Integrating gender analysis and gender indicators into programmes and projects can identify where specific vulnerabilities to climate change lie and where opportunities for behavioural interventions and for mitigating and adapting to climate change can be found (Allen et al., 2021a).

Develop and use approaches to measure social and health impacts and inequities

To enable climate policy to respond appropriately to social and health impacts and inequities, these inequities must be measured in a way that policymakers can use. For instance, if a renewable energy project causes the loss of some jobs in fossil fuel production, this must be compared with the new jobs to be created by the renewable energy project. The impacts on health of the old and new energy production methods should be factored in, including the mental health impacts of possible job losses. This highlights the need for strengthening public health surveillance.

The various costs and benefits, some of which will be external to the project itself, should be compared. Evidence-based economic models can be used to build tools to project the costs and benefits of specific projects. For example, the Greenkeeper software developed in the United Kingdom calculates location-specific economic values for health and the social and environmental benefits of urban green infrastructure (Patterson-Waterston, 2021). In addition to cost–benefit analysis, other approaches used to assess the social and health impacts and equity of projects include econometrics, natural capital accounting, cross-sectional data analysis, and geographic information systems.

Research and surveillance capacity-strengthening needs

Strengthen research skills in vulnerable populations

To achieve the research and surveillance objectives above, peer research capacities among the vulnerable populations themselves must be strengthened. This will help to ensure that the research is efficiently targeted at the community's needs and at the building of appropriate adaptation and mitigation strategies (R4ACCHC, 2023). Deficits in basic education in some of these populations should be addressed, and grants and scholarships provided for specialised education. Equipment such as computers and statistical software should be provided.

Strengthen statistical and epidemiological skills

More people, especially in vulnerable populations, should be skilled in the conduct of basic and advanced epidemiological analysis of the differences between populations. This is critical in order to identify and measure inequalities in health outcomes. Skills in the measurement of association are also needed to identify environmental risk factors. Multivariate analysis will be necessary to investigate the contribution of climate change-related exposure relative to other factors in determining health outcomes.

Strengthen skills in environmental and social assessment and mapping

Skills and equipment to conduct environmental and social assessments and map them geographically are needed, such as for spatial epidemiology and geographic information systems (Nayak et al., 2021).

Train healthcare workers to record and analyse sociodemographic data

Health information systems should be strengthened to enable the recording of sociodemographic data on patients, and healthcare workers should be trained and supported to use these systems. This should be accompanied by human rights training to ensure that all people are treated equitably. Issues of climate justice and equity should be included in health students' curricula (Sood, 2021).

Disciplines needed

A wide range of different disciplines is needed to conduct research that will serve to address inequities in health.

Lawyers are needed to investigate the rights of various populations that determine access to key resources, including land, property, education and health care. The local and regional frameworks of anti-discriminatory and equal opportunities legislation should be examined with a view to achieving equity between all people.

Other disciplines and skills needed include biomedicine, communications studies, disaster needs assessment, sociology, economics, engineering, environmental health, ethnic studies, gender studies and geography.

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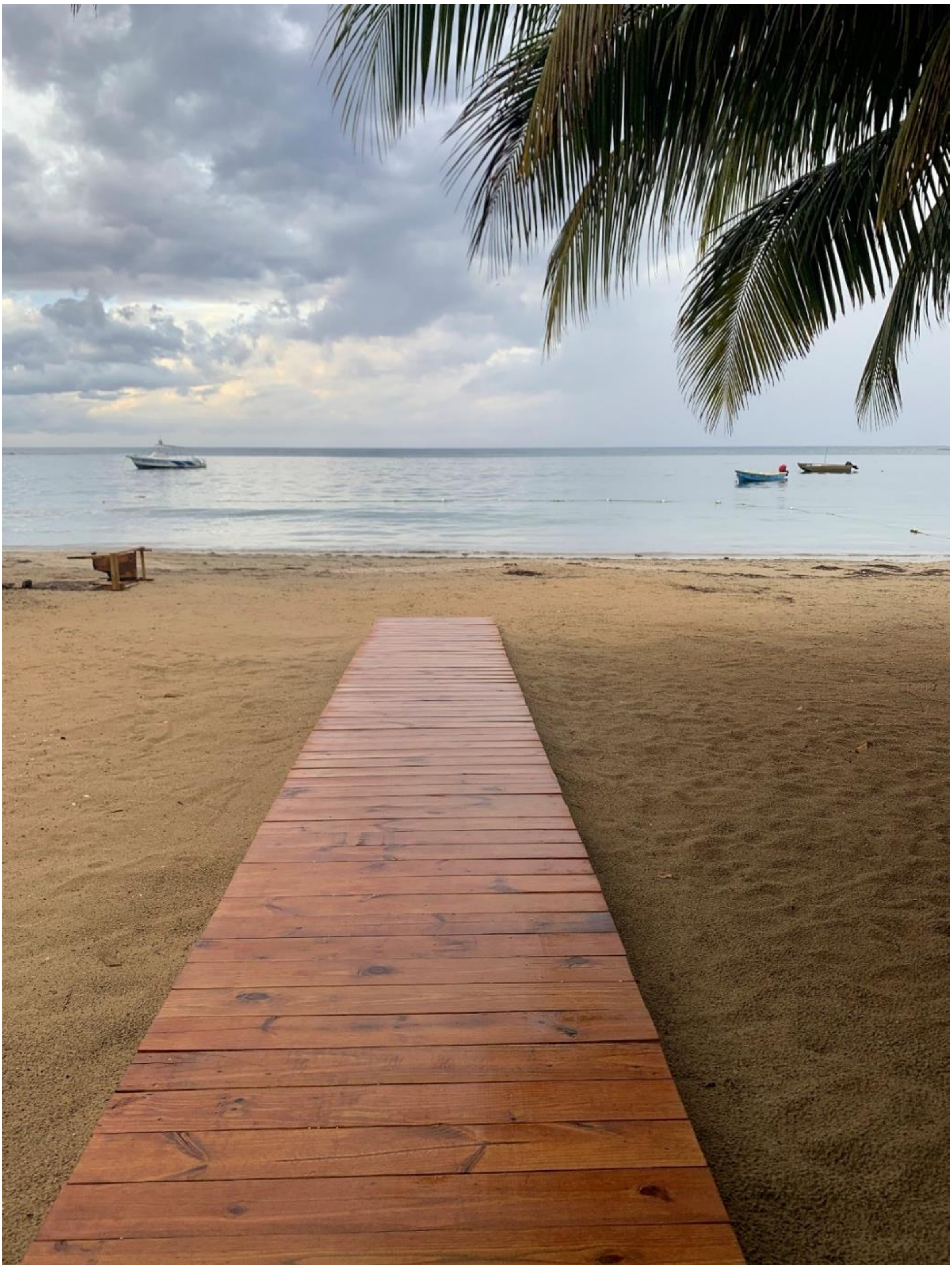


DOMAIN 2: ADAPTATION, PLANNING AND RESILIENCE FOR HEALTH

10. COLLABORATION BETWEEN AGENCIES

10.1. WHAT IS HAPPENING?

Caribbean countries and territories, as Small Island Developing States (SIDS), have severe resource limitations, making it very important that they pool and share resources in a coordinated way (Lichtveld, 2021). In addition, addressing the effects of climate change on health requires multiple types of interventions and expertise. If health impacts due to climate change are to be reduced, it is important that government, civil society and private sector agencies reduce the practice of operating in silos and instead form active partnerships. Adaptation to the various health risks posed by climate change must also involve collaboration between the health sector and other sectors, especially agencies responsible for planning, infrastructure, disaster management and meteorological data collection and forecasting. All sectors must take account of the likely impacts of climate change on health when developing their plans. In this report, we have examined the roles of various sectors, including water, sanitation and hygiene (Chapter 3), agriculture, food safety and security (Chapter 12), marine resources (Chapter 14), climate-friendly health-promoting infrastructure (Chapter 15) and smart health facilities (Chapter 16).

There are several important examples of Caribbean collaboration between agencies to address climate change and health challenges.

Caribbean Action Plan on Health and Climate Change

The Caribbean Action Plan on Health and Climate Change 2019–2023 is the only regional policy that addresses both health and climate change together. It was developed in consultation with countries through preparatory meetings and by convening regional health and environment leaders of the Caribbean during the Third Global Conference on Health and Climate Change, held in Saint George's, Grenada, on 16–17 October 2018. It aims to protect the health of Caribbean SIDS populations from the adverse effects of climate change by developing climate-resilient health systems, by increasing awareness of the adverse health effects of climate change, by mainstreaming funding opportunities to support countries, and by promoting intersectoral mitigation actions in the health sector. The plan proposes several actions at the national, regional and global levels. Among these, it singles out collaboration, advocating that actors in the health sector "Engage, coordinate, and collaborate with other sectors and development partners for resources to address health and climate change". Further detail is provided in Chapter 18, "Government engagement" (PAHO, 2019).

EU/CARIFORUM Project – Strengthening Climate Resilient Health Systems

In an effort to assist in the implementation of the Caribbean Action Plan on Climate and Health, in 2020, the European Union (EU) in collaboration with the Caribbean Community (CARICOM), funded a multi-partner grant – Strengthening Climate Resilient Health Systems – to six Caribbean institutions (see Table 1). Actions undertaken as part of this project focus on enhancing surveillance systems; supporting public health systems that prioritise adaptation and mitigation needs; generating climate and health data and facilitating communication between government and the public; developing national climate-sensitive early warning systems (EWSs); training personnel working with water, sanitation and food systems; and developing climate-resilient food, water and sanitation safety plans.

Table 1: EU/CARIFORUM Strengthening Climate Resilient Health Systems grant implementation partners

Partner	Contributions/linkages to the project	Examples of multidisciplinary approach
Caribbean Community (CARICOM)	• Organisation of climate change and health youth leadership programmes and engagement of ministries • Empowerment of health leaders and strengthening of institutional structures on climate change and health	Engagement of young people from many disciplines, including health, with other sustainable development and climate partners
Caribbean Community Climate Change Centre (CCCCC)	• Development of climate and health concept notes for financing activities in climate change and health and communicating the importance of the climate and health nexus • Strengthening the capacities and coordination to access resources and improve communication	Formation of links between the health sector and climate, planning and financing activities across the Caribbean
Caribbean Institute for Meteorology and Hydrology (CIMH)	• Development of enhanced EWSs and climate and health bulletins • Development and provision of climate-informed health services	Publication of climate and health bulletins, making linkages between the health and climate sectors
Caribbean Public Health Agency (CARPHA)	• Creation of climate and health EWSs • Creation of climate-resilient water, sanitation and food safety plans • Implementation of EWSs for climate-related diseases and conditions	Development of systems to collect data across multiple disciplines
Pan American Health Organization (PAHO) (lead implementing partner)	• Development of health vulnerability and adaptation assessments, health chapters in National Adaptation Plans and health co-benefits tools • Development of climate-resilient water, sanitation, and food safety plans • Promotion of health in the intersectoral climate change agenda and the creation and use of evidence for planning and decision-making	Formation of interministerial committees for conducting national assessments and developing national plans
University of the West Indies (UWI)	• Organisation of climate change and health leadership programmes • Strengthening of institutional structures on climate change and health	Formation of a cadre of future climate and health leaders across different sectors and disciplines

Source: Adapted from Drewry and Oura (2022), licensed under CC BY-NC-ND 4.0 DEED.

To implement this project, it is necessary to form multisectoral and interdisciplinary teams that will be led by regional organisations and national ministries of health (Drewry and Oura, 2022). There are 17 beneficiary countries (Caribbean Forum [CARIFORUM] states[1] and Cuba).

The project has four components (Drewry, 2021; Drewry and Oura, 2022; Hassan, 2021a; PAHO, n.d.):

[1]Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname and Trinidad and Tobago.

- Adaptation and testing of PAHO/World Health Organization (WHO) tools to estimate health co-benefits (led by PAHO);
- Inclusion of comprehensive health chapters in National Adaptation Plans (led by PAHO and CCCCC);
- Improved surveillance capacity of professionals working in the health sector and health-determining sectors (led by CARPHA and CIMH);
- Strong effective climate change leadership (led by CARICOM and UWI).

A final cross-cutting element is to promote awareness around climate change and health by providing information to key target populations about the importance of climate, health and the environment. This work is led by PAHO, CARICOM and CCCCC.

PAHO/WHO tools used to estimate health co-benefits include the Health Risk Assessment of Air Pollution tool (AirQ+), Health Economic Assessment Tool (HEAT) for active transport and Green Urban Spaces (Green UR) tool. These tools will give decision-makers necessary data to understand the co-benefits of reductions in air pollution, and increased active transport and parks and open spaces, thus allowing for the development of effective polices and surveillance systems (Drewry and Oura, 2022).

Early warning systems

Agencies have collaborated to develop EWSs that provide alerts on climate-related health risks. Climate-informed disease surveillance platforms have been developed, along with novel ways of reporting integrated surveillance information.

The CIMH and the Instituto de Meteorología de la República de Cuba (INSMET) have both focused on predicting and preventing adverse health outcomes through collaboration with the health sector, public utilities, academia and disaster management agencies (Allen et al., 2021a). For example, INSMET has established a multi-agency Group on Climate and Health, resulting in research projects and publications based on combining climate and health data (Linares-Vega et al., 2020; Ortiz et al., 2015). INSMET also communicates to the public information about predicted climate-related disease outbreaks.

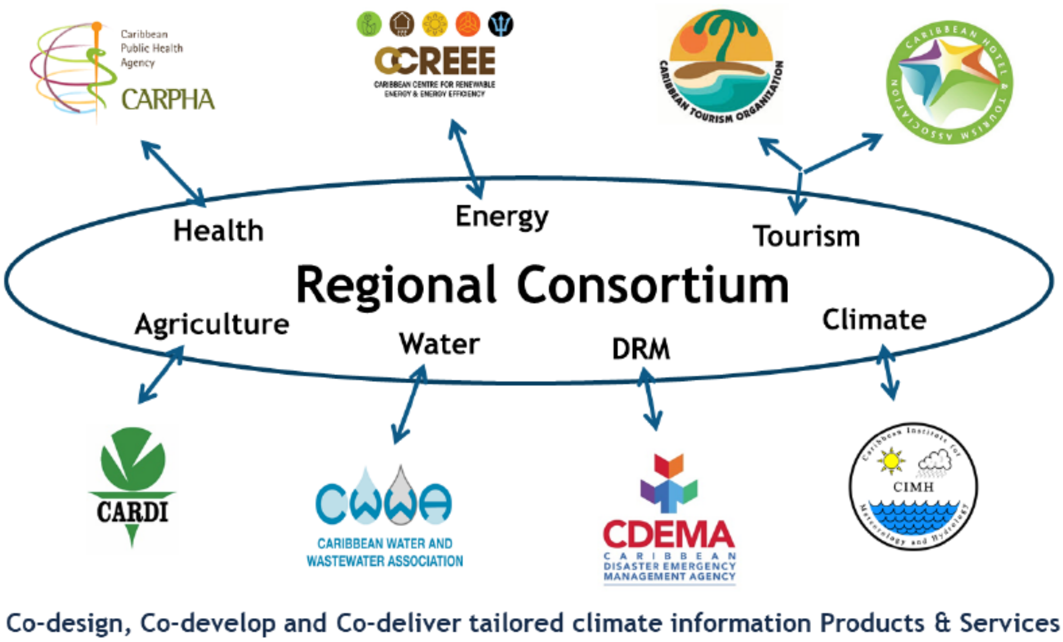
The Early Warning Information Systems Across Climate Timescales (EWISACTs) programme involves the development of EWSs for different sectors (e.g. health, agriculture) and issues (e.g. drought, coral reefs). The Consortium of Regional Sectoral EWISACT Coordination Partners was formed in 2017 under the three-year (2014–2017) Building Regional Climate Capacity in the Caribbean programme. The consortium is a mechanism to drive the co-design, co-development and co-delivery of tailored climate products and services in the agriculture and food security, disaster risk management, energy, health, tourism and water sectors in the Caribbean. Since 2015, the ad hoc meetings of the consortium have provided an important opportunity for seven lead regional technical sectoral agencies (see Figure 1), as well as regional observer organisations,[2] to raise sectoral and governance issues, positions and recommendations related to weather and climate in a cross-disciplinary context within the Caribbean Regional Climate Centre.[3] These sessions facilitate the consultative and participatory processes necessary for successful joint development and implementation of EWSs and are a key

[2]Regional observer organisations include technical organisations (e.g. the CCCCC and the Climate Studies Group at the University of the West Indies, Mona Campus), sector organisations (e.g. the PAHO and the Agricultural Alliance of the Caribbean) and geo-political coordination organisations (e.g. the CARICOM Secretariat and the Organisation of Eastern Caribbean States Commission).

[3]The CRCC serves as the World Meteorological Organization's Caribbean branch. It is housed at the CIMH (https://rcc.cimh.edu.bb/about/about-the-rcc/).

enabler of the significant strides made to date towards the development of sectoral EWSs in the region (CIMH, 2017, 2020; Trotman et al., 2021).

Figure 1: Consortium of Regional Sectoral Early Warning Information Systems Across Climate Timescales (EWISACTs) Coordination Partners



Consortium partners: Caribbean Public Health Agency (CARPHA), Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE), Caribbean Tourism Organization (CTO), Caribbean Hotel and Tourism Association (CHTA), Caribbean Agricultural Research & Development Institute (CARDI), Caribbean Water and Wastewater Association (CWWA), Caribbean Disaster Emergency Management Agency (CDEMA) and Caribbean Institute of Meteorology and Hydrology (CIMH).

Source: CIMH (2017).

The EWISACTs Consortium has developed sector-/issue-specific climate bulletins that include key messages from CIMH's technical climate products, describing opportunities and risks associated with climatic conditions relevant to the particular sector (CRCC, 2018a):

- The **Caribbean Health Climatic Bulletin**. This bulletin is published quarterly and is developed and disseminated by CARPHA, PAHO and CIMH to help the sector manage risk. The bulletin offers insights into predicted climatic conditions (how hot, how wet) for the upcoming season and their health implications, It provides guidance to health professionals on how to manage health conditions that will potentially be affected by upcoming unfavourable weather conditions, such as noncommunicable diseases (NCDs), vector-borne diseases, acute respiratory or gastrointestinal illnesses, physical injury and well-being and mental health (CRCC, 2018b). The bulletin is based on seasonal climate forecasting by CIMH, in collaboration with national meteorological services through the Caribbean Climate Outlook Forum (CariCOF), supplemented by advice from technical officers at CARPHA and PAHO as to the likely health outcomes of the predicted weather. A limitation of the bulletin is that the health predictions are not based on statistical modelling of associations between climate and health variables. This highlights a general limitation in capacity to link climate data and health outcomes in the Caribbean. The bulletin is available at http://rcc.cimh.edu.bb/caribbean-health-climatic-bulletin.

- The **Caribbean Agro-Climatic Bulletin** of the **Caribbean Society for Agricultural Meteorology (CariSAM)** is a monthly bulletin published by the CIMH and CARDI. This is an operational tool designed to help the agricultural sector manage climate risks and take advantage of climate opportunities. The bulletin is available at http://rcc.cimh.edu.bb/carisam-bulletin.
- The **Caribbean Tourism-Climatic Bulletin** is a monthly bulletin produced by the CIMH, the CTO and the CHTA. It aims to help the tourism sector manage climate risk and take advantage of climate opportunities (R4ACCHC, 2022a). The bulletin is available at http://rcc.cimh.edu.bb/caribbean-tourism-climatic-bulletin.
- The **Caribbean Drought Bulletin** is a monthly bulletin providing early warning of drought in the Caribbean. It packages drought monitoring and forecast information, highlighting in particular the parts of the region where there are concerns about short- and long-term drought (Trotman et al., 2021). The bulletin is available at http://rcc.cimh.edu.bb/climate-bulletins/drought-bulletin.
- **Caribbean Coral Reef Watch** is published between May and December, to correspond with the season in which coral reef bleaching can occur. It is developed by the CIMH in collaboration with the National Oceanic and Atmospheric Administration (NOAA) Coral Reef Watch and tracks the current sea surface temperatures and related coral reef health, globally and regionally. It maps regional thermal stress levels and coral bleaching potential with a lead time of 20 weeks. In addition, included in this early warning tool is a detailed outlook for the countries most at risk of coral bleaching. The bulletin is available at http://rcc.cimh.edu.bb/caribbean-coral-reef-watch.

Dominica’s National Resilience Development Strategy

Nationwide collaboration to achieve climate resilience is exemplified by Dominica’s National Resilience Development Strategy 2030 (NRDS). This strategy considers six key areas: strong communities, a robust economy, well-planned and durable infrastructure, enhanced collective consciousness, strengthened institutional systems and protected and sustainably leveraged natural and other unique assets. The Climate Resilience and Recovery Plan 2020–2030 seeks to operationalise the NRDS through various initiatives . For each initiative the concept is described, and the key organisations responsible for delivery of the initiative, resources required and outcomes are specified. Collaboration was established by naming key delivery entities for each initiative set out in the plan.

One such initiative is the Enhanced Social Safety Net Initiative, which seeks to ensure that the most vulnerable communities are socially protected from, and resilient to, threats from climate change. This will be achieved by enhancing Dominica’s social service delivery to reach the most vulnerable with welfare assistance, creating a registry of citizens who qualify for support, focusing on prevention of poverty and considering cash transfer programmes where payments are linked to resilience-building activities. Collaborative partners include representatives of the Climate Resilience Execution Agency for Dominica (CREAD); government ministries, such as those responsible for finance, sustainable development and health; and village councils (Government of the Commonwealth of Dominica, 2020).

Collaboration with international agencies is an important aspect of collaboration for SIDS. Since Hurricane Maria, the Government of Dominica has partnered with the PAHO, supported by funding from the Foreign, Commonwealth and Development Office of the United Kingdom, in the Smart Health Care Facilities Project (see Chapter 16, “Smart health facilities”). There have also been collaborations with the EU to construct purpose-built emergency shelters in key locations around the country, to safeguard the lives of citizens, particularly the vulnerable; this complements national efforts to build resilient housing. With support from the World Bank, the Food and Agricultural Organization and the Inter-American Institute for Cooperation on Agriculture, practical assistance has been provided to farmers and agricultural policies to prevent food insecurity have been developed (Baron, 2021).

Lancet Countdown Regional Centre for Small Island Developing States

In 2022, the *Lancet* Countdown Regional Centre for Small Island Developing States (SIDS) was launched. The centre is a collaboration between the *Lancet* Countdown on Health and Climate Change at University College London and the Caribbean Institute for Health Research at the University of the West Indies, Jamaica. The aim of the centre is to bring together academics, researchers, professionals, government officials, advocates and health practitioners concerned with climate change from island states in the Caribbean Sea, the Pacific Ocean, the Atlantic Ocean, Indian Ocean, the Mediterranean Sea and the South China Sea. It will provide high-resolution data for SIDS and collaborate with professionals in the cross-cutting fields of health and climate change. The centre proposes to (Lancet Countdown on Health and Climate Change, 2022):

- Develop integrated climate and health surveillance systems in each SIDS region, to monitor illnesses that are driven or made worse by climate change.
- Develop and implement EWSs based on the integration of health and meteorological surveillance for climate-sensitive diseases, with a priority focus on highly vulnerable groups.
- Increase public financing towards strengthening the climate resilience and capacity of healthcare facilities.

In 2020–21, the *Lancet* Countdown on Health and Climate Change conducted research with stakeholders from the Caribbean and Pacific SIDS working in academia, and national, regional and international public health and environmental agencies, as well as nongovernmental organisations (NGOs). The research critically examined the *Lancet* Countdown suite of climate change and health indicators and led to the suggestion of priority areas for research and the development of indicators appropriate for SIDS. At a 2021 meeting, the results were presented to and discussed by those consulted in the research and a few additional stakeholders. The meeting endorsed the recommendation that a new indicator area be developed – collaboration between agencies – as this was perceived to be important by SIDS and is an area that is not presently monitored by the *Lancet* Countdown on Health and Climate Change (Allen et al., 2021a; Romanello et al., 2022). It was partly in response to this recommendation that this chapter on collaboration between agencies was included in this report.

10.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Include civil society, NGOs and communities in planning, design and implementation of national and local projects/programmes

An important dimension of collaboration is vertical: between agencies at all levels of society. Individuals and communities most directly exposed to climate change risks must be integrally involved and contribute to "bottom-up" decision-making. This is a matter of equity and justice (see Chapter 9, "Distribution, equity and justice in climate change and health"). A multisectoral solution for climate change must include those most affected, who can become champions of action to address climate change (Greaves, 2021).

Individual and community involvement also assists in operationalising decisions made collectively. National plans, including nationally determined contributions (NDCs; i.e. non-binding national mitigation plans required by the Paris Agreement), need to be implemented and delivered by people "on the ground" and are likely to be more efficiently and effectively carried out if local people are involved in both the strategic and operational decisions (Patterson-Waterston, 2021). Service providers and producers of goods should be brought into dialogue on how they can incorporate adaptation and mitigation actions into their work practices and resource utilisation. This implies the need to develop strategies of community consultation and engagement in ways that are informed by developments in communication strategies and technologies (Allen, 2021; R4ACCHC, 2022b, 2023; Scobie et al., 2021). It is important to consider the logistics and timing of collaborating with communities.

Box 1: Examples of Caribbean nongovernmental organisations' current and potential collaboration in climate change initiatives

Caribbean Alliance for Sustainable Tourism

Caribbean Alliance for Sustainable Tourism (CAST) is made up of 32 national tourism associations throughout the Caribbean region. Its parent organisation is the CHTA, whose members are mostly private sector organisations. Like other nongovernmental organisations, the CHTA has an important role to play, engaging its members, other businesses and the public in the implementation of sustainable approaches and driving policy change. For example, CAST and CHTA have the ability to reach not only government and public sector workers but also those working in the private sector in hospitality and tourism, retail and distribution, manufacturing, construction, agriculture, the blue economy and the off-shore oil and gas industry. CAST has the ability to communicate and collaborate at the national (e.g. national associations), regional (e.g. the CTO) and international (e.g. the World Tourism Organization) levels (Williams, 2021).

Faith-based organisations

Faith-based organisations (FBOs) can reach communities through national councils of churches, regional ecumenical organisations (e.g. the Caribbean Council of Churches [CCC]) and globally, for example, through the World Council of Churches, which has 400 member churches worldwide, and the Global Christian Forum. FBOs carry a significant degree of moral authority and suasion and have long been working on the environment and climate change. The World Council of Churches has a dedicated department and educational and advocacy resources on the environment. The CCC contributed to the region's first solar heating venture by establishing a company called Solar Dynamics Limited (www.solardynamicslimited.com). Many within the Caribbean population have deep religious beliefs, and it would be wise to collaborate with FBOs in policy development and project implementation (Granado, 2021; R4ACCHC, 2022c; Scobie et al., 2021).

Participation and engagement will be insufficient if, for example, meetings are planned in places and at times which are inconvenient to community members. It is also important to consider how best to present information to different stakeholders (R4ACCHC, 2023).

National and regional NGOs and/or NGO networks have a large customer or membership base. See Box 1 for examples of ways that NGOs in the Caribbean can be involved in collaboration.

An international example of civil society involvement is the Zurich Flood Resilience Alliance, which consists of humanitarian, NGO, research, and private sector partners working together to increase public and private investment in evidence-informed community-based flood resilience (R4ACCHC, 2023; Zurich Flood Resilience Alliance, 2023). Another international example is an initiative by the NOAA, which involves community groups in mapping the urban heat island effect across the United States of America (see Chapter 6, "Heat-related illness") (Poon, 2022; R4ACCHC, 2023). In Africa, the Cityzens4CleanAir Campaign recruited young people as citizen scientists, who, together with adults, ran along designated routes collecting air quality data using wearable sensors (UrbanBetter, 2022). These examples show the potential for civil society involvement in climate change adaptation and in research that can contribute to evidence-based decision-making.

Structural/governmental and private sector actions

Develop multisectoral coordinating mechanisms, such as national and regional Climate Change and Health Commissions

Governance of the overall response to climate change and health requires the establishment of coordinating mechanisms in each country and in regional institutions. Lessons can be learned from the formation of NCD commissions in the Caribbean. These were established to plan and coordinate the comprehensive prevention and control of NCDs. Some core principles of successful national NCD commissions have been identified: legitimacy emanating from being established by the government; multisectoralism; credibility; transparency; accountability; conflict of interest procedures; adequacy of resources; sustainability; and strategic planning and management. Effective multisectoral lessons learned from NCD commissions include the need for collaboration rather than partnership, for networking of stakeholders, for knowledge of stakeholder skillsets, for staying the course, and for strong leadership (Greaves, 2021). They can be translated to combating health-related impacts of climate change through the establishment of Climate Change and Health Commissions. There needs to be harmonisation in planning for resilience with a 'one agenda, many leaders' approach to addressing climate change (Kumarsingh, 2021).

These commissions, or any other proposed mechanism for collaboration, must include stakeholders from all levels of society and across sectors, such as civil society, the community, the private sector and the government (Allen, 2021). Representatives of different economic and governmental sectors are also needed. This approach is consistent with the Caribbean Action Plan on Health and Climate Change, which has as one of its proposed national actions, 'N.4.5. Engage, coordinate, and collaborate with other sectors and development partners for resources to address health and climate change' (PAHO, 2019). Agreements (e.g. memoranda of understanding) can be established between the health ministry and main stakeholders at the national level (e.g. meteorological services and ministries of environment, food and agriculture, energy, transport, planning, water, sanitation, infrastructure, and public works), which include specific roles and responsibilities in relation to protecting health from climate change (WHO, 2022).

Designate national and agency focal points for climate and health

There should be someone within either the ministry responsible for health or the ministry responsible for the environment who can coordinate efforts to ameliorate the health-related impacts of climate change: a national focal point, in other words. This person should play a key role in any climate change and health commission that may be established. In addition, there should be climate and health focal points at the regional level within health, disaster management and climate/meteorological agencies, for example CARPHA, PAHO/WHO, the CIMH, the Caribbean Disaster and Emergency Management Agency (CDEMA) and the CCCCC, and the many academic and higher education institutions and their relevant departments (e.g., at UWI, the Faculty of Medical Sciences, the Centre for Resource Management and Environmental Studies, the Institute for Sustainable Development and the Centre for Marine Sciences, among others) (Allen, 2021; Harewood, 2021).

Form alliances between health and other sectors to mitigate climate change

Sectors such as agriculture, energy, sanitation, transportation, and construction are high emitters of greenhouse gases (GHGs), which cause global warming. Furthermore, the same processes that emit GHGs (e.g. burning of fossil fuels) emit air pollutants that directly harm human health (see Chapter 5, "Air quality"). Health issues have not previously been considered in energy planning, for example. Caribbean governments and other entities have started an energy transition from fossil fuels to "clean" renewable energy. There is a need to increase the focus on the health co-benefits of this transition, by, for example, increasing monitoring of air pollution and its impacts on health. Because every sector is involved in the energy transition, the ministry of energy needs to liaise not only with the ministry of health, but also where appropriate, with ministries of planning, transportation, agriculture, manufacturing and industry. Alliances with the private sector are also very important as they provide an "incubator for new ideas" (R4ACCHC, 2023).

Form alliances between health and disaster management agencies and systems

As detailed in Chapter 1, "Health impacts of extreme weather events", collaboration between health and disaster management agencies, notably CDEMA at the regional level in addition to national disaster management agencies, is needed to develop severe weather event responses and strategies. Areas of collaboration include the procurement and logistics of medical supplies; identification of people at medical risk; the provision of climate-resilient storage and emergency response facilities and equipment; and data integration, monitoring and evaluation (Allen et al., 2019; CARPHA, 2018; Harewood, 2021; R4ACCHC, 2023).

Use communication skills to develop mutual understanding between agencies

Agencies and communities have their own "cultures" and means of expression. For true collaboration to take place, communication needs focused attention. Communications specialists should work with agencies and communities to translate information and messages and present them in formats and in ways that promote mutual understanding (R4ACCHC, 2023). At the regional level, there is a literal need for translators and interpreters to enable collaboration between countries and communities that speak different languages.

Develop collaborative mechanisms for research and surveillance

Given the limited resources for research and surveillance, it is important to establish means of cooperation between academic institutions, government ministries and the regional agencies concerned with providing the evidence base for action. Collaboration between agencies involved in health and meteorological research and surveillance is especially necessary. Mechanisms include data-sharing agreements and protocols, central repositories for publications and data, cooperation in the development and/or procurement of climate-resilient facilities/equipment for data collection and storage, and the establishment of joint research ethics review and oversight mechanisms (Allen, 2021; Allen et al., 2019; CARPHA, 2018; Glasgow, 2021; R4ACCHC, 2022b, 2023). (see Chapter 11, "Research and surveillance on climate change and health").

It is also important for research agencies to pursue alliances with implementing agencies and to communicate their research in ways that facilitate evidence-based action (R4ACCHC, 2023).

Research and surveillance gaps and how to address them

Research is necessary to identify suitable models of collaboration, to examine ways to establish and maintain such models in the Caribbean context, to identify the agencies to be involved and to establish indicators for monitoring and evaluation. These indicators should be built into regular schedules of monitoring of collaborative ventures, with systems for data collection, analysis and dissemination (Allen et al., 2021a).

Monitor and evaluate collaborative projects

It is important to establish monitoring and evaluation mechanisms to ensure that the outcomes and impacts of collaborative programmes can be assessed. This includes monitoring of collaborative processes such as the contributions of different agencies and communities to decision-making, using qualitative research. It also includes assessing the contribution of collaborative mechanisms and programmes to goals such as climate resilience and improved health outcomes. Regional and national collaborative health and climate change programmes and projects should each have specified indicators for monitoring and a clear methodology for evaluation. It is important for policy purposes to monitor costings so that the cost-effectiveness of various options can be assessed (Harewood, 2021).

As recommended in the *Lancet* Countdown assessment of climate change and health in SIDS (Allen et al., 2021a), collaboration between agencies should itself be monitored. The extent of collaboration and policy integration between agencies may be difficult to quantify, and qualitative indicators may be necessary. These may, for instance, show the existence of interagency collaborative mechanisms (such as memoranda of understanding or shared data repositories) and meetings, and track progress in implementation of their decisions. Such monitoring mechanisms may be complex to set up and implement, but interviewees emphasised that collaboration is at the root of eventual success in addressing climate change and health links, and must be given priority (Allen et al., 2021a,b).

Process, impact, cost–benefit and/or cost-effectiveness evaluations of collaborative projects may be conducted. Determining the barriers to and facilitators of implementation of a suggested action would also be helpful in determining recommendations for the way forward. Research questions could include, for example:

- Were NGOs included in the planning and design of national projects/programmes?
- Have national and agency focal points been designated for climate and health?
- How many mechanisms have been developed between health ministries/agencies and other sectors/agencies?

Explore ways to promote cross-sectoral collaboration among government departments and between the government and private sectors on climate change and health

Governmental institutions and agencies tend to work in silos. To effectively address the adverse health effects of climate change, a “health in all policies” approach is needed, promoting cross-sectoral collaboration and embedding health considerations into decision-making across sectors. There is a need to understand the best strategies to integrate climate and health discussions into all sectors and across sectors, including the private sector (e.g. the tourism, energy, insurance, and finance industries) (Hassan, 2021b). Questions may include (Hassan, 2021b):

- How do governments effectively engage with the private sector on climate action for health?
- What government–private sector collaborations are needed to address supply chain disruptions that result from climate change and can worsen food insecurity and healthcare service delivery? How can governments realise equity in the global supply chain?

- Which sectors need to be involved in policy development and implementation for health and climate change?
- What are the different ways in which coordination between these sectors could be improved?
- How can we overcome economic and regulatory barriers to facilitate collaboration?
- How can we encourage the financial sector to invest capital and leverage its data science capabilities to facilitate collaboration?
- How do we promote private sector players with an interest in providing solutions and partner them with technical experts in a community of practice or consortium?
- How can we leverage existing examples of collaboration? For example, the Ministry of Planning and Development in Trinidad and Tobago, through the Multilateral Environmental Agreements Unit, is coordinating climate policy and implementing it in collaboration with other Ministries. A cabinet-appointed Ministerial Committee will provide high-level guidance to the implementation of NDCs. This is supported by a Technical Support Committee that can make policy recommendations.
- How can we develop effective tools in the region to foster collaboration such as memoranda of understanding?

Research and surveillance capacity-strengthening needs

To address the research and surveillance needs to ensure collaboration among the private sector, NGOs, national and regional agencies and academia, capacity must be built in implementation science and implementation research, impact evaluation, qualitative and mixed methods research, and advanced statistical methodologies. The following additional specialist expertise is required:

- Participatory monitoring and evaluation;
- Mechanisms to improve data collection and sharing;
- Theories of collaborative and partnership work and organisational effectiveness (R4ACCHC, 2023);
- Communication and media expertise so that research can be presented in ways that different communities can understand (R4ACCHC, 2023);
- Public policy;
- Development of legislation.

There is also a need for enhanced information technology infrastructure and expertise, along with surveillance expertise, to build the databases needed for sharing of information. Statisticians and communications specialists with writing skills are needed to make technical reports accessible to decision-making. UWI can serve as a regional hub for projects, as the university operates from many Caribbean states and has many partners. Furthermore, UWI is interested in expanding the implementation side of its research (R4ACCHC, 2023).

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11. RESEARCH AND SURVEILLANCE ON CLIMATE CHANGE AND HEALTH

11.1. WHAT IS HAPPENING?

In July 2021, there were reported to be 239 universities and colleges across Caribbean countries (Glasgow, 2021). In addition, several regional and multilateral agencies in the region conduct health and/or climate research and surveillance, and ministries of health also collect health data. This is indicative of the potential capacity for climate change and health research, surveillance and action within the region. However, the evidence presented in other chapters of this Caribbean Research for Action Agenda shows that this potential has largely not been realised.

There are two main categories of research and surveillance data that are helpful in developing strategies to address climate change and health:

- Identifying and monitoring climate change health impacts, exposures and vulnerability;
- Identifying and monitoring appropriate actions and capacity-building needs.

In this chapter we provide a summary of the status of research and surveillance in the region with respect to these two categories, based on analyses of other chapters of this report.

We then go on to provide an overview of the institutional landscape and the capacities for research and surveillance, and some of the factors that must be overcome to produce sufficient high-quality information for action.

Research on climate change health impacts, exposures and vulnerability in the Caribbean

Evidence on several health outcomes is presented in this report, i.e. in Chapters 1, "Health impacts of extreme weather events", 2, "Vulnerability to vector-borne diseases", 4, "Noncommunicable diseases and risk factors", 6, "Heat-related illness", and 7, "Mental health". Evidence on exposure pathways and their health outcomes is also described, i.e. in Chapters 3, "Water, sanitation and hygiene", 5, "Air quality", and 8, "Population displacement and migration". Behavioural, biological, social and economic vulnerabilities associated with variations in health outcomes are explored in Chapter 9, "Distribution, equity and justice in climate change and health".

Each of these chapters includes analysis of the scope of, and gaps in, Caribbean research on the topic in question. A few observations on these will be made in this chapter. References to the literature pertaining to each topic can be found in the relevant chapter of this report (e.g. Chapter 2, "Vulnerability to vector-borne diseases", includes references to the Caribbean research in this area; they have not been repeated here).

Health outcomes

Health outcomes are unevenly covered in primary research in the Caribbean, and there is a lack of population-based studies (Lichtveld, 2021). The only topic with a full programme of research that looks at the steps along the pathway from climate drivers to health outcomes, including mediating factors, is **vector-borne disease**, specifically disease borne by the *Aedes Aegypti* mosquito. Much of this research was conducted in the early 2000s. More recent work has focused on the development of early warning systems (EWSs) for mosquito-borne diseases. This has revealed the need for further local capacity-building in areas such as statistical modelling and geographic information systems.

Within the last decade or so there have been moves to extend the knowledge base on **health impacts of extreme weather events** beyond government statistics on immediate deaths and injuries and donor-supported post-disaster needs assessments. This has involved studies to assess health outcomes such as gastrointestinal illness, mental health and incidence of and morbidity from noncommunicable diseases (NCDs). There have also been analyses of the integration of health in disaster preparedness and response, but not much primary research in this area. It has been observed that studies are needed that span periods between disasters, so that the impact of disasters can be measured and slow-onset health challenges of climate change can be tracked (Lichtveld, 2021).

The Caribbean has a strong history of research on **NCDs**, but there has been little empirical research on the impact of climate change on NCDs. There is increasing interest in how extreme weather events affect incidence of NCDs and health outcomes among people living with NCDs, including some important recent empirical studies. The development of NCD registries in some countries can assist in monitoring impacts and enabling research. The Caribbean Institute for Health Research (CAIHR) at the University of the West Indies (UWI) is increasing its focus on climate change and NCD research.

The work of the Climate Studies Group at UWI has been critical in providing longitudinal data and analyses of climate conditions in the region. Studies have shown that air temperatures conducive to **heat-related illness** are becoming more frequent in the Caribbean. A study in French overseas territories in the region found an association between increased heat stress and mortality. There have been qualitative studies on clinicians' perceptions of increasing heat-related illness and the experiences of patients with specific conditions.

Several studies look at **mental health** outcomes of severe weather events. Some impacts of environmental changes, not restricted to climate change, on mental health have been observed in vulnerable populations such as indigenous people.

Exposure pathways

Almost all published primary research studies on **air quality** and health in the Caribbean have focused on Saharan dust, which may be associated with climate change. Other Caribbean publications discuss, with real-world Caribbean examples, how air quality is affected by severe weather events and use of fossil fuels, extrapolating the health outcomes from the global literature. Multilateral agencies have conducted important work with Caribbean governments to establish air quality surveillance, and academic institutions have established air quality monitoring and forecasting mechanisms for the region.

Caribbean technical agencies such as the Centre for Resource Management and Environmental Studies (CERMES) and the Caribbean Public Health Agency (CARPHA) have been involved in monitoring **water, sanitation and hygiene (WASH)** quality, availability and infrastructure, and water-borne diseases. No primary research studies on WASH showing pathways from climate change to health were identified.

There appears to be no original research from the Caribbean on **climate migration**. Authors have extrapolated information on the health status of migrants and their access to care from existing studies and observations from outside the Caribbean.

Vulnerabilities to health impacts of climate change

Several Caribbean studies have examined how exposure to the effects of climate change, such as extreme heat, affect people with preexisting conditions such as NCDs and disabilities. No Caribbean studies were identified on how exposure affects both sexes and people across the life course, e.g. how it affects functioning in older people.

Conference papers have identified behavioural, social and economic vulnerabilities of specific populations to social and health impacts of climate change in the region. However, there is a lack of empirical data and research to identify and pinpoint needs. This prevents the development of action to address inequities in health and achieve climate justice. More precision in identifying populations and areas at risk is needed (Lichtveld, 2021).

Surveillance data for research on health impacts, exposures and vulnerabilities

Across all these health outcomes, it has been observed that health surveillance is weak, with data on most climate-sensitive health conditions not being systematically collected by healthcare providers or presented in national statistical collections. This substantially limits capacity to conduct research to explore correlations between climate conditions and health conditions. There is a lack of secondary data that a variety of researchers can make use of, restricting the scope for comparative and longitudinal research. The field of research is fragmented, relying on individual studies where researchers and agencies have funds to collect their own data.

Research on action to address climate change and health links, including adaptation, mitigation, resource management and stakeholder engagement

To address the health outcomes of climate change, action must be taken to adapt to and mitigate climate change, manage resources and engage key stakeholders.

Adaptation, planning and resilience for health are addressed in Chapters 10, “Collaboration between agencies”, 12, “Agriculture and food safety and security”, and 13, “Awareness- and skills-building”. The current chapter on research and surveillance also addresses a key component of adaptation.

Mitigation actions and health co-benefits are addressed in Chapters 14, “Marine resources and health”, 15, “Climate-friendly health-promoting infrastructure”, and 16, “Smart health facilities”.

Managing resources and engaging stakeholders in climate change and health action are addressed in Chapters 17, “Funding streams for climate and health action”, and 18, “Government engagement in health and climate change”. However, issues of resource management and stakeholder engagement are cross-cutting themes that are also discussed in the subsections below on adaptation and mitigation.

The following subsections provide a summary of research conducted on adaptation, mitigation, resource management and key stakeholder engagement.

Adaptation, planning and resilience for health

Collaboration between agencies on health and climate change has not been the subject of empirical, published research in the Caribbean. The monitoring and evaluation of existing Caribbean-wide and national collaborative projects may provide insights into factors for successful collaboration. Conference papers have suggested areas and methods for collaboration. The *Lancet* Countdown assessment of climate and health in Small Island Developing States (SIDS) suggested methodologies for assessing and monitoring collaboration.

Food insecurity and challenges to **agricultural production** in the Caribbean have been studied, but their links with climate change have received little attention, with the exception of some limited research on the impacts of extreme weather events and rising temperatures. How their impacts on food insecurity and agricultural production then go on to affect health has not been the subject of empirical research, however. There is a lack of Caribbean operational research on how agricultural and food systems can be configured for climate change adaptation and mitigation.

There is a small but growing body of research on **awareness- and skills-building** on climate change and health in the Caribbean. The number of knowledge, attitudes and practice (KAP) studies is increasing, with some being general population surveys and some using quantitative or qualitative methods to assess the KAP of health professionals. A few studies look at the availability of climate change training for health professionals in the region. Welcome developments include the emergence of studies that present and evaluate training courses and other capacity-building for health professionals, and research on the effectiveness of media, communications and social influencer methods in altering KAP.

The World Health Organization (WHO) recommends **vulnerability, capacity and adaptation assessments** as a component of health information systems in the "Operational framework for building climate resilient health systems" (Shumake-Guillemot et al., 2015). This framework includes the range of assessments that can be used to generate policy-relevant evidence on the scale and nature of health risks, including risks affecting vulnerable populations, taking into account local circumstances. The main elements of the assessments are as follows (Shumake-Guillemot et al., 2015):

Vulnerability

- Baseline rates and monitoring of health conditions against climate variability data;
- Vulnerable populations and geographical areas;
- Status of key health-determining sectors.

Capacity

- Available human, technical and health service delivery capacity, with identification of weaknesses;
- Recommendations for addressing gaps.

Adaptation

- Use of evidence to prioritise allocation of resources and effective interventions across sectors;
- Plans and mechanisms for iterative review of adaptation options.

Within each country, then, existing evidence and new data should be collected to inform adaptation strategies. Given the paucity of research and surveillance that is indicated in the current report, it is clear that most Caribbean countries are not in a position to draw on sufficient local evidence. Some countries have conducted such assessments, relying to varying extents on external funding and technical support (Carmalt, 2014; Schnitter et al., 2019). The development of evidence-based Health National Adaptation Plans is at an early stage in most Caribbean countries. Adaptation planning is under way, but with little focus on health to date (see Chapter 18, "Government engagement in health and climate change").

Thomas et al. (2019) assessed 89 adaptation planning documents from Caribbean SIDS, focusing on the inclusion of key stages of adaptation planning that were identified in international and regionally specific adaptation guidance instruments. The adaptation planning documents included policies, strategies, programmes and projects, and the study revealed that they differed considerably from guidance instruments. For instance, only 9% of adaptation plans conducted a primary hazard, impact, vulnerability or risk assessment (HIVRA), 42% referred to a secondary HIVRA and 22% did not include any reference to HIVRA. Of HIVRA documents, 60% included qualitative hazard information and 70% included qualitative impact information, while only 30% included quantitative impact information. The authors concluded that key areas for improvement include the need for (1) more direct linkages between identification of adaptation options and assessment of climate hazards, impacts, vulnerability and risk; (2) identification and appraisal of a range of adaptation options; and (3) increased inclusion and use of quantitative information about hazards and impacts (Rise et al., 2022; Thomas et al., 2019). The study shows that Caribbean climate change adaptation plans are generally insufficiently informed by rigorous evidence on hazards, impacts, vulnerability and risk.

Mitigation actions and health co-benefits

Research on the Caribbean **marine environment** has looked at the ecosystem services it provides in regulating the climate and mitigating climate change impacts. Impacts of climate change on Caribbean marine and coastal environments and thus on economic activities and ocean-dependent communities have been examined, focusing on fisheries and tourism. Research has discussed the potential health impacts of the proliferation of sargassum seaweed and damage to coral reefs and fish stocks as a result of climate change. However, there is a lack of primary research demonstrating the health impacts of changes in the Caribbean marine environment. Data on civilian and commercial marine pollution are scarce and have not been translated into effective protection for oceanic resources. Thus, opportunities for mitigation are lost. There is more research to be done on oceanic renewable energy options for the Caribbean.

Damage to **infrastructure** resulting from extreme weather events is a major topic of post-disaster assessments. Caribbean governments, regional and multilateral agencies, and individuals are increasingly focusing on the development of climate-resilient infrastructure. However, with the exception of work on **smart health facilities**, there is insufficient operational research on how to construct and maintain resilient infrastructure that protects and enhances health in the face of climate change. There is increasing attention on how to develop blue–green infrastructure, maximising the mitigation potential of water and plant features, but research is lacking in the Caribbean. Monitoring and evaluation (M&E) indicators for smart health facilities have been developed, but M&E for the health outcomes of other types of infrastructure is lacking.

Resource management and stakeholder engagement

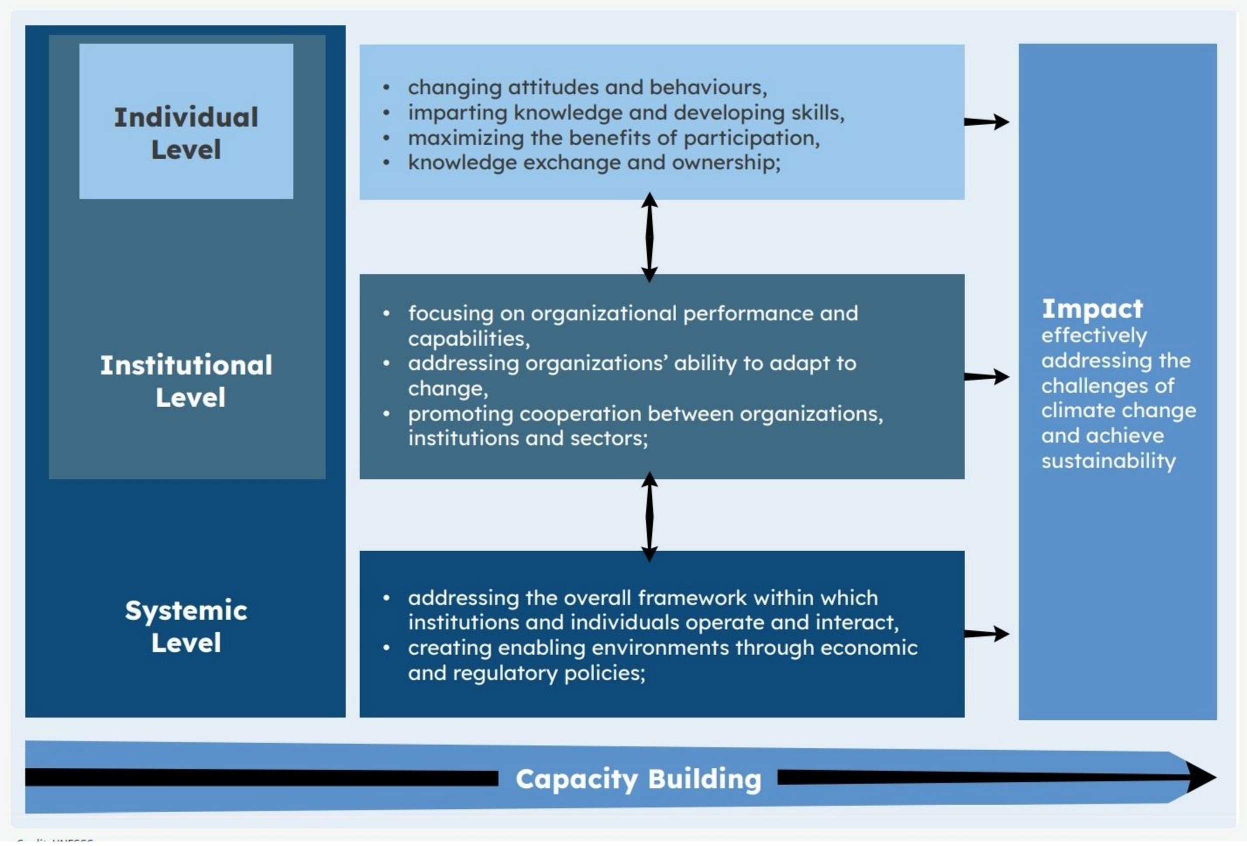
There is very little research on **funding streams** for research and action on climate change and health. As part of regional initiatives to increase access to finance, indicators are being developed to monitor financial flows. There are studies of the economic impact of hurricanes and other tropical storms in individual countries, usually as part of post-disaster needs assessments.

Government engagement in health and climate change has not been the subject of empirical research in the Caribbean. Globally, the *Lancet* Countdown on Health and Climate Change monitors government engagement in health and climate change. This has tracked health content in Caribbean political leaders’ statements on climate change at United Nations meetings and the inclusion of health considerations in nationally determined contributions. Government action on implementing international agreements and national climate and health policies and programmes has not been systematically monitored and assessed.

Capacities to conduct research and surveillance on climate change and health in the Caribbean

The United Nations Framework Convention on Climate Change (UNFCCC) has developed a conceptual framework showing the different levels – individual, institutional and systemic – at which capacity is needed for climate change action (Figure 1) (Glasgow, 2021; UNFCCC, 2021). This can be applied to research and surveillance and other fields of climate change action. Here we focus on what is known about existing capacities at each of these levels. In Section 11.2, “What should be done?”, we recommend capacity-building action at each level.

Figure 1: Capacity-building at the systemic, institutional and individual levels



Source: UNFCCC (2021).

Capacities at the individual level

Knowledge and skills are perhaps the most important type of capacities individuals need for research and surveillance. Knowledge and expertise are needed in specific academic and professional fields relevant to climate change and health research (Sood, 2021). There is also local traditional and lay knowledge that is based on histories of interaction with the local environment. Climate change may damage reserves of local knowledge and solutions to health challenges. For example, biodiversity loss threatens resources used to make traditional medicines, and local communities who have developed ways to address environmental health challenges (Boston et al., 2021).

Most higher education institutions in the Caribbean are primarily training institutions with only a minor focus on research; this applies to most of those called "colleges". They provide training in a wide variety of relevant disciplines but have generally not framed what they offer in terms of contributing to climate change and health research and surveillance.

Universities in the region vary in their capacities to conduct and train people in research. UWI and the University of Puerto Rico have relatively high proportions of academic staff with advanced research degrees (PhDs). There are gaps in the skills of academic staff and students in the Caribbean in critical fields such as biomedicine, epidemiology, geography, law (including human rights), marine biology, oceanography, physics, psychology and statistics (including modelling). Some SIDS may not have even one person resident with advanced statistical skills, for instance.

Caribbean college and university courses do not generally include special modules or content on climate change and health. This limits the likelihood that professionals being trained will bring their skills to climate change and health research and action. However, courses are beginning to be developed. For example, climate change is an issue that has been covered for some years in undergraduate and postgraduate teaching at the Institute for Gender and Development Studies (IGDS) at the UWI Mona Campus (Allen et al., 2021a). UWI has developed a Climate Change Portal (https://uwi.edu/climateaction), which details the research and teaching being done. It has also set up the Global Institute for Climate Smart and Resilient Development (https://uwi.edu/gicsrd/#cover). Neither of these UWI initiatives feature health as a major topic. A content analysis of UWI Faculty of Medical Sciences courses to qualify as a doctor found that only 4.4% of these courses included content on climate change (Nunes and Mundle, 2021).

The five-year European Union (EU)/CARIFORUM Project – Strengthening Climate Resilient Health Systems – (2020–2025), funded by the EU, is aimed at strengthening climate resilient health systems in the Caribbean and is being implemented by the Pan American Health Organization (PAHO)/WHO. It includes a Climate Change and Health Leaders Fellowship Programme in partnership with UWI. This programme involves the training of multisectoral stakeholders in the One Health approach, the Safe Hospitals Initiative and other strategies to develop strong and effective climate change leadership (EU et al., 2023). The first cohort of six fellows graduated in 2022 and a further cohort of six fellows from four Caribbean countries is currently being trained (PAHO and WHO, 2023). Further efforts to develop and evaluate training for professionals in the health sector and health-determining sectors on climate change are presented in Chapter 13, “Awareness- and skills-building”.

Little has been done to build the capacity of the general public to conduct citizen science, that is, gather data that can be used to monitor climate and health. For instance, the Local Environmental Observer Network enables people to register unusual environmental events on an online platform, helping people become aware of dangers (www.leonetwork.org). Scientists can use the information to help explain these events and warn the public about hazards.

Capacities at the institutional level

As well as colleges and universities, several regional and multilateral agencies in the region have research and surveillance capacities. Some are departments of UWI, such as the Caribbean Institute for Meteorology and Hydrology (CIMH) and CERMES, which play a critical role in monitoring and studying weather and environmental conditions. PAHO/WHO has collaborated with ministries of health and regional agencies to strengthen institutional and infrastructural capacity in generating data to boost health systems performance. Notably, the Smart Health Facilities project involves the use of indicators to monitor achievements (see Chapter 16, “Smart health facilities”). PAHO/WHO has also helped establish systems for monitoring air and water quality. PAHO/WHO and CARPHA training and technical support have strengthened the research and surveillance capacities of ministries of health throughout the region.

Other UWI research centres can play important roles in climate and health research, including CAIHR, the George Alleyne Chronic Disease Research Centre (GA-CDRC), the IGDS, the Institute for Sustainable Development and the Centre for Environmental Management. The UWI Faculty of Medical Sciences has an initiative on planetary health headed by a Global Outreach Fellow at the Planetary Health Alliance, who is employed by the faculty (UWI, 2020).

Other academic institutions, such as St. George’s University in Grenada, have also worked closely with Caribbean governments on climate issues. The Windward Islands Research and Education Foundation (WINDREF), based at St. George’s University, hosts several climate-relevant institutions: the UNFCCC secretariat’s Regional Collaboration Centre for the Caribbean; the Global Water Partnership – Caribbean; and the Caribbean Cooperative Measurement, Reporting and Verification Hub (Allen et al., 2021a).

The CIMH is the technical arm of the Caribbean Meteorological Organization (CMO), and acts as the CMO's education, training and research unit. CIMH is the leading institution in the English-speaking Caribbean engaged in focused and interdisciplinary research in tropical meteorology, tropical climatology, hydrology and water resources management. In Cuba, the Instituto de Meteorología de la República de Cuba (INSMET) conducts similar work on behalf of the government and has many links with academic institutions in Latin America as well as with UWI (Allen et al., 2021a). At INSMET, a multi-agency group on climate and health has been established, resulting in research projects and publications that combine climate and health data. INSMET also communicates with the public when climate-related disease outbreaks and risks are predicted (Allen et al., 2021a).

Since 2015, a Caribbean regional consortium of partner agencies has been working on the Early Warning Information Systems Across Climate Timescales (EWISACTs) programme. The programme is based on the World Meteorological Organization's Global Framework for Climate Services, which focuses on five sectors, including health. CIMH also focuses on these five sectors plus tourism. Regional agencies from the agriculture, water and sanitation, health and tourism sectors work with CIMH to produce sector-specific climate products. EWISACTs recently established a roadmap for action up to 2030, including plans for institutional collaboration. It has a formalised working relationship with PAHO and CARPHA; among the results of this relationship is the joint publication of a quarterly Health Climatic Bulletin, disseminated to policymakers in an accessible format (Allen et al., 2021a). Further details of EWISACTs and its information products are provided in Chapter 10, "Collaboration between agencies".

CARPHA is tasked with public health surveillance for the region, and ministries of health provide CARPHA with data on notifiable diseases and causes of death. The frequency of data-reporting varies between countries and across calendar time, creating challenges for health monitoring. Time periods for reporting health conditions are much longer (monthly or yearly) than weather reporting time periods, making it challenging to link climate and health data. Some climate-sensitive diseases, such as selected vector-, food- and waterborne diseases, are reported by ministries of health to CARPHA. Syndromic data, such as data on fevers and gastrointestinal symptoms, are reported weekly to CARPHA, providing the opportunity to assess associations between climate events and disease outbreaks. With a few exceptions, CARPHA surveillance data have not been used by researchers in the region looking at climate change and associations with health. CARPHA is able to share aggregated regional data with researchers and can help researchers obtain permission from ministries of health for access to national data.

However, for some important, climate-sensitive health issues, there is no regular surveillance at national or regional level, as stressed by this interviewee from the *Lancet* Countdown assessment on climate change and health in SIDS (Allen et al., 2021a):

> Data is only collected when there is a programme to collect the data for a particular reason. For example, if there is an outbreak of leptospirosis, we collect data on rodents; if there is a problem with gastro, we do water quality analysis.
>
> Interviewee from the Environmental Health Department, Ministry of Health, Dominica, in Allen et al. (2021a)

There is also no system to bring together climate and health surveillance and monitoring data in a systematic way:

> What we lack in the region are integrated surveillance systems to bring together information from health and climate services.
>
> Interviewee from CARPHA, in Allen et al. (2021a)

The EU/CARIFORUM Project – Strengthening Climate Resilient Health Systems – was formed in part to assist with the implementation of the Caribbean Action Plan on Climate and Health. It is presented in detail in Chapter 10, "Collaboration between agencies". One of the notable features of this multi-component, multi-agency project is that it has a major focus on strengthening information systems. Relevant actions include:

- Adapt and test tools to estimate health benefits. Led by PAHO.
    - Provide standardised climate and health situation profiles by country.
    - Provide tools for decision-makers relating to harmful emissions and the health benefits of active transport and green spaces, such as the Health Risk Assessment of Air Pollution (AirQ+), the Health Economic Assessment Tool (HEAT) for active transport and the Green Urban Spaces (Green UR) tool (Drewry and Oura, 2022).
    - Conduct health and climate change impact, vulnerability and capacity analysis.
- Provide support to countries that are preparing chapters on health in their National Adaptation Plans. Led by PAHO and the Caribbean Community Climate Change Centre (CCCCC).
- Improve the surveillance capacity of professionals working in health and health-determining sectors. Led by CIMH and CARPHA.
    - Strengthen intersectoral surveillance systems, including the development of climate-informed integrated systems and protocols to monitor selected determinants of health (e.g. heat, water and sanitation) as well as health outcomes (zoonosis, vector-borne diseases, foodborne diseases and antimicrobial resistance).
    - Improve routine data collection and systems analysis to advance understanding of the spatio-temporal relationships between weather and climate variability and climate change-induced environmental determinants of health.
    - Develop dedicated long-term surveillance capacity and instruments to strengthen in-country expertise to use, maintain and implement climate-resilient health systems, including by developing or updating surveillance curricula (e.g. updating the monitoring aspects in UWI's two-year curriculum in the One Health Leadership series.

Efforts to strengthen relevant surveillance and research were given a further boost with the establishment of the *Lancet* Countdown Small Island Developing States Regional Centre in 2022 at UWI, Jamaica. It aims to provide high-resolution data for SIDS and collaborate with professionals in the cross-cutting fields of health and climate change. It proposes to develop integrated climate and health surveillance systems in each SIDS region that monitor illnesses driven or exacerbated by climate change, and develop and implement EWSs, with a priority focus on highly vulnerable groups (*Lancet* Countdown on Health and Climate Change, 2022). The centre builds on the work of CAIHR at UWI to establish a climate and health observatory, and CAIHR's collaboration with GA-CDRC to analyse associations between climate and strokes by using data from the Barbados National Stroke Registry (Allen et al., 2021a).

Some researchers have formed collaborative groups to advance relevant regional research. The Caribbean Climate Modellers' Consortium has members from UWI and other regional universities. The core members are from Barbados, Cuba (INSMET), Guyana, Jamaica, Suriname and Trinidad and Tobago. They seek to make the science accessible to policy-makers and the general public, "to keep our decision-makers and our sectors capable of having the high-level discussions or making the decisions that they need" (interviewee from the Climate Studies Group, UWI). In the *Lancet* Countdown assessment of climate change and health in SIDS, the strategies of this consortium were said to have paid off in enabling policymakers to speak knowledgeably on the international stage (Allen et al., 2021a):

> Our policy makers, our people who negotiate at the global stage, our technocrats in the Caribbean countries can speak that language [of Representative Concentration Pathways], and speak it with the knowledge about [the]

> Caribbean region… We have a strong Caribbean community of scientists working on a common agenda for what needs to be achieved to keep [the] Caribbean climate at the level of the other global discussions.
>
> Interviewee from the Climate Studies Group, UWI, in Allen et al. (2021a)

A significant constraint on evidence-based action is that academic institutions in the region tend to have weak links with governments. Systematic methods or mechanisms to include researchers and data in decision-making are rare. Researchers may be called upon on an ad hoc basis, and sometimes local experts are bypassed in favour of experts from outside the region with less local knowledge. Therefore, much government policy has little basis in Caribbean research (Langlois et al., 2019). However, some Caribbean researchers and groups (such as the Caribbean Climate Modellers' Consortium) proactively seek connections with relevant branches of government. CARPHA and PAHO/WHO often interact with both academic and government institutions on projects, and to some extent perform a bridging role. The Caribbean Centre for Health Systems Research and Development (CCHSRD) at UWI works on translational research, policy briefs and other methods to smooth the process from research to action.

Caribbean higher education institutions are not richly endowed with facilities and equipment, including both standard and advanced information technology and specialised equipment for scientific data collection, testing and analyses. This constrains their capacity to be self-sufficient in scientific research on climate change and health. Furthermore, facilities, equipment, data and biological specimens may themselves be damaged by climate drivers such as extreme heat, floods and hurricanes (Lichtveld, 2021). For instance, Hurricane Maria did considerable damage to a newly established computerised health surveillance system in Dominica, and some paper records were also destroyed (Allen et al., 2019; CARPHA, 2019).

A further challenge to institutional capacity may be academic, interinstitutional and intercountry rivalries within the Caribbean, which prevent sharing of knowledge and lead to duplication of precious effort. There are few cooperative and data-sharing agreements between countries and institutions that can help overcome such challenges. This was a challenge highlighted by interviewees in the *Lancet* Countdown study of climate change and health in SIDS (Allen et al., 2021a,b):

> Caribbean nations need to have laws and regulations around data sharing. Some countries have started legislation, particularly Barbados and Jamaica. I'm not sure what's happening with the Eastern Caribbean states. That's a critical thing where we have to talk about the ethics of data sharing.
>
> Interviewee from GA-CDRC, UWI, in Allen et al. (2021a)

> In terms of data, I think of it as the cup being half full rather than half empty. It is not where we want it to be. And data sharing is a real problem. Some of the barriers are rooted in legal constraints, others of them, information is power, and we have inherited a very colonial system where there's a lot of hierarchy. As you would know as a researcher, if you want to get some information you have to go through several hoops unless you know someone.
>
> Interviewee from IGDS, UWI, in Allen et al. (2021a)

These interviewees highlight the need to address ethical and legal issues in establishing data-sharing protocols and mechanisms.

There are deficiencies in the capacity of some institutions to protect the human rights of research subjects through ethics review procedures. Regional bodies such as CARPHA and CCHSRD have made considerable strides in providing technical support for the establishment of national research ethics review boards or procedures in Caribbean countries. Chief medical officers are generally supported by a panel of local experts in reviewing and approving local health research. Other agencies, such as CARPHA, UWI and PAHO/WHO have their own institutional review boards (IRBs) to review research conducted by or with these institutions. Ministries of health sometimes call upon these IRBs to conduct additional reviews of research proposals, and some proposals are reviewed by more than one ethics committee. In some of the smallest Caribbean SIDS, there may be a lack of local ethics review skills. Regional institutions such as CARPHA and UWI are among the bodies that can provide support when local ethics review skills are lacking, with the understanding that chief medical officers make the final decision on research proposed for their countries.

Institutional capacity for data analysis and management is a significant area of concern. The lack of sufficient specialists such as statisticians and people with an understanding of research design is a further constraint.

The Caribbean also currently lacks a repository and centralised database for climate change and health research and relevant data. This results in the loss of important information and other researchers across the region being unable to access it.

> What the Caribbean tended to experience over previous years was data loss. So lots of small studies happen around the region that are really important, but the data is then shipped back off to the US or Europe, and nothing is left behind. There's no system of continuity with respect to data across the board.
>
> Interviewee from GA-CDRC, UWI, in Allen et al. (2021a)

One of the objectives of the newly formed *Lancet* Countdown Small Island Developing States Regional Centre is to serve as a hub for information on these topics.

Capacities at the systemic level

The Caribbean's position within the global system of research production and funding, and Caribbean governments' attitudes to research, pose challenges to health and climate change information systems in the region. Geopolitics are an important factor in local research capacities (MacGuire and Ng Shiu, 2021).

Funds available for research in the Caribbean consist mainly of grant funding, very often from institutions outside the region, and national governments hardly become involved in funding academic research. In the context of developing countries, research is seen by some as a luxury, which may make it politically unpopular, especially relative to economic development projects.

> One of the challenges we have with the Caribbean governments is that they view research as an expense item. Therefore ideally it is something that they try to keep off their books, and so a lot of the research that is actually done in the Caribbean is being funded primarily by external agencies. Therefore, in a sense as researchers we have to tailor our agendas, not so much for the Caribbean-specific needs, but to suit the external agenda.
>
> Professor Marvin Reid, Deputy Dean for Research, UWI Mona campus, at the Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (Reid, 2021)

This makes research programmes on particular topics unsustainable and patchy and prevents much of the necessary longitudinal research.

> The Ministry of Health does not have a budget for climate change and health research. Funding has to be sourced externally, through projects, writing proposals, through PAHO and other agencies.
>
> Interviewee from the Ministry of Health, Dominica, in Allen et al. (2021a)

In SIDS, there are also some fundamental resource constraints to research and surveillance, compared with large, industrialised countries of the global North.

> You will not get data on everything from all the countries in the SIDS. You also will not get them for the Least Developed Countries either. The problem is this. It's easy to collect data for the OECD [Organisation for Economic Co-operation and Development], but frankly we don't need those data. The OECD are already developed. The less developed countries, the SIDS, the landlocked developing countries and all the ones that have development problems don't collect data, not because they don't want to, but because it's too expensive, because they don't

> have the technology, because they may not have the access to science, maybe because they only have two people in that speciality in the entire country, so the data are not collected.
>
> Interviewee from the Institute for Sustainable Development, UWI, in Allen et al. (2021a)

In SIDS, lack of financial and other resources is compounded by challenges relating to small size (such as few or no qualified people with requisite skills in a single state) and other SIDS characteristics. One of these is the precariousness and volatility of financial flows; this may be caused by global fluctuations in the price of the few commodities and services they produce, or by climate change itself, through which climate drivers devastate, or at least damage, entire economies or sectors. The impacts on health can also be extremely damaging economically, as, for example, when Zika and chikungunya epidemics severely reduced the number of tourists coming to the Caribbean in 201516. Each of these SIDS characteristics reduces the amount of resources available for research and surveillance. The situation has been aggravated by the global economic downturn associated with the COVID-19 pandemic and the war in Ukraine, which have raised the prices of the imports on which SIDS depend.

Global research funding to address challenges affecting developing countries tends to be channelled according to levels of national income per capita. Some Caribbean SIDS fall into the middle- to high-income categories, and thus miss out on important sources of funding. It has been argued that access to research funding should not be based solely on the measure of income per capita. The vulnerabilities of SIDS to climate change should be taken into account in allocating research and surveillance funding and other forms of support. This is important for climate justice, as a move towards addressing inequities caused by the level of greenhouse gases emitted by developed countries and other practices. It also helps avoid unhelpful divisions between Caribbean countries with shared vulnerabilities regarding climate change and health.

> So, the problem with data is not that we don’t have the capacity, intellectual or otherwise, to collect it, but the way that funding is set up in the Caribbean – everyone thinks the Caribbean is low middle income, but it’s not. So, you always get a patchwork of information and data and studies, because you can’t get continuity, you can’t get studies that are collaborative enough. So, you know, we have to go and check with the Wellcome Trust, or the MRC [Medical Research Council], to say, well, ‘Can Barbados be included in this study?’ So, for example this year we are looking to do studies in Saint Vincent and Haiti, but we can’t get money to do studies in Barbados … It’s almost like, a segregation system that is not helpful, particularly for the small island states. It does not matter to the World Bank that focuses on larger countries like India while here we are struggling with things like the blue economy and we get decimated. We’re always excluded.
>
> Interviewee from GA-CDRC, UWI, in Allen et al. (2021a)

11.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Involve individuals and communities in research and build research and surveillance capacities

There is tremendous potential to draw on the experiences and skills of Caribbean people in addressing climate change and health through research. Involving vulnerable communities in "bottom-up" research for action projects is also critical to achieving health equity and climate justice. There is a need to move from seeing people as victims to recognising their agency and ability to work with others on research projects (MacGuire and Ng Shiu, 2021). Indigenous knowledge and traditional medicine, which are threatened by biodiversity loss associated with climate change, should be drawn on in designing research to develop practical, locally appropriate and acceptable solutions (Boston et al., 2021; R4ACCHC, 2022a).

There should be a two-way rather than top-down exchange between academic experts and local communities (R4ACCHC, 2022b; Reid, 2021). Academic experts should help develop the research skills of local communities and provide them with tools and methodologies for citizen data collection and analyses. For instance, the use of cell phone apps can empower people to record and analyse their findings (R4ACCHC, 2023). The scale of the climate and health challenge is too large for research to be left to a small group of academic researchers. Involving and training community members creates potential for them to be climate and health ambassadors, as well as to contribute to research findings (Lichtveld, 2021; R4ACCHC, 2023). It is important to identify key people in each community who can help organize activities to build the capacity of community members to contribute to research (R4ACCHC, 2023).

An example of good practice from Pacific SIDS is the collaboration between youth organisations and 350 Pacific (www.350.org/pacific/) to design research in line with young people's priorities. This involved dialogues and focus groups with young people to share knowledge, identify priorities and carry out environmental mapping and literature reviews, with the results shared in research design workshops. Young people were themselves involved in conducting the research (MacGuire and Ng Shiu, 2021).

Professional groups can act as bridges between citizens and conventional experts by collecting data and translating and disseminating findings. For instance, primary-care physicians can play an important role in community-based research and implementation by acting as a link between research findings and implementing these findings within the community (Reid, 2021).

Build and strengthen skills in climate and health research among professionals and laypeople

Colleges and universities can play a critical role in training and accrediting people in applied disciplines and skills areas related to health and climate change research, such as data management, geographic information systems, information technology, laboratory science, meteorology, microbiology, nursing, public health inspection, remote sensing and vector control. Caribbean agencies and governments need to make a concerted and coordinated effort to reach out to more of the many higher educational institutions to encourage their involvement in developing the necessary skillsets. Targets for the number of professionals needed in key areas should be established, and progress in attaining these targets monitored. Graduates of the Climate Change and Health Leaders Programme based at UWI can assist in increasing the number of skilled people through collaboration with a range of higher education institutions.

It is also important to build research skills among people in the general population to facilitate the development of "citizen science" and community-based participatory research. Doing this will strengthen evidence-based practice at community level and increase the amount of information generated for local and national decision-making. Higher education, academic and technical agencies should offer short courses and conduct outreach to increase the involvement of citizens in research (R4ACCHC, 2023).

Improve communication of scientific information

> All the data and science is useless unless it gets into the hands of those who need to act on the information, including the youth.
>
> Lalla (2021)

Sustaining good health in the face of climate change depends on providing evidence in ways that large numbers of people, and populations with different characteristics, can access, understand and use. Effective communication can widen access to existing knowledge and facilitate involvement in current research (R4ACCHC, 2023). Attention should be given to the language, presentation and means of communication delivery. Further development of climate information services for health is recommended. This should include EWSs for health and environmental outcomes, while noting that communication must be tailored to each audience. Health professionals, schools and civil society organisations can help convey messages in understandable and engaging ways for various audiences. Messages tailored to different audiences should indicate how climate change is likely to affect the health of each audience. Media companies and journalists should receive training in science communication (R4ACCHC, 2023).

> Climate information services for health, well, the messaging and language has to resonate with the local context. With a lot of the information that is being disseminated, there is no connect. Dissemination could be done through meetings and forums, reporting back to communities and families. Youth forums and churches are important ways of disseminating information.
>
> Interviewee from University of Auckland, New Zealand, in Allen et al. (2021a)

Mobile apps and social media can be important platforms for the transmission of scientific information in accessible ways (see Chapter 13, "Awareness- and skills-building").

Structural/governmental and private sector actions

Convince Caribbean governments and the private sector of the value of research as an investment in the future

To be sustainable, dependency on foreign research funds and expertise needs to be reduced, and reliable and consistent local sources of funding need to be developed. National governments have primary responsibility for developing such funding and can help leverage resources from the private sector as well. They must appreciate that developing the evidence base is essential for climate resilience and economic development (R4ACCHC, 2023). Advocacy and possibly technical support from regional and academic institutions, such as presenting cost–benefit analyses of research, may help (R4ACCHC, 2022c). The need to act within the next 10 years to avoid catastrophic climate impacts should be underlined (MacGuire and Ng Shiu, 2021).

> If we can convince Caribbean governments of the value of research as an investment in our own future, then we can move towards the kind of national investment that we need to get this effort to be successful.
>
> Professor Marvin Reid, Deputy Dean for Research, UWI Mona campus, at the Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (Reid, 2021)

The scale of the challenge is vast, but academics can help policymakers by identifying strategic interventions for research that will have multiplying effects. For instance, research on methods to reduce air pollution can bear fruit in reducing greenhouse gases and respiratory, cardiovascular and other diseases while promoting environments conducive to exercise and reducing NCDs (MacGuire and Ng Shiu, 2021). Capacity-building among policymakers may be needed so that they are better able to use research to inform decision-making (R4ACCHC, 2023).

The private sector can be encouraged to support climate change and health research by framing it as part of corporate environmental, social and governance (ESG) initiatives. To date, many ESG initiatives have been led by multinational companies in the tourism sector, focusing on reducing greenhouse gas emissions. There is a need to extend this to local and smaller companies and increase the support for research relating to health (R4ACCHC, 2023).

Build regional solidarity, mutual support and collaboration in research

Given the small size of individual Caribbean states and territories and the low levels of human and other types of resources, it is essential to develop collaborative mechanisms to share and build expertise (Lichtveld, 2021). An important aspect of this is developing data-sharing protocols among countries, including protocols on how to ensure data security. Standardised data collection forms and research methodologies should be developed to facilitate a regional picture, with each country enabled to measure progress relative to other countries. Short courses in climate and health research should be offered at the regional level (R4ACCHC, 2023).

Countries should also seek funding collectively, and develop Caribbean sources of research funding. Regional agencies such as CARPHA should continue and increase their provision of research training and funding (R4ACCHC, 2023).

The recently established *Lancet* Countdown Small Island Developing States Regional Centre can help establish such protocols. Its plans to establish a regional hub for information-sharing should be supported. Specialist equipment such as research boats and laboratory facilities should be shared wherever possible. National rivalries and turf disputes must not get in the way of building the evidence base for action and ensuring no state gets left behind. Countries presenting a united front can help leverage financial and technical resources for research and surveillance at the regional and international levels (MacGuire and Ng Shiu, 2021; R4ACCHC, 2023).

Make research facilities and products climate resilient

Research facilities, including laboratories, and equipment must themselves be designed and built to climate-resilient standards. This includes the safe storage of electronic and hard-copy data. One important strategy is the decentralisation of equipment and supplies (CARPHA, 2019; Lichtveld, 2021).

Strengthen the research–policy interface

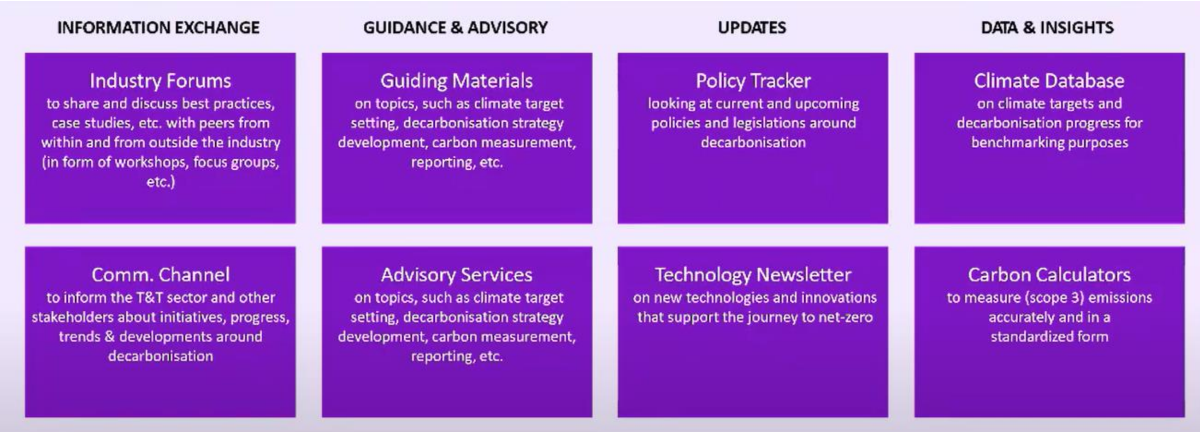
The research community can improve the use of research and surveillance by policymakers through improved and accessible communication methods. Specialised training and tools are needed to promote the science literacy of policymakers, and the policy literacy of scientists (MacGuire and Ng Shiu, 2021).

Governments can help researchers understand the kinds of problems that need to be solved from their perspective, ultimately improving the uptake of evidence (Glasgow, 2021). Science needs to be translated and applied to real-world problems as perceived by the policymakers (Lichtveld, 2021; Reid, 2021). Researchers and policymakers should collaborate in the development and implementation of monitoring and evaluation systems for climate change and health projects (Lichtveld, 2021).

Support and collaborate with the private sector by providing climate information services for health

To develop practices that support health in the face of climate change, businesses need information to guide their decision-making. Alliances between the agencies that produce the evidence and the businesses that can usefully consume it would be mutually beneficial. Figure 2 presents a range of information services suggested by the Caribbean Alliance for Sustainable Tourism.

Figure 2: Climate information services to support sustainable business practices



Note: T&T, travel and tourism.
Source: Williams (2021).

Businesses should also be supported in developing guidelines, checklists and metrics to monitor their progress in attaining environmental sustainability and public health goals (R4ACCHC, 2023; Williams, 2021).

Build capacity in higher education and other research/surveillance institutions

A range of institutions engaged in research and surveillance, including Caribbean universities, colleges, national healthcare provider agencies and regional and multilateral entities (such as CARPHA and PAHO/WHO) can benefit from the following actions:

- Create an institution-based climate change and health research policy.
  - This may be hinged on a regional and international policy agenda, such as the United Nations Sustainable Development Goals or national climate resilience plans.
  - The mandate should apply across all levels of learners, faculty and other staff and administrators.
- Build climate change and health into curricula across disciplines.
- Invest in climate change and health research centres of excellence.
  - Develop institutional infrastructure for managing grants, personnel, coordination and outcomes.
  - Recruit experts on part- and full-time contracts.
- Cultivate the research culture and talent in the institution.
  - Provide coaching and mentoring. One area where mentoring is important is how to write for peer-reviewed journals (R4ACCHC, 2023).
  - Incorporate roles for students, faculty and other staff and administrators.
  - Present research in a relatable way to all staff.
- Establish institution-wide structures for seeking funding.
  - Support and incorporate young researchers/students and new faculty members.
  - Leverage expertise across departments.
- Provide results to key stakeholders and beneficiaries.
  - Formalise partnerships with policymakers, climate change organisations and representatives from populations most affected by climate change.
  - Provide results to key technical agencies such as PAHO, WHO, UNFCCC, the United Nations Environment Programme and the United Nations Development Programme.
- Develop hard and soft capacity for science-oriented research.
  - Purchase and maintain equipment, laboratories, and tools.

    - Incorporate climate change and health research in promotion criteria.
- Cater for succession planning for climate change and health research (Glasgow, 2021).

Strengthen capacity for ethics review in climate change and health research

Efforts to develop ethics review procedures for health research at regional and national levels should continue. Ethics review of health research considers ways to minimise risk to the individual research participant. In the context of climate change, it may be necessary to also consider the environmental impacts of the research, which can affect research participants and the communities they inhabit. This would be consistent with the One Health approach (Oura et al., 2017).

Research and surveillance gaps and how to address them

Move towards real-time reporting of health conditions and associated socioeconomic data

Health surveillance in the Caribbean currently continues to rely mostly on handwritten records. The data are then entered into computers, analysed and then reported at health authority, national and (for certain conditions) Caribbean regional levels. This process creates an often months-long delay between the health incident and reporting. Electronic information systems involving the use of electronic devices to input and possibly conduct analyses at sentinel sites and while in the field can cut down the reporting time considerably (Golden, 2023a). They also increase the frequency of reporting, enabling more integration with climate and other environmental information systems and thus permitting more analyses of climate and health associations. More timely and frequent reporting of health information, along with the capacity for timely reporting about emerging issues of concern, is crucial as a basis for evidence-based climate-responsive health practice.

To enable equity and justice, health information systems should include sociodemographic, economic and location data to help identify vulnerable communities and populations and enable targeted interventions. These additional data should also be integral to climate-smart health surveillance systems (see below).

Develop climate-smart health surveillance systems

Climate-smart health surveillance has been defined as a new type of health surveillance that will weave together epidemiological, climate, agricultural and environmental information systems. It integrates these disparate data streams to examine the climate-related drivers of ill health. Health data are linked with data from meteorological agencies and satellites (Golden, 2023a). Remote-sensing data from satellites are increasingly used to assess the risk of health conditions arising from environmental factors such as air quality, precipitation and ocean characteristics (Haynes, n.d.).

For example, in Madagascar, a project is using remote-sensing data from satellites on climate change-associated phenomena, such as droughts, deforestation, tropical cyclones, sea temperature and coral bleaching, in conjunction with health data. The new information platform combines remotely sensed satellite observations with community-based sentinel health surveillance to enable health research, rapid prediction and public health planning. It looks at associations between (1) drought-induced crop failures and malnutrition; (2) deforestation and vector-borne disease transmission; (3) natural disasters and mental health; (4) sea temperature-driven harmful algal blooms and diarrhoeal disease; and (5) coral bleaching-induced seafood scarcity and malnutrition. Predictive algorithms are then developed linking climate and health data to develop early warning systems (Golden, 2023a). The observations and predictions are then translated into interministerial policy action across health, agriculture, the environment, rural development and other sectors to create systemic interventions that promote health and well-being (Golden, 2023b).

Remote sensing has also been used to monitor climate variability and environmental conditions and their impacts on the dynamics of infectious diseases, specifically vector-borne diseases. Geographical information systems and Earth observation satellites have been used to monitor the climate, environmental and anthropogenic factors that influence the reduction or the reemergence of vector-borne diseases. This work is part of the WHO Special Programme for Research and Training in Tropical Diseases–International Development Research Centre Research Initiative on Vector-Borne Diseases and Climate Change (Ceccato et al., 2018).

Build a rigorous body of surveillance data and research on priority topics

The limitations of current research and surveillance within each of the Priority Areas covered by the Caribbean Research for Action Agenda on Climate Change and Health were outlined in Section 11.1, "What is happening?". In this subsection we discuss surveillance and research together, as longitudinal and comparative research often depends on the existence of standardised and regularly and systematically collected surveillance data.

To address existing limitations, some general recommendations can be made (Dubrow, 2021; Glasgow, 2021; Lichtveld, 2021; R4ACCHC, 2022a,c; Reid, 2021). Some of these are being actively pursued in regional projects such as the EU/CARIFORUM Project on Strengthening Climate Resilient Health Systems and the EWISACTs project. The *Lancet* Countdown Small Island Developing States Regional Centre potentially provides an institutional hub for implementing these recommendations, but sustainable funding is needed for this:

- Invest in strengthened and expanded surveillance for climate-sensitive health conditions.
    - It is particularly important to strengthen surveillance in resource-constrained settings, such as SIDS, where large research grants for surveys are not frequently available.
    - Key health conditions that may be initiated or aggravated by climate drivers should be selected, and local agencies should be provided with technical and financial support to collect data on them at regularly defined intervals (R4ACCHC, 2023).
    - Protocols for data-sharing among researchers across the Caribbean region and beyond should be strengthened (R4ACCHC, 2023).
    - Standardised forms and methodologies should be developed for collecting data on climate-sensitive health conditions (R4ACCHC, 2023).
    - Levels of access to different types of data should be established to ensure information security (R4ACCHC, 2023).
    - Employers should develop and implement policies that allow staff the time to develop and employ their research skills, and encourage dissemination of research findings (R4ACCHC, 2023).
- Integrate climate/weather and health surveillance data and test associations between them.
    - Agencies responsible for collecting health surveillance and meteorological data should continue to collaborate and present evidence of associations between health and climate indicators. Methodological research guidelines should be developed to facilitate this.
    - Health and meteorological/climate scientists should continue to collaborate in the development of EWSs and in making the findings accessible to key audiences (R4ACCHC, 2022d).
- Develop ways to collect data on key aspects of the climate change and health nexus. This should include:
    - Greenhouse gas emission accounting. Levels of emissions from the driving forces, such as industry, energy, transport and agriculture, should be measured.
    - Risk modelling. How are populations exposed and what are the probabilities of spatial and temporal impacts?
    - Disaggregated data. Assess the differences in impact of climate change by population and identify key characteristics that increase vulnerability.
    - Future projections. Identify key features of the region that influence the probability of adverse outcomes (Glasgow, 2021).
- Develop research protocols that propose models of the pathway of causation from climate drivers to health outcomes. Collect data and test associations for each step.

    - For instance, when examining associations between increasing ambient temperatures and heat-related illness in the Caribbean, it is important to look at a range of contextual variables, such as variations in temperatures and health outcomes between urban and rural areas. Contextual factors can serve as sites for intervention. For instance, how can infrastructural design appropriate for urban and rural settings moderate the effects of rising temperatures on health? Can we create low-cost, sustainable and resilient infrastructure/housing that protects low-income communities from heat stress?
    - Conduct qualitative research to enable people to explain how and why actions are taken that aggravate or alleviate climate change impacts on health.
- Conduct systematic reviews of evidence on health outcomes and selected risk factors.
    - The scope of the current report is too wide to cover every study conducted on each of the Priority Areas. More detailed study is needed to establish and probe the evidence base between health outcomes and specific climate-related risk factors.

Develop climate and health indicators appropriate to Caribbean Small Island Developing States

Developing indicators to track climate-related health outcomes, adaptation in the health sector and mitigation measures with health co-benefits can enable the development of evidence-based policy and initiatives. It is important to develop indicators appropriate to the Caribbean.

A start has been made with the *Lancet* Countdown assessment of climate change and health in SIDS (Allen et al., 2021a,b). The assessment aimed to determine the relevance of existing *Lancet* Countdown global indicators for monitoring climate change and health in SIDS, and propose Priority Areas for the development of indicators in the Caribbean and Pacific SIDS. Following consultations with stakeholders, four health and environmental outcomes emerged as priorities for measurement: (1) the health impact of severe weather events; (2) WASH; (3) vector-borne diseases; and (4) NCDs. Interviewees also emphasised the need to measure intersectoral collaboration, research and surveillance capacities, investment in climate and health research and surveillance, and government engagement (Allen et al., 2021a,b).

These Priority Areas were included, along with others, in the current research agenda. There is a need now to develop appropriate Caribbean metrics to measure progress in addressing each Priority Area. Dedicated workshops involving experts and stakeholders in each of the Priority Areas should be held to select ways to measure progress, for example, progress in establishing sustainable WASH systems and measuring their health outcomes. Responsibility for leading the data collection and monitoring progress in each Priority Area should be allocated to agencies in the Caribbean, with external resources and technical assistance employed when necessary.

Research and surveillance capacity-strengthening needs

Increase funding and support from developed countries for climate and health research in Caribbean Small Island Developing States

Developed countries, who have benefited economically from their long history of greenhouse gas emissions, have to some extent accepted their responsibility to channel some resources to SIDS and other developing countries to assist their adaptation and mitigation efforts (see Chapter 17, “Funding streams for climate and health action”). Similarly to other components of development aid, this tends to be channelled according to definitions of development based on levels of national income per capita. Research funds are no exception. As some countries in the Caribbean do not fall into the low- and middle-income bracket, they tend to receive very little research funding. This creates disparities between countries and difficulties in developing collaborative and comparative research.

Criteria for research grants need to be modified in recognition of the vulnerabilities of SIDS to climate change and other challenges associated with their small size. Special grants and funding for institutions and staff should be dedicated to Caribbean SIDS.

A positive example is the funding and technical support the *Lancet* Countdown is providing in setting up a climate and health research hub at UWI (Allen et al., 2021a; Parker et al., 2022). Further work is required to redress the balance in research funding and publications between developed and developing countries (Hamilton, 2021; MacGuire and Ng Shiu, 2021).

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12. AGRICULTURE AND FOOD SAFETY AND SECURITY

12.1. WHAT IS HAPPENING?

Agriculture and greenhouse gas emissions

Agriculture is both a contributor to and threatened by climate change (Gordon-Strachan, 2021). By various estimates, farms emit around one-eighth of global emissions of greenhouse gases (United States Environmental Protection Agency, 2021; World Resources Institute, 2014). Most farm-related emissions come in the form of methane and nitrous oxide; both gases are many times more potent than carbon dioxide in their global warming effects but last in the atmosphere for far less time than carbon dioxide. For instance, methane has 84 times the 20-year global warming potential of carbon dioxide, but it stays in the atmosphere for an average of about 10 years compared with 300–1000 years for carbon dioxide (Climate Change Connection, 2020). Methane is produced by livestock during digestion due to enteric fermentation and is released via belches. Beef and dairy cattle produce large amounts of methane; pigs and poultry produce smaller amounts (Friel et al., 2009). Nitrous oxide emissions are an indirect product of organic and mineral nitrogen fertilisers (United States Environmental Protection Agency, 2021). Cattle belching and the addition of natural or synthetic fertilisers and wastes to soils represent the largest sources of emissions, making up 65% of agricultural emissions globally. Smaller sources include manure management, rice cultivation, field burning of crop residues and fuel use on farms (World Resources Institute, 2014). The Caribbean has only small-scale cattle farming, with most of its beef and milk products being imported, so Caribbean agriculture makes little contribution to total global methane emissions from cattle. However, beef and milk are major import items. The extent of emissions of nitrous oxide from Caribbean agriculture does not seem to have been the subject of research.

Climate drivers and food insecurity

Climate change also threatens and damages agriculture, and therefore food safety and security, in various ways. Climate change impacts such as hurricanes, extreme precipitation, increasing temperatures and sea level rise all affect agricultural production locally and globally (USGCRP, 2016). Given the region's high import dependency, when food import costs increase because of climate change influences on the agricultural sector globally, the risks of poor nutrition in the Caribbean are amplified. Climate change, combined with an abundance of highly processed foods, contributes to reduced access to nutritious and fresh foods (Baldeosingh-Arjune, 2022; Buenfil, 2021; Bueno et al., 2008; CARICOM, 2020; Dubrow, 2021; FAO, 2008; Gordon-Strachan, 2021; UN-OHRLLS, 2015). People tend to be anxious at the start of the hurricane season for many reasons, including the possibility of food insecurity (R4ACCHC, 2022a).

In 2020, the Food and Agriculture Organization of the United Nations (FAO) reported that the Caribbean[1] had a 32.1% prevalence of moderate food insecurity and a 39.2% prevalence of severe food insecurity[2] (i.e. 31 million people facing moderate or severe food insecurity) compared with a global prevalence of moderate insecurity of 18.5% and of severe food insecurity of 11.9% (FAO et al., 2021). The Caribbean islands are challenged with regard

[1]The countries included in the 2020 estimate for the Caribbean subregion are the Dominican Republic, Grenada, Haiti, Jamaica, Saint Lucia, and Saint Vincent and the Grenadines, which together represent 58.8% of the Caribbean population (FAO et al., 2021).

[2]Moderate food insecurity describes the situation when individuals face uncertainties about their ability to obtain food and have been forced to reduce, at times during the year, the quality and/or quantity of food they consume because of a lack of money or other resources. Severe food insecurity refers to situations when individuals are likely to have run out of food, experienced hunger and, at the most extreme, gone for days without eating, putting their health and well-being at serious risk (FAO et al., 2021).

to food production. Some of these challenges include the small size of the islands, the fact that less than 40% of the land is suitable for agriculture, the diminishing supply of fish (Chapter 14, “Marine resources and health”, provides explanations for the shrinking supply of fish in Caribbean waters), the small areas of land with limited catchment basins[3] and the fact that agriculture is mainly small scale with low productivity and insufficient market access (Buenfil, 2021). Food insecurity may be exacerbated by the limited local workforce available for food production. Encouraging young people to be interested in agriculture as a form of employment or income is challenging (R4ACCHC, 2022b). In 2019, 3.3% of the workforce in countries belonging to the Caribbean Regional Fisheries Mechanism[4] were employed in the fisheries sector (Headley, 2021).

Partly because of these challenges and for historical reasons, Caribbean countries are highly dependent on imports of food and agricultural products. It has been estimated that more than 60% of food is imported (Gordon-Strachan, 2021). Challenges for food security include the relatively low nutritional value of the imported food and its high cost:

- Much of the imported food is cheaper than food produced locally but highly processed and therefore less healthy (Buenfil, 2021).
- Between 2018 and 2020, the region’s imported food bill was USD 13.8 billion[5] (CARICOM, 2022).
- There was a 36% increase in the region’s imported food bill from 2016 to 2020 (CARICOM, 2022).

The Caribbean is also challenged by food price inflation, which affects both imported and local food prices (Bueno et al., 2008). In 2020, in response to the region’s high food bill, the Caribbean Community (CARICOM) introduced the “25 in 5” initiative, aimed at reducing the Caribbean imported food bill by 25% in five years (CARICOM, 2020).

Vulnerable groups

A consistent supply of nutritious food is necessary for physical and mental health and well-being throughout the life course, from before birth to old age. Climate change and climate variability affect the production, availability and accessibility of agricultural crops, livestock and fisheries and thus the consistent supply of safe and nutritious food. Food insecurity affects vulnerable groups disproportionately, including indigenous groups, women, children, older people and those from lower socioeconomic groups. Food insecurity and loss of income can increase anxiety and depression, particularly among indigenous communities and smallholder farmers (Buenfil, 2021; Cashman, 2021; R4ACCHC, 2022c; Vreedzaam and de Kom, 2021). See Chapter 7, “Mental health”.

Indigenous populations that depend on locally obtained food from land and sea are especially at risk of either undernutrition or overnutrition (the latter due to dependence on processed food when crops or fisheries fail). In Suriname, pineapples and cassava are examples of crops on which the indigenous communities depend. The planting and harvesting of these crops are affected by the weather and animal behaviour[6] and they take a long time to grow; furthermore, they are not irrigated and depend on rainwater. Flooding renders these crops inedible. It also contaminates the drinking water wells, and access to food and health care are further reduced

[3]Catchment basins provide humans with water for drinking and other domestic purposes. They are also used for agricultural purposes for irrigation and drinking water for farm animals.
[4]The member states of the Caribbean Regional Fisheries Mechanism are Anguilla, Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Turks and Caicos.
[5]The top five importing countries based on key commodities – rice, water, sugar, maize, wheat, poultry meat, dairy products, meat (sheep, goat, beef, swine), edible vegetables and roots, fish, fresh fruits, and ginger and turmeric – were Haiti (USD 3.1 billion), Jamaica (USD 1.2 billion), Trinidad and Tobago (USD 1.1 billion), the Bahamas (USD 556 million) and Barbados (USD 408 million).
[6]Some bird songs are more prominent in the rainy season and others in the dry season. Indigenous communities often use these natural world patterns to determine when to plant and harvest their crops.

when flooding renders the airstrips inaccessible. The extreme floods and heavy rains caused by climate change have affected not only the indigenous populations of Suriname but also the population of the capital city, Paramaribo (Vreedzaam and de Kom, 2021).

Under- and overnutrition and food insecurity

Food insecurity may be associated with undernutrition or overnutrition, especially among children. The prevalence of overweight among children under 5 years old is 7.0% in the Caribbean, which is above the global average of 5.6% (Gordon-Strachan, 2021). Overweight and obesity have been linked to high levels of consumption of processed foods in the Caribbean, where people are overly reliant on high-calorie, energy-dense, nutrient-poor, imported processed foods (CARPHA, 2018; Dubrow, 2021; Gordon-Strachan, 2021). A major risk for noncommunicable diseases (NCDs) and their complications is from high levels of consumption of processed foods, inadequate consumption of micronutrients and insufficient daily intake of fruit and vegetables. After hurricanes, fresh foods, especially fruit and vegetables, are usually in short supply and what is available tends to be highly processed, increasing the risk of onset of new NCDs and exacerbating existing NCDs (CARPHA, 2018; Flemming, 2021). See Chapter 4, "Noncommunicable diseases and risk factors", for more information.

However, research suggests that the relationship between food insecurity and the prevalence of overweight and obesity is inconsistent across country income groups, regions and genders. In a global study, a link was noted between obesity and food insecurity, particularly among women in high-income countries, while it was almost absent in men. In children the results were mixed. In middle- and high-income countries, the evidence that food insecurity is associated with an increased risk of being overweight was more pronounced in girls than boys (Maitra, 2018). Evidence from the Caribbean indicates, however, that the positive correlation found globally in some groups between food insecurity and the prevalence of overweight may not hold in this region. The 2007 Jamaica Youth Risk and Resiliency Behaviour Survey of 1674 children aged 10–11 years found that 11% of children in the sample were overweight. Children living in a food-insecure household had significantly lower odds of being overweight than those living in a food-secure household. In this analysis there was no difference between boys and girls in the relationship between food insecurity and overweight (Dubois et al., 2011).

Globally, food insecurity is associated with an increased risk of low-birthweight babies and anaemia in women (Maitra, 2018). Pregnant women and their developing foetuses may also be affected by a possible lack of folic acid in their diets, which causes neural tube defects. In the 10–18 months following Hurricane Gilbert in Jamaica in 1988, a sharp increase in the number babies born with such defects was noted. It was found that these babies were born to mothers who had significantly less folate in their diet during the periconceptional period (Watson-Duff and Cooper, 1994). It should also be noted that men, women, children and older people have different nutritional needs, and these may be amplified by gendered norms, differences in access to information and resources, and power differentials (CARPHA, 2018; FAO et al., 2018; IPCC, 2019).

Effects of climate change on agriculture and food security

Increases in the frequency and intensity of hurricanes, landslides and floods (Figure 1) have the potential to destroy crops and livestock, through waterlogged fields and soil erosion along slopes; contaminate clean water; damage fishing boats; and reduce fish stocks (Dubrow, 2021; R4ACCHC, 2022a,c,d, 2023a). There will also be loss of agricultural land on the coasts because of coastal flooding and erosion (Buenfil, 2021). Between 1990 and 2018, there were 119 flooding events recorded in the Caribbean (Fontes de Meira and Phillips, 2019). Increasingly heavy rainfall and floods cause contamination of pastures with enteric microbes (e.g. *Salmonella*) that can enter the human food chain (CARPHA, 2018). See Chapter 1, "Health impacts of extreme weather events", for further information.

Figure 1: Flood in Trinidad and Tobago, 2018

Source: Trinidad Express Newspapers (2018) (https://trinidadexpress.com/news/local/national-disaster-declared/article_16ff68d4-d47a-11e8-9e2f-e3a80bd3c43c.html).

In 2017, 100% of Dominica's agricultural crops were destroyed by Hurricane Maria. In addition, 90% of the poultry, 65% of the rabbits and 50% of the cattle and small ruminants were lost. The infrastructure for the fishing industry (e.g. fishing boats and equipment) and fish stocks were damaged. Moreover, food shops were destroyed or damaged. Power outages and the destruction of most of the secondary roads necessary to transport labour and agricultural products to markets and ports also contributed to food shortages (CARPHA, 2017; International Medical Corps, 2017). Likewise, in the Bahamas following Hurricane Dorian in 2019, food security was threatened (R4ACCHC, 2022e).

The findings above suggest the need to increase agricultural production in the Caribbean. However, it should be noted that dedicating more land to agriculture may modify natural landscape features such as river courses which may provide protection from environmental impacts of climate change such as flooding. Andrewin et al. (2015) found a positive association between the percentage of agricultural land and the number of deaths due to floods and storms during 2000–2012, suggesting that the amount of land dedicated to agriculture determines the lethality of floods and storms in the Caribbean.

In the Caribbean, water scarcity has been increasing because of the intensive use of water in the agricultural sector, among other factors, some of which are climate related (CIMH and FAO, 2016; Cashman, 2021; IPCC, 2014a; R4ACCHC, 2022c, 2023a; Trotman et al., 2017). Low availability of clean water compromises food safety (R4ACCHC, 2023a). In addition, ocean saltwater intrusion due to rising sea levels could affect both agriculture and water security (Dubrow, 2021). In the low-lying islands of the Bahamas, it was found that, during periods of reduced rainfall, groundwater catchment areas shrank, and rising sea levels allowed ocean saltwater to penetrate further inland into the terrestrial ecosystem, resulting in water scarcity and damage to agriculture (Greaver and Sternberg, 2010; R4ACCHC, 2022a).

After a hurricane, food can easily spoil when there are power outages and damage to storage facilities. The availability of clean water declines because of contamination, partly from damaged sewage infrastructure and saltwater intrusion (Buenfil, 2021; CARPHA, 2018; Dubrow, 2021). (See Chapter 1, "Health impacts of extreme weather events", for more information on the impacts of hurricanes and Chapter 3, "Water, sanitation and hygiene", for more information on water security). Degradation and spoilage of products in storage and transport can also result from changes in humidity and temperature, notably from microbial decay but also from potential changes in the population dynamics of stored product pests (e.g. mites, beetles, moths) (Moses et al., 2015).

In the last two decades, the Caribbean experienced two intense periods of droughts – 2009–2010 and 2014–2016 – with 2015 being the driest year on record in several Caribbean islands including Antigua, Barbados, Jamaica, Saint Lucia and Tobago, (Trotman et al., 2017). In Haiti, the 2015–2016 drought affected food security when 70% of the local agriculture production was lost (WFP, 2021). The regional drought of 2009–2010 reduced agricultural crop production in several countries, including Antigua and Barbuda (onions and tomatoes), Dominica (bananas) and Guyana (rice). Saint Vincent and the Grenadines was able to produce only cucumbers, pumpkins and sweet potatoes. The 2005 drought in Jamaica resulted in agricultural losses of JMD 300 million (Gordon-Strachan, 2021). Drought also affects food security through increased food prices (R4ACCHC, 2022a,c; Trotman et al., 2017). Less intense wet seasons followed by more intense dry seasons can lead to an increase in bush fires. Such fires can cause destruction of agricultural crops and related infrastructure. In addition, after the land has been damaged by fire, when the wet season comes, flooding and land slippage can occur (Farrell et al., 2010). See Chapter 1, "Health impacts of extreme weather events", for more information on the impacts of droughts and wildfires.

The increased temperatures associated with climate change threaten food security by increasing the risk of crop failure and potential loss of livestock. For example, root crops and vegetables are likely to be affected by heat stress and changes in soil moisture and evapotranspiration. Additional causes of food insecurity due to hot temperatures include agricultural workers' reduced capacity for outdoor work and the increased spread of plant and animal pests (Buenfil, 2021; Dubrow, 2021; Parker et al., 2022; R4ACCHC, 2022a; UNFCCC, 2005). In 2020 the Caribbean experienced a record-breaking hot season; new air temperature records were set in Cuba, Dominica, Grenada and Puerto Rico (WMO, 2021).

Effects of climate change on fisheries and food security

Coral reefs are important for the supply of most edible seafood and fish (Burke et al., 2011; Dubrow, 2021; IPCC, 2014b). By 2030, 90% of Caribbean reefs will be at risk because of thermal stress and ocean acidification, and by 2050 this will have increased to 100% (Burke et al., 2011). Virtually no species, including commercially important fishery species, is expected to be spared from climate change-related damage. Suitable habitats for these species are projected to decline across most of the Caribbean region, resulting in high levels of extinction locally and declining fishery catches. In the Caribbean the most vulnerable species to climate change are high-value species, such as groupers, snappers and parrotfish. By 2050 it is expected that there will be a 10–30% decline in catch availability across species in a scenario of low greenhouse gas emissions or a 20–60% decline in a high-emissions scenario. Snapper and grouper populations will decline by 50–100% in both low- and high-emissions scenarios (Grant, 2021; Headley, 2021; Maximay, 2021).

Biodiversity, on land and sea, is affected by climate change. Warming oceans also affect the growth of *Sargassum* and harmful algal blooms. The latter produce phycotoxins – notably ciguatera toxin produced by dinoflagellate algae, which causes ciguatera fish poisoning in people who have eaten fish that have accumulated the toxin (CARPHA, 2018). Excess *Sargassum* reduces access to fish, clogs boat propellers, damages boats and fishing gear, and forces fisherfolk to travel longer distances (Dubrow, 2021). See Chapter 14, "Marine resources and health".

Regional and national interventions and studies

Figure 2: Caribbean Agro-Climatic Bulletin of the CariSAM (January 2023 issue)


CARIBBEAN AGRO-CLIMATIC BULLETIN OF THE CARISAM

KEY MESSAGES

NOVEMBER IN REVIEW

AGRI-NEWS

ABOUT CariSAM

Source: Caribbean Regional Climate Center (2023) (https://rcc.cimh.edu.bb/carisam-bulletin-vol-6-issue-8-january-2023/).

The bulletin of the Caribbean Society for Agricultural Meteorology (CariSAM) is prepared by the Caribbean Institute for Meteorology and Hydrology in collaboration with the Caribbean Agricultural Research and Development Institute. Each issue of the CariSAM bulletin reviews the climate of the previous month, highlighting any agricultural impacts. It also provides climate-smart agricultural information. Figure 2 shows the front page of the January 2023 issue (CIMH, n.d.; Flemming, 2021).

There have been regional post-hurricane disaster assessments. For example, in Dominica, following Hurricanes Irma and Maria, an assessment was conducted of the impact of these hurricanes on the health of the local population and its response to them. It was found that fruit and vegetables were destroyed, livestock were killed or injured, and fish stocks and fishing boats were damaged. Food safety was compromised because of damaged infrastructure and lack of water. Power outages increased food spoilage. In the aftermath of the hurricanes, the government focused on providing agricultural supplies and fishing equipment to farmers and fisherfolk. It also reconstructed the water infrastructure and delivered water to citizens. This was accompanied by a major public health campaign on drinking water, food preparation and hand washing (Caribbean Public Health Agency, 2018). There are, however, limited regional data relating to climate change, agriculture and food insecurity and their impacts on health (Buenfil, 2021).

In 2019, the United Nations Economic Commission for Latin America and the Caribbean undertook a study of riverine flooding in Jamaica (2012, 2017) and Trinidad and Tobago (2018). In Trinidad, several areas and approximately 150,000 people in 4100 households were affected: Saint Helena, Kelly Village, Santa Monica, Madras, Vega de Oropouche and North Oropouche. Seventy-five per cent of local farmers were severely affected through loss of crops and livestock, harvesters, tractors and other equipment. The damage to the agricultural sector was the result of the destruction of the actual and/or potential production capacity of the soil (e.g. erosion, sedimentation or salinisation); destruction of infrastructure including roads, farm property, storage buildings, irrigation systems, pens, corrals, farming machinery and equipment; and the need to replant permanent crops. In Jamaica, in the parish of Saint Mary where the study was focused, agricultural losses were estimated at JMD 225 million (2012) over 415 hectares of farmland and 5500 affected farmers. In 2017 the agricultural impacts were related to flooding and land slippage from excessive rainfall, which was exacerbated by slow runoff of persistent rainfall over several days (Fontes de Meira and Phillips, 2019).

Research has demonstrated a decline in the number and abundance of fish species, with potential fishery catches projected to decline as the ocean temperature increases (Grant, 2021). Other research has examined water flows associated with maize production and trade in the Caribbean to explore the implications of import substitution for sustainable water use and food security (Yawson, 2022).

One study examined adaptation and coping strategies employed by farmers to reduce damage to their farming systems before and during the immediate aftermath of Hurricane Dean in 2007. Strategies before the arrival of the hurricane included the protection of nurseries (e.g. covering with roof sheeting or taking seedling trays indoors), re-transplanting (e.g. lifting tomato plants, putting them in a box, spraying the leaves and bringing them indoors to be replanted later), cutting trenches to channel water away from crops, spraying with leaf fertiliser or fungicide to enhance the resilience of the crops to extreme rainfall, and harvesting and storage, which generally ensured that the crops fetched a good price after the disaster, as fresh food was in short supply (Campbell and Beckford, 2009).

Strategies after the hurricane had passed included post-hurricane harvesting of marketable produce; restoring plants to salvage crops and mitigate losses (e.g. weeding, moulding, mulching, fertilising and manuring, spraying and watering); relocating farm plots, especially those previously on hillsides, to the foot of the hill, where topsoil and fertilisers had accumulated; and the scaling down of production in terms of both land area and number of crops planted (Campbell and Beckford, 2009).

The Asociación Cubana de Técnicos Agrícolas y Forestales in Cuba has undertaken research to explore the mitigation, adaptation and resilience aspects of agriculture. Areas of study included (Vasquez, 2021):

- The vulnerability of the main types of agricultural production systems (2012–2015);
- The sensitivity of production components (e.g. soil, crops, irrigation pest control systems) to drought and tropical cyclones on farms (2012–2016);
- The resilience of farms in terms of agroecological transformation (2016–2021);
- The main resilience functions identified in farm design and management (2016–2017).

12.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Promote backyard and community gardening

The Caribbean imported USD 1.4 billion in processed foods in 2018–2020. The high levels (> 60%) of imported foods and an estimated 50% rise in the region's food bill from 2000 to 2020 increase the looming threat of food insecurity (Gordon-Strachan, 2021). Climate change threatens food security further. Backyard gardens can provide fruits, vegetables and herbs that can contribute to a healthy, nutritious, low-cost diet. In addition, gardening is known to improve mood and encourage physical activity (R4ACCHC, 2023b). Every household has the power to help change the way we produce and consume food in the Caribbean, thus contributing to a more sustainable regional food security system, especially if sustainable farming methods are used such as rainwater harvesting and aquaponics (Healthy Caribbean Coalition, 2020, n.d.a).

The Healthy Caribbean Coalition in partnership with the action team of its childhood obesity prevention civil society organisation has launched a backyard gardening initiative, which aims to promote this practice by providing helpful tips and a platform to showcase backyard gardening initiatives from civil society organisations across the region (Healthy Caribbean Coalition, n.d.b). To date there have been backyard gardening initiatives in several Caribbean countries including Antigua and Barbuda, Barbados, Bermuda, the British Virgin Islands, Guyana, Jamaica, Saint Kitts and Nevis, and Saint Lucia (Healthy Caribbean Coalition, n.d.b). Backyard gardening can provide small agricultural business opportunities, with produce marketed through community farmer markets and channelled into school food programmes (Buenfil, 2021; R4ACCHC, 2023b,c). Box 1 presents a case study of a small business that produces vegetables and fish using sustainable methods in Saint Lucia.

Box 1: Case study on using aquaponics and rainwater harvesting to support healthy eating

Alex Happy Greens (AHG) provides organic fresh produce to communities in Saint Lucia, including vulnerable populations such as people living with NCDs and disabilities. AHG uses both rainwater harvesting and aquaponics. Rainwater is a natural and free source of water that can be used to irrigate plants. After filtration, the water is salt, pathogen and pesticide free, the final point being key for organic farming. Rainwater can be harvested at home, where rain runs from the roof into a downspout containing filters and is collected in a barrel. No chemicals are needed for water treatment.

AHG has also invested in aquaponics, a combination of aquaculture, which is growing fish and other aquatic animals under controlled conditions, and hydroponics, which is growing vegetable crops in water without soil. AHG uses aquaponics to raise tilapia fish, the most widely raised warm water aquaponics crop product in the world. In aquaponics, plants are fed the fish waste and in return clean the water for the fish. Beneficial bacteria gather in the spaces between the roots of the plants and convert the fish waste into nutrients that the plants use for growth. The result is a good collaboration between aquaculture and gardening.

Source: Healthy Caribbean Coalition (2020); photo by Andrew Felix.

Structural/governmental and private sector actions

Build knowledge and awareness of climate change impacts on agriculture and food safety and security

Climate change adversely impacts on food security, in terms of the availability of fresh and nutrient-rich crops and livestock products, and on food safety. It is important to improve understanding of these impacts to motivate effective action on food security and safety. This awareness-raising can be at the population level using social media as well as traditional communication channels such as newspapers, radio and television.

The basics of nutrition, agriculture, and food safety and insecurity should be taught in schools. For example, at the primary level it is important to impress on children the importance of healthy eating, including fruit and vegetables, and washing hands and raw foods before eating. At secondary schools, concepts such as climate change pathways and impacts, as well as mitigation and adaptation, can be taught. For example, the relationship between climate change and increasing ocean temperatures and acidification, causing a reduction in fish supplies, can be taught, thus raising awareness of the importance of individuals reducing their carbon footprint.

How to grow your own food and the hazardous effects of climate change on food availability can also be taught in schools. This will build capacity in technical agricultural areas, potentially encourage students to pursue careers in agriculture and may stimulate agri-entrepreneurship (R4ACCHC, 2023b).

Schools can also assist through nutrition policies that ban the sale of sugar-sweetened beverages (SSBs) and encourage the provision of healthy meals using locally sourced ingredients (R4ACCHC, 2023d). Proper nutritional advice and guidelines for pregnant women and newborns should be stressed at pre- and postnatal clinics.

It is also necessary to build awareness in the agriculture and health sectors, among farmers and healthcare practitioners alike, as well as among policymakers. There needs to be further research into how this information should be disseminated to the different levels of society and the different sectors that are primarily affected by the impact of climate change on agriculture and food safety and security (Gordon-Strachan, 2021).

Ensure sufficient numbers of trained health inspectors to ensure food safety at all eating establishments

It is important that all establishments serving food, including those in hotels and guest houses, and people handling food in public domains, for example street vendors, meet minimum basic food hygiene standards. Each country needs to have sufficient numbers of skilled personnel to provide training and conduct inspections. Food vendors who have received such training and dining establishments that have passed minimum standards should be provided with certification that is clearly displayed. The Caribbean Public Health Agency (CARPHA) provides an advanced food safety and certification train-the-trainer course for health and hospitality stakeholders through its Tourism Health Programme. Training is conducted by certified experts using the globally recognised SERVSAFE food safety material adapted for the Caribbean context (CARPHA, n.d.).

Include food safety and security in national disaster preparedness and recovery plans

Immediately following climate-related or natural disasters such as hurricanes, earthquakes or volcanic eruptions, there is a high potential for food insecurity and threats to food safety. These especially affect vulnerable communities such as indigenous groups, women – especially pregnant women – children, older people, those from lower socioeconomic groups and people living with NCDs. Because of the damage to local food production, there may be increased reliance on high-calorie, energy-dense, nutrient-poor, imported processed foods. Therefore, food safety and access to nutritious food should be included in national disaster preparedness and recovery plans, with a focus on vulnerable communities.

Damage to utilities and infrastructure can threaten food safety. Planning for such hazards must be built into disaster preparedness and recovery plans. For example, prior to the region's hurricane season (July–December), food storage facilities, with back-up generators, should be assigned and located in each country's urban and rural areas, the drainage infrastructure should be cleared to prevent flooding that could damage agriculture, and sewage and sanitation structures should be inspected for any potential damage.

Encourage climate-smart agriculture, adaptation and resilience-building, more local agricultural production and the use of appropriate technology

Climate-smart agriculture (CSA) solutions assist with adaptation to the impacts of climate change on agriculture and food insecurity. Agricultural technologies and practices are considered CSA if they enhance food security while addressing at least one of the three other objectives of CSA (sustainably increasing agricultural productivity and farmers' incomes, adapting and building resilience to climate change, and reducing and/or removing greenhouse gas emissions) (CIAT and World Bank, 2018). CSA includes growing high yielding varieties of crops and breeding animals that are resilient to heat, drought, pests and diseases. Also encouraged are the use of climate-proof irrigation systems, drainage and sustainable land management (World Bank, 2022). CSA has been proposed and is already being implemented by some Caribbean countries such as Antigua and Barbuda, Belize, Dominica, Grenada, Saint Vincent and the Grenadines, Saint Kitts and Nevis, Saint Lucia and Suriname (CIAT and World Bank, 2018; Gordon-Strachan, 2021; IICA, 2017; Itoewaki, 2021).

The implementation of CSA will incur costs for retrofitting and reorganising agricultural practices in line with climate mitigation and adaptation. Governments must develop policies for CSA and consider providing incentives and possibly compensation to farmers implementing CSA practices. Such incentives will help with promoting compliance and will build sustainability into CSA initiatives (Buenfil, 2021; Dubrow, 2021; Gordon-Strachan, 2021; R4ACCHC, 2023b). Box 2 demonstrates an example of CSA in Belize. The World Bank has agreed to provide additional funding for CSA in Belize.

Encourage the production and consumption of plant-based foods

Moving away from meat and dairy (especially cattle) and fish production and consumption towards fruit, vegetable, bean and grain production and consumption can reduce greenhouse gas emissions and help to mitigate climate change, while also reducing import dependency and the region's food import bill. Moving away from fish can also help compensate for reductions in fish stocks associated with climate change and reduce the challenges for marine biodiversity caused by overfishing, but this would also mean less consumption of this nutritious, protein-rich food. There are substantial health benefits in increasing the proportion of plant-based foods in people's diets if managed with due attention to the balance of nutrients. For example, the risks of developing NCDs associated with meat consumption would be reduced (Friel et al., 2009).

In the Caribbean, some cultural groups already have a plant-based diet, including many Hindus and Rastafarians. Some vegetarian food items, such as callaloo, ackee, stewed peas, roti and doubles, are very popular. However, most people appear to regard meat and fish as dietary staples. Plant food products designed to taste like meat and fish are mostly imported and expensive. Governments should provide incentives to local food manufacturers to increase the development and marketing of local plant-based alternatives to meat, fish and dairy products. Health promotion should highlight the health benefits of increasing the proportion of plant-based food in the Caribbean diet and emphasise that this change is important for climate change adaptation and mitigation.

Box 2: Case study on building resilient communities in Belize through climate-smart agricultural practices

Ya'axché Conservation Trust is a Belizean conservation organisation founded in 1997, whose mission is to maintain a healthy environment with empowered communities by fostering sustainable livelihoods, protected area management, biodiversity conservation and environmental education in the Maya Golden Landscape (MGL) of southern Belize. Ya'axché's geographical focus area, the MGL, is a 311,850-hectare mosaic landscape of globally important protected areas, communities, private land and state land covering a diverse range of ecosystems. Within this landscape, Ya'axché works with eight local communities made up of mostly Mopan and Q'eqchi' Mayas and Hispanic members under its Community Outreach and Livelihoods Programme. This programme focuses on empowering communities in conservation through environmental education; capacity-building; training in leadership, governance and microenterprises; and ongoing extension support to mentor farmers in implementing sustainable agriculture.

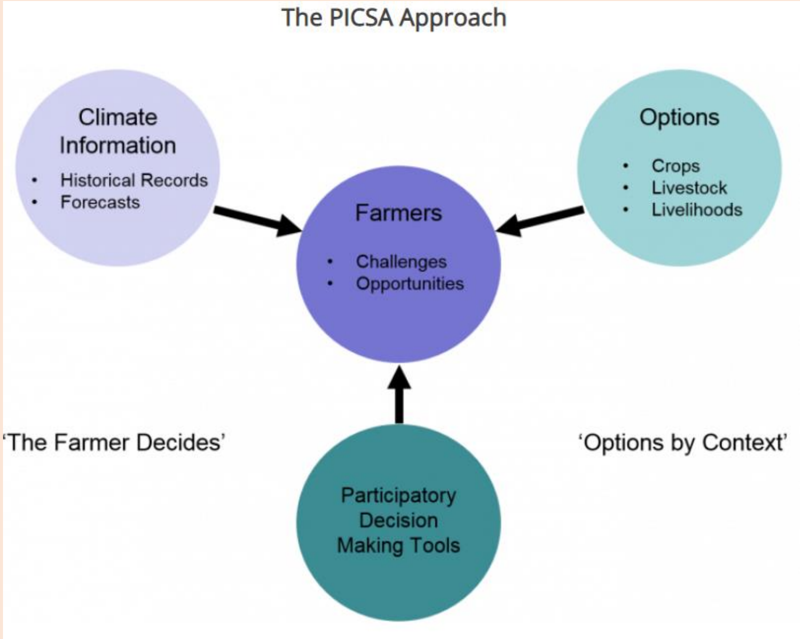
Ya'axché promotes the adoption of sustainable agricultural practices, namely cacao agroforestry, *Inga* alley cropping (growing of crops between rows of *Inga* trees) and beekeeping with agroforestry to improve the economic and food security of disadvantaged farmers and improve wildlife connections between fragmented forests. Farmers are provided with materials, equipment, training and technical support to shift to environmentally friendly farming techniques. A 0.4-hectare demonstration plot of *Inga* alley cropping is located in a 380-hectare plot of community agroforestry concession land in the MGL. This plot is used to restore the degraded soil and as a platform for promoting peer-to-peer learning among farmers. Farmers learn from each other about agroecology and alternatives for conserving soil in this innovative way. As of 2017, 31 farmers from the Trio Farmers Cacao Growers Association had converted 18% of the concession land into cacao-based agroforestry farms.

Source: CIAT and World Bank (2018).

Promote Participatory Integrated Climate Services for Agriculture

Participatory Integrated Climate Services for Agriculture (PICSA) is a participatory approach for climate services and agricultural extension, developed by researchers at the University of Reading, United Kingdom. PICSA aims to support smallholder farmers to make informed decisions under variable and changing climatic conditions. It does this through combining accurate, locally specific weather information; locally relevant crop, livestock and livelihood options; and participatory decision-making tools. PICSA places the farmers at the centre of its approach and helps them to address issues of rainfall variability, extreme temperatures, seasonal changes and extreme conditions such as droughts and floods (Flemming, 2021; University of Reading, n.d.) (Figure 3).

Figure 3: The PICSA approach



Source: Clarkson et al. (2019).

Encourage hospitals to grow their own food for their patients and staff

In 2021, the South-West Regional Health Authority (SWRHA) in Trinidad and Tobago, through its largest health facility, the San Fernando General Hospital, created its own culinary medicine food park to supplement patients' nutritional needs. The primary goal of this farm-to-hospital initiative is to promote the sustainable production of fresh, safe and nutritious food while ensuring a consistent and varied supply for its patients. Overseen by nutrition aides, the first crops – fine thyme, pak choi, lettuce and chives – were ready just five weeks after setting up the hydroponic system. The hospital, the first in the country to grow its own food, joins Cancer Treatment Centers of America in Phoenix, Arizona, and the Hawaii State Hospital, which have all improved their nutrition offerings with food from their onsite farms (see Figure 4). The plan is to have farms set up at other health facilities in the SWRHA area. This initiative forms part of the Trinidad and Tobago Health Services Programme, funded by the Inter-American Development Bank, to support healthy lifestyles to address NCDs (Felmine, 2021).

Figure 4: Culinary medicine food park at San Fernando General Hospital, Trinidad and Tobago

Source: Felmine (2021), with permission from Guardian Media Limited.

Such an initiative can be used as a model for other hospitals and health facilities throughout the Caribbean. The farmland does not necessarily have to be on the health facility's grounds nor be managed directly by it; off-site communal grounds for several health facilities can be negotiated with ministries of local government and/or agriculture. This can also provide employment opportunities (R4ACCHC, 2023b).

Develop nutritional and agricultural polices to improve the health of the population

Regional food security policies for the Caribbean region include the Regional Food and Nutrition Security Policy and Action Plan, the CARICOM Common Fisheries Policy and the CARICOM COVID-19 Agri-food Plan. The main pillars of the action plan are food availability and food access; food utilisation/nutritional adequacy; and stability of food supply (CARICOM, 2020).

With the decline in fish availability, it is estimated that more than 10% of the global population could face micronutrient and fatty acid deficiencies. It is important to encourage sustainable fishery practices in the Caribbean (R4ACCHC, 2022a,e). The Third Strategic Plan of the Caribbean Regional Fisheries Mechanism, 2022–2030, which considers regional policies such as the CARICOM Common Fisheries Policy, has the following as its strategic objective 3.2: promote improved access to and consumption of nutritious fish and seafood. At the national and regional levels, it is important to consider fish availability in nutrition-sensitive policies (CRFM, 2021; Grant, 2021).

A tax of at least 20% on SSBs is one of many evidence-based interventions put forward by the Pan American Health Organization and World Health Organization for the prevention and control of NCDs. Taxation of SSBs is supported by the regionally endorsed CARPHA Six Point Policy Package. In Barbados, a 10% tax contributed to a 4% reduction in SSB consumption. Bermuda's 75% tax on sugary soft drinks, sweets, pure sugar and cocoa products raised USD 5.4 million in the 14 months post implementation, which funded health and wellness initiatives. Policymakers in the Caribbean have noted this evidence, and both Antigua and Barbuda and Saint Kitts and Nevis announced commitments to tax SSBs in 2022 (Healthy Caribbean Coalition, 2022; R4ACCHC, 2022b, 2023b). Associated with SSB policies is the use of mandatory front-of-packaging warning labels to warn consumers when foods are high in sugar and unhealthy fats (Healthy Caribbean Coalition, 2021; R4ACCHC, 2022b). Other important policies include school-related policies that target childhood obesity. This includes regulating the availability and marketing of unhealthy food and drink close to schools (R4ACCHC, 2022b, 2023b).

Research gaps and how to address them

Gain a better understanding of climate-smart agriculture and how it can benefit agriculture and food insecurity in the Caribbean

CSA has been proposed and is already being implemented by some Caribbean countries. It is necessary to understand more about its feasibility and effectiveness in the Caribbean context. Some questions include (Gordon-Strachan, 2021; Maximay, 2021):

- What is the current situation of climate-resilient or smart agriculture in the Caribbean?
    - What are the understanding of, attitudes toward and practice of CSA in the Caribbean among farmers and the general public?
- Which climate-smart practices (e.g. drought-resilient crops such as sweet potato) are best suited to the Caribbean region?
- How do we promote CSA, adaptation and resilience-building to improve local production?
- What technologies do we need for effective CSA, and do such technologies already exist?
- What is the cost–benefit ratio of developing CSA in the Caribbean?
- What are the links between soil and gut microbiomes under differing types of CSA operation?

Investigate the reasons for the overreliance on imported foods in the Caribbean and the extent to which this is driven by climate change effects on local fisheries and agriculture

The reasons for high levels of reliance on imported food include the limited availability of land, dumping of untreated wastewater into the sea, the limited size of catchment basins and a small agricultural economy (Buenfil, 2021). To reduce this overreliance on imported food it is necessary to identify factors that cause it (e.g. trade policies) and to what extent it is caused by climate change impacts (Dubrow, 2021; R4ACCHC, 2023b).

Explore the impact of food insecurity on vulnerable populations

Vulnerable populations are disproportionately affected by climate change effects on food security and safety. Studies should be conducted to establish the impact of climate change-related food insecurity in the Caribbean on vulnerable communities such as older people, children, pregnant women, people living with NCDs and indigenous populations.

Conduct research on the role of fish in providing nutrition to Caribbean people

Given the importance of fish and the marine environment for nutrition, potential research questions include (Dubrow, 2021; Grant, 2021):

- What raw materials are needed to develop innovative fish products with improved nutritional value?
- What raw, plant-based materials are needed to develop alternatives to fish, with similar or improved nutritional value?
- What is the nutritional value and consumption of fish by age group and sex? Which types of fish provide the optimal nutritional value for vulnerable communities such as pregnant women and children?
- What is the nutritional value of fish species that are resilient to climate change in the Caribbean?

Conduct studies to develop evidence-based strategies to reduce disruption to food availability in the event of a climate-induced disaster

To facilitate food safety and security, research questions include:

- How does a country ensure that there is adequate food after a natural disaster?
- What routes are used to transport fresh foods to vulnerable communities? Are these routes still passable after a hurricane, e.g. have the drains been cleared pre-hurricane season to prevent flooding, and have large trees been trimmed to prevent road blockages due to fallen branches?
- Are there emergency generators on hand to assist with preventing food spoilage?

Determine the effectiveness of actions at the individual, community, structural/government and private sector levels

Monitoring, evaluation and research questions include:

- What is the cost-effectiveness of backyard gardening in the Caribbean?
- Is there increased awareness of the impacts of climate change on food security among the general public, farmers and healthcare providers?
- What proportion of eating establishments have food safety certificates?
- What are the recommendations for incorporating food safety and security into national disaster preparedness and recovery plans?
- Have there been government incentives for the use of CSA? If so, what was the uptake of these incentives?
- Has the use of PICSA increased?

- How many health facilities are growing their own food for their patients?
- Are national nutritional and agricultural polices being implemented? Have their impact and cost-effectiveness been evaluated?

Surveillance gaps and how to address them

Monitor the association between climate change, extreme weather and food security

The relationship between climate, severe weather events and food security should be established and monitored. Potential research questions include (Dubrow, 2021; Gordon-Strachan, 2021; R4ACCHC, 2023b):

- How have food supplies changed following severe weather events?
- How have stocks of various commercially important fish species changed over time and before and after hurricanes?
- What are the effects of ocean warming and acidification on commercially important fish stocks?

Development of indicators for a monitoring and evaluation framework at the country level to evaluate the "25 in 5" CARICOM initiative

In 2020, in response to the region's high food bill, CARICOM introduced its "25 in 5" initiative, aimed at reducing the Caribbean imported food bill by 25% in five years (CARICOM, 2020). However, strategies to achieve this "25 in 5" goal must be grounded in a framework involving CARICOM, the private sector and international donor partners, supported by multilateral collaboration, particularly in the areas of policy intervention, institutional strengthening, investment and sector financing (CARICOM, 2020). The implementation of the CARICOM Agri-Food Systems Strategy in the Member States is expected to help achieve this target. This strategy will give special attention to priority crops and products such as poultry, maize, soya, meat (goat, sheep, beef), rice and niche vegetables, of which large amounts are imported in the region (CARICOM, 2022). Currently, national agricultural activities working towards achieving the targets set by the Special Ministerial Taskforce on Food Production and Food Security are reported through a template. In 2022, 10 CARICOM member states[7] reported using this template (CARICOM, 2022). However, to ensure that the "25 in 5" targets are met there needs to be an accompanying monitoring and evaluation framework against which progress can be monitored (Gordon-Strachan, 2021; R4ACCHC, 2023b).

Research and surveillance capacity-strengthening needs

To address the research and surveillance needs in relation to agricultural crops, livestock and fisheries and food safety and security, capacity must be built in implementation science, impact evaluation, qualitative and mixed methods research, and advanced statistical methodologies. The following additional specialist expertise is required: basic food production and management principles, such as hazard analysis critical control points and One Health (Maximay, 2021; Oura, 2021); integrated water resource management; geospatial and marine spatial technology (Grant, 2021); integrated crop–livestock systems; polyculture; the integration of auxiliary vegetational structures such as green roofs and facades; spatial and altitudinal structure of farm matrices (Vasquez, 2021); aquaculture and aquaponics; and PICSA.

[7] Antigua and Barbuda, the Bahamas, Barbados, Grenada, Guyana, Montserrat, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

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13. AWARENESS- AND SKILLS-BUILDING

13.1. WHAT IS HAPPENING?

For action against climate change-related health hazards to be effective, awareness- and skills-building are needed across society at large. Understanding of scientific evidence and skills to act on this understanding are needed by individual citizens, policymakers and specialists such as healthcare and public health experts. Expertise is also needed in a wide range of fields, such as meteorology, statistics, oceanography, disaster management, engineering, research design and grant writing, to name but a few. Cultural shifts are needed towards ecosystems protection and creation of health-promoting environments that mitigate and adapt to climate change.

Here we analyse what is known about awareness and skills relating to climate change and health. Much of the evidence is from presenters at the 2021 Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean, most of whom extrapolated global evidence to the Caribbean. There are a few Caribbean studies of the subject, which are also presented.

Public awareness and knowledge

There are few knowledge, attitudes and practice (KAP) studies of climate change and health in the Caribbean. An online survey of Caribbean residents that used convenience sampling provided an overview of public perceptions regarding climate change and health, which informed the communications and visibility plan of the European Union (EU)/Caribbean Forum (CARIFORUM)[1] Project. Most of the approximately 3000 respondents from 10 Caribbean countries thought that climate change affects health a great deal (43%) or a moderate amount (33%). Fewer thought that climate change had an effect on mental health compared with physical health. More than half thought that extreme events, vector-borne diseases (VBDs), heat and air quality are ways that climate change affects health. Less than half picked Saharan dust and mental health, and less than one-third picked contaminated water or food or malnutrition as ways by which climate change affects health. Just over half thought that people with pre-existing health conditions would be affected, while less than one-third thought that the health of outdoor workers, immigrants, pregnant women, indigenous people and healthcare workers would be affected. These findings point to knowledge gaps about which populations are vulnerable to the health effects of climate change. Doctors and nurses were seen as the most trusted information sources, highlighting the importance of having a health workforce educated on the effects of climate on health. Radios, newspapers and Facebook were seen as the most important ways to disseminate information (Drewry, 2021a). The study's principal limitation is in the use of convenience sampling, which may have biased the sample towards people already interested in and relatively knowledgeable about climate change and health. Gaps in knowledge may be larger than identified in this study.

As part of the University of the West Indies (UWI) project on climate change impact on dengue in the early 2000s, KAP studies were conducted in Jamaica, Saint Kitts and Nevis and Trinidad and Tobago. These addressed several questions to inform public engagement strategies, to reduce susceptibility to mosquito-borne diseases, including (Rawlins et al., 2006):

- What do Caribbean people know about the apparent impact of climate change on the environment?

[1]The CARIFORUM is a subgroup of the Organisation of African, Caribbean and Pacific States and serves as a base for economic dialogue with the European Union. Its membership comprises the 15 Caribbean Community (CARICOM) states and the Dominican Republic.

- What do they know about dengue fever and its transmission?
- What are their attitudes towards disease prevention by government agencies and by communities?
- What disease prevention strategies are used by communities?

KAP studies conducted with samples of the general population in Saint Kitts and Nevis (*n* = 227) and Trinidad and Tobago (*n* = 650) found that most respondents understood climate change to mean an increase in temperature and rainfall. When asked to rank five climate change issues in terms of importance to life, participants ranked health as most important, followed by water resources, agriculture, biodiversity and coastal degradation. Heat stress and foodborne diseases were considered the most important health issue by participants in Saint Kitts and Nevis and Trinidad and Tobago, respectively (Rawlins et al., 2007).

In Saint Kitts and Nevis, a survey was administered between 2015 and 2017 to assess knowledge of climate change health adaptation. Although 88.6% of respondents had heard of climate change, almost 43.2% felt personally unprepared to manage potential impacts. Approximately 35% of respondents were unaware of any government actions aimed at enhancing adaptive capacity. Half of the respondents indicated a willingness to invest in adaptive capacity. The three most common adaptive capacity-building activities proposed by respondents as improving future resilience were (1) education and awareness programmes, (2) enhanced sustainable land use and (3) renewable energy. The preferred sources of climate change information were internet (62%), television (62%) and radio (44%) (Whittaker and Bell, 2019).

There is little Caribbean research on the effectiveness of public communications on climate and health, and how messages are received by the public. International studies suggest that this is an important area for research. In one study on communicating climate change and health in the media, the authors concluded the following:

> The scientific voice struggles to globally highlight this issue to a general audience and that messages that address the topic do not meet the challenges, going from a dramatic framing to a basic adaptation framing. This study gives an insight into the key role of the media and communications in addressing themes relating to climate change and transmitting information to the public to take action.
>
> Depoux et al. (2017), licensed under CC BY 4.0.

In a study from the United States of America, it was found that some climate change terminology used by scientists confounds the public (e.g. phrases like “unprecedented change” and “tipping point”) and participants offered helpful language for improving communication (Bruine de Bruin et al., 2021).

Health professionals’ and other professionals’ capacity

Health professionals occupy a critical position in the response to climate change. First, they are charged with protecting individual and community health through public health measures, which may reduce the impact of climate change on health. Their expertise can be brought to bear on cross-sectoral solutions, and they can articulate climate risks and solutions to patients, the public and policymakers. Second, clinical health professionals will increasingly care for patients whose health conditions are caused or exacerbated by climate change, and they will be tasked with counselling and treating these individuals. Third, health professionals can help modify healthcare systems to cope with increasing burdens of disease, thus becoming more resilient and environmentally sustainable (Sorensen et al., 2023).

An international survey with members of health professional associations (*n* = 4654) revealed that most viewed climate change as an important and growing cause of health harm. They felt a responsibility to educate the public and policymakers about the problem, with 89% willing to engage with policymakers on climate change and health goals. Despite their high levels of commitment to the issue, many survey participants indicated that a range of personal, professional and societal barriers impede them from doing so, with time constraints being the most widely reported barrier. Other barriers identified included lack of knowledge, perceptions that their personal involvement won't make a difference and lack of support from peers. However, participants said that various resources – continuing professional education, communication training, patient education materials, policy statements, action alerts and guidance on how to make healthcare workplaces sustainable – can help to address those barriers (Kotcher, 2021; Kotcher et al., 2021).

Two studies looked at the perspectives of health sector personnel in several Caribbean countries. A mixed-methods study was conducted with public decision-makers and practitioners from the climate and health sectors in regional agencies and in Barbados and Dominica (n = 73) with respect to the development of climate services for VBDs. Participants perceived that VBDs are increasing due to climate change and that current human and technological resources need to be boosted in specific areas to address this challenge (Stewart-Ibarra et al., 2019) (see Chapter 2, "Vulnerability to vector-borne diseases"). In Grenada and Trinidad and Tobago, focus group discussions were conducted with nurses, doctors, veterinarians and technicians. Participants described rises among humans and animals in vector-borne, flood-related, heat-related, respiratory and mental illnesses, and attributed these to local impacts of climate change (Macpherson and Akpinar-Elci, 2015).

A qualitative study with 10 health professionals in Barbados assessed their knowledge of health risks of climate change as it relates to noncommunicable diseases (NCDs). They expressed concern about the prevalence of NCDs among Barbadians. There was less concern about the future burden of NCDs in the context of a changing climate, largely because of a lack of knowledge among most of the health experts interviewed. Those with knowledge of health risks of climate change noted the challenges that climate change would pose to the prevention and management of NCDs, given the impacts of climate stressors on food security, the built environment, and physiological and psychosocial health impacts. Lack of awareness among health professionals of the risk climate change poses to NCD prevalence and impact was said to be reflective of the country's health priorities, which fail to recognise the risk of climate change (Springer and Elliott, 2020).

A 2019 survey by the International Federation of Medical Students' Associations in 112 countries found that 15% of medical schools included climate change in the curriculum, although the extent of coverage varied widely. This included the medical school at UWI Mona, Jamaica, which is the oldest and largest medical school in Caribbean Community (CARICOM) countries. Two former students of the UWI medical school conducted content analysis of UWI Mona courses to qualify as a doctor. They found that only 4.4% of these courses addressed climate change. In discussing their findings, they noted that changing the curriculum may be a lengthy process. They suggested that the Jamaican Medical Students Association Standing Committee on Medical Education could offer supplementary courses to medical students and professionals (Nunes and Mundle, 2021). This highlights the role of nongovernmental organisations (NGOs) in supplementing the education and training provided by formal educational institutions.

A 2022 study that included 299 doctors and nurses, mainly from Barbados, Guyana, Jamaica and Trinidad and Tobago, and the Caribbean College of Family Physicians, assessed the perspectives of health professionals in the Caribbean as a basis to improve the design of education, training and engagement programmes of health professionals as credible leaders in society. Health professionals in this study overwhelmingly thought that climate change was real, but were less clear on causal mechanisms and specific health impacts, and they perceived many barriers to communicating to the public or patients, particularly lack of time, knowledge and support from peers (De Freitas et al., 2023).

The challenge of developing training for Caribbean health professionals has been taken up by the NGO EarthMedic/EarthNurse and its colleagues. They piloted an online course for health professionals in the Caribbean on climate and health, detailed in Box 1. Outside the region, courses to train health professionals in preparedness for extreme events have shown successes (Rivas et al., 2018). In the Caribbean, an online training initiative is providing disaster-related psychological trauma and mental health training for emergency professionals in 10 countries, in collaboration with UWI and the Pan American Health Organization (PAHO) (Ocho et al., 2023).

Box 1: The Caribbean Climate Change and Health Responder Course: a pilot

In March–May 2022, a free, live-virtual, evidence- and competency-based climate change and health course targeted toward health risks in the Caribbean was deployed to (1) increase communication among health professionals about climate and health, (2) equip health professionals with knowledge and skills that could be readily incorporated into practice and (3) engage health professionals with climate and health initiatives within their communities.

The course was based on the Global Consortium on Climate and Health Education (GCCHE) core competencies for health professionals, which cover climate and health analytic skills and knowledge, communication and collaboration, and public health and clinical practice competencies. The training was delivered as follows:

- Ten didactic modules delivered weekly in 60 minutes followed by 30 minutes of moderated questions and answers.
- Bi-monthly interactive 90-minute "skills and practice" sessions, structured around clinical cases, climate tools, communication and leadership strategies, and teaching tools.

All lectures were delivered by local and regional climate and health experts and had accompanying online reading and learning resources. Participants who completed at least 7 of the 10 didactic sessions and passed a short test at the end of the training (with a score of 70% or greater) received a Climate and Health Responder Certificate of Participation. Continuing Medical Education Credit was provided by the American Association of Continuing Education through the Trinidad and Tobago Medical Association.

Invitations to participate were sent via email and social media to individuals and groups representing health professionals, public health workers, hospital administrators, health system leaders, health educators, policymakers, environmental health professionals and government officials. A promotional video was also sent to presidents of medical and nursing associations, chief medical officers, regional universities and PAHO offices. Outreach was also done via the Caribbean Public Health Agency, Healthy Caribbean Coalition, Caribbean Community Climate Change Centre and the Global Climate and Health Alliance.

Participants came from 37 countries, with 1.2% of those registered coming from outside the Caribbean. Occupations included medic/physician, environmental health professional, nurse, student, public health practitioner, mental health professional, emergency responder, social worker and pharmacist. Places of work included governmental agency, academic institution, hospital, private practice and community-based organisation/NGO.

Pre- and post-participation surveys were completed electronically by participants. They revealed significant changes in health professional communication, engagement and application of climate and health knowledge and skills.

The authors concluded that the live-virtual, evidence- and competency-based courses, as well as the regional-specific courses, have the potential to change health professional behaviours toward addressing climate impacts on health.

The project is a collaboration between EarthMedic/EarthNurse, the Caribbean Institute for Meteorology and Hydrology and various institutions at Columbia University, New York, including the GCCHE, Columbia University Irving Medical Center and Mailman School of Public Health.

Source: Sorensen et al. (2023).

A novel educational workshop was offered by EarthMedic/EarthNurse, the GCCHE and the Bahamas Ministry of Health in 2022. This was designed to increase the knowledge and awareness of healthcare professionals and community members while empowering them to engage in climate mitigation and adaptation strategies. A gap analysis to inform the design of the workshop showed that awareness of climate change was high, but understanding of the causes of climate change was low, as was awareness of potential solutions or steps that could be taken within the control of environmental officers, community members and health professionals. Following the training, participants demonstrated increased knowledge of the causes of climate change, health exposures, climate-sensitive diseases and vulnerable populations relevant to the Bahamas. Furthermore, participants reported high levels of willingness and readiness to tackle climate change and its health consequences (Hamilton et al., 2023).

The need for building a cadre of Caribbean leaders with a broad range of skills to address climate change and health challenges has been recognised in the One Health programme and the Climate Change and Health Leadership Fellowship programme managed by UWI (EU et al., 2023). These programmes will help develop a systems approach involving action and mechanisms across sectors. As of 2021, 35 One Health leaders had been trained, and 24 Climate Change and Health leaders were to be trained, to make a strategic difference to the policymaking landscape. The goal is to build networks of Caribbean professionals with multidisciplinary perspectives, given the need to build capacity and alliances across sectors. An academic involved in both capacity-building initiatives noted that progress in designing leadership capacity-building is evolving and that the experience of the One Health programme was built upon in developing the Climate Change and Health Leadership Fellowship programme. The One Health programme provided regular themed, didactic workshops over three years. The design of the Climate Change and Health Leadership Fellowship programme involves more experiential learning through implementing projects, participating in internships and leading workshops and discussions with peers and other experts in seminars. It was noted that support of the trainees by senior management is critical for these initiatives to have impact and be sustainability (Oura and Stephen, 2021).

With around 239 universities and colleges across Caribbean countries (Glasgow, 2021), there is immense capacity for orienting training across disciplines to respond to the growing challenges of climate change and health. UWI is increasing its focus on climate change across its teaching programmes and is developing a ONE-UWI multidisciplinary policy-oriented postgraduate climate studies degree. The integration of health into UWI's teaching on climate change is currently limited, with the notable exception of the One Health and Climate Change and Health Leadership Fellowship programmes, which directly build the capacity of only a small number of people. Primary and secondary schools are also places where content on climate change and health should be infused across subjects. Executives at the head of these institutions may themselves require awareness- and skills-building exercises so that education and training can trickle down to the general population and effect the necessary cultural shifts and skills-building.

There is also a need for tools such as evidence-based manuals and guidelines to help equip professionals and advocates with the skills and processes to achieve their climate change and health goals. PAHO and the World Health Organization (WHO) have developed several such tools, for instance the AirQ+ tool that links health effects and exposure to air pollution (Drewry, 2021b), and also guidelines and standards for the development of climate-smart health facilities (see Chapter 16, "Smart health facilities"). Technical assistance from regional and multilateral institutions also makes important contributions to building and complementing local capacities.

Media, communications and influencers

A wide range of media, including newspapers, radio and television, websites and social media, is important in raising awareness and building skills among the general public. Messages may also be targeted to specific populations. Communications research is needed to identify the specific interests, knowledge, attitudes and behaviour of specific populations and thus design messages and artwork and choose media (Bailey, 2021; Drewry, 2021a).

In a large global study, Perga et al. (2023) reviewed 50 000 scientific publications on climate change in 2020, including an analysis of how the results made their way into the media. The analysis showed that media is biased to natural science-based, large-scale climate projections on a narrow range of threats. Media coverage does not support pro-environmental actions by people and communities, and may promote denial and avoidance, perhaps because people don't relate to the reports. The authors conclude that "if the goal of mediating research is to have a societal impact, then it seems that we are pushing all the buttons that don't work" (Perga et al., 2023).

By conducting content analysis of articles published by the Loop online news network across Caribbean countries, Ewing-Chow (2021) showed that there are many more articles on health than on climate change. Health is the third most popular topic for news articles in Barbados, the Cayman Islands and Jamaica, and the most popular topic in Trinidad and Tobago. This means that discussing health outcomes is a good way to attract interest in climate change action. Ewing-Chow (2021) also noted that there is a lack of news-related content that marries the concepts of health and climate change.

The emotional and spiritual dimensions of climate change (see Chapter 7, "Mental health") are also important to consider in communication. It is important to involve faith-based organisations as they have moral authority and can exercise suasion. People often turn to faith-based organisations for comfort and shelter in times of disaster, including climate change-related disasters. Faith-based organisations can also provide an outlet, solace and hope for people grieving over the damage being done to the Caribbean environment and people. Faith leaders can channel emotions into positive actions to reduce damage to the environment and provide support to people whose health has been affected (Granado, 2021). Celebrities can also exercise their influence in positive directions. In the Caribbean, sportspeople are held in especially high esteem and can build on their expertise to encourage people to take health-promoting action (Murray, 2021).

It is important also to identify influencers within communities who are especially affected, such as youth and indigenous people. They can help lead activism within their own communities and can exercise suasion over other audiences by showing how climate change is affecting them (Alvarado, 2021; Caribbean Organization of Indigenous Peoples, 2015; Itoewaki, 2021; Kronik and Verner, 2010; Lalla, 2021; Lashley, 2021; Nurse-Allen, 2021; Vreezdam, 2021).

Major challenges and the limitations of current research

The findings above point to barriers to engagement in climate change and health action, including lack of knowledge; lack of support from peers, managers and leaders; and lack of a systems-wide, "joined-up" multisectoral and multi-agency approach to skills-building. The limited evidence suggests that the general public and health professionals in the Caribbean are willing to act to reduce the health impacts of climate change, but these barriers prevent them from doing so.

There is no research in the region on the role of the media in communicating climate and health research and stimulating action at the personal, community or societal levels. Given that the Caribbean media carry health stories extensively, and that climate change affects many aspects of health and well-being, there is promise for linking climate change and health, perhaps through programmes to train and sensitise health and environmental journalists together.

Caribbean responses include the One Health programme and Climate Change and Health Leadership Fellowship programme. These build skills among small numbers of professionals but are expected to have multiple impacts, as these professionals are equipped to exercise leadership across multiple fields. These two leadership programmes used different educational designs and their strategies continue to evolve.

Tools and courses have been, and are being, developed, with the Caribbean Climate Change and Health Responder Course being a capacity-building initiative specifically for the Caribbean. Pre- and post-course evaluation suggests increases in health professionals talking to patients, community members and colleagues about climate change, incorporation of climate change and health knowledge in their work, and confidence that they could engage in a climate and health initiative in their community, institution or practice.

There is an absence of longitudinal research to assess the medium- to long-term impact and sustainability of awareness- and skills-building initiatives in the Caribbean. Monitoring and evaluation of what works is in its infancy in the region. There is also limited communications research around strategies to effect the necessary attitudinal and behaviour changes. While youth, indigenous people, faith-based organisations and other civil society actors are becoming increasingly involved in climate change initiatives, their involvement in the health aspects is lagging behind, and there is little research appraising the effectiveness of their strategies. Overall, monitoring and evaluation of this area is weak in the Caribbean.

13.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Speak about health and social impacts to help engage individuals and communities in climate change action

Health is a common human concern that is more immediately felt than climate change, and so communicating about health can help motivate people to take action on climate change and health (Ewing-Chow, 2021). It is important to emphasise the human angle in messaging about climate change, using human interest stories and appealing to emotions, spirituality and morality (Bailey, 2021; Granado, 2021). This recommendation applies to all agencies and individuals who wish to mobilise action on climate change and health. Health professionals have an important role in speaking to patients and the communities they serve.

Engage civil society organisations and activists in educating and mobilising their peers

Peer-led approaches across all segments of society can motivate action, as peers are likely to be able to identify the challenges that are relevant to their communities. Young people are especially important in engaging their peers, providing information to and inspiring the upcoming generation (Lalla, 2021; Lashley, 2021; Nurse-Allen, 2021):

> My experience and reflection [of climate change following Hurricanes Irma and Maria] inspired me to launch a group called Estudiantes de Puerto Rico para la Acción Climática (Puerto Rico Students for Climate Action). We have met virtually and started our journey to learn more about climate and motivate others to appreciate that we can't delay action. We devised a drawing contest for middle and high school students. Through similar activities, we plan to engage more teenagers and provide a channel for their voices as advocates for our planet.

Alvarado (2021), licensed under CC BY-NC-ND 3.0 DEED.

Peers can also assist in translating scientific information in ways that communities understand. For instance, Caribbean tourism professionals have formed the organisation Caribbean Alliance for Sustainable Tourism, which acts as a conduit for technical information from agencies such as the Caribbean Public Health Agency on ways in which their peers can adapt to and mitigate climate change in the interest of health (Williams, 2021). Civil society organisations and activists can build solidarity and skills for advocacy on behalf of vulnerable and marginalised populations, such as indigenous people (Itoewaki, 2021; Vreezdam, 2021). The Caribbean Health Alliance for Climate Action, comprising national medical associations and EarthMedic/EarthNurse, have established as a top priority the raising of public and health professional awareness of the impact of climate change on health (statement released to the media 24 July 2023). Faith-based organisations can be involved in both peer and leadership approaches informed by spirituality and morality (Granado, 2021). Globally, faith leaders have been advocating for more action on climate change, including the Papal Encyclical of 2015, "On care for our common home" (Pope Francis, 2015).

Influencers such as sportspeople can set examples and speak on issues that are important to their fans, motivating them to take action on climate change and health (Murray, 2021; R4ACCHC, 2023). At the global level, the United Nations has established a "Sports for Climate Action Framework" to leverage the role of sport as a vehicle for climate action, education and sustainable consumption, but no Caribbean sports entities are signatory (UNFCCC, 2023).

Provide practical skills and projects that individuals and communities can implement

Caribbean and global research has shown that people are generally willing to assist in climate change and health action and want to know what to do and how to do it (Bailey, 2021; Kotcher et al., 2021; Williams, 2021). For cultural and systemic change, people must be empowered to take actions that they believe will benefit them and their communities. With sometimes small investments in outreach, education and equipment, people can be involved in positive action and experience psychological benefits from feeling that they can make a difference (Benjamin, 2015). The practical actions people can take should be clearly presented, for example as is done at the beginning of each hurricane season, when people are advised to assemble certain foods and supplies and determine an evacuation plan (R4ACCHC, 2023). Culturally appropriate communications using music, dance and sport can present factually correct information, for example the Caribbean Disaster and Emergency Management Agency's 2021 "Disaster Fighters" YouTube video, which has garnered 1.7 million views.[2] Learning by doing may be especially effective in achieving climate and health goals, while contributing to a positive spiral of awareness- and skills-building and action (Oura and Stephen, 2021).

Structural/governmental and private sector actions

Use evidence-based strategies to educate and build skills on climate change and health

Behavioural science approaches should be brought to bear on how to motivate behaviour change. For any given social intervention, once the behavioural goals have been set, a systematic approach should be taken to educational and intervention development, identifying barriers to uptake and the abilities of individuals and communities to be able to follow through. This includes looking at documentation and published research of previous interventions and involving key communities (R4ACCHC, 2023). Building the Caribbean body of research is very important to developing effective interventions.

Build a cadre of climate change and health ambassadors

Community influencers can play a key role in motivating behaviour change. Doctors, faith leaders and sportspeople are generally held in high esteem in Caribbean society. Doctors and nurses have been identified as highly trusted sources of information and are in an excellent position to share information with their patients, community members and colleagues (Drewry, 2021; Sorensen et al., 2023). Civil society organisations, including community groups, youth groups, faith-based groups, advocacy groups and professional organisations can play extremely important roles in mediating and asserting on behalf of the communities they represent. It is especially important to provide the relevant people with the information and tools to advocate in support of scientifically based approaches to promoting health in the face of climate change. Their baseline understanding and attitudes should be assessed in designing capacity-building interventions (R4ACCHC, 2023). Providing them with a seat at the table when policy decisions are being made is an important component of engaging them as ambassadors. The Climate and Health Advocacy Network currently being developed in the Bahamas is an example of preparing climate and health ambassadors (Hamilton et al., 2023).

Leadership capacity-building strategies such as the One Health programme and Climate Change and Health Leadership Fellowship programme should continue. They should be continually strengthened through monitoring and evaluation.

Provide climate change and health education in schools

As part of general population education on climate change and health, it is critical to educate children, as they will be increasingly affected by climate change as they get older (R4ACCHC, 2023). Education on climate change and health should be included in school curricula across disciplines to help create unified, systemic approaches to climate change and health in the future (Lashley, 2021; Nurse-Allen, 2021). School principals and teachers should themselves be trained in content and delivery of climate change and health education. The Caribbean

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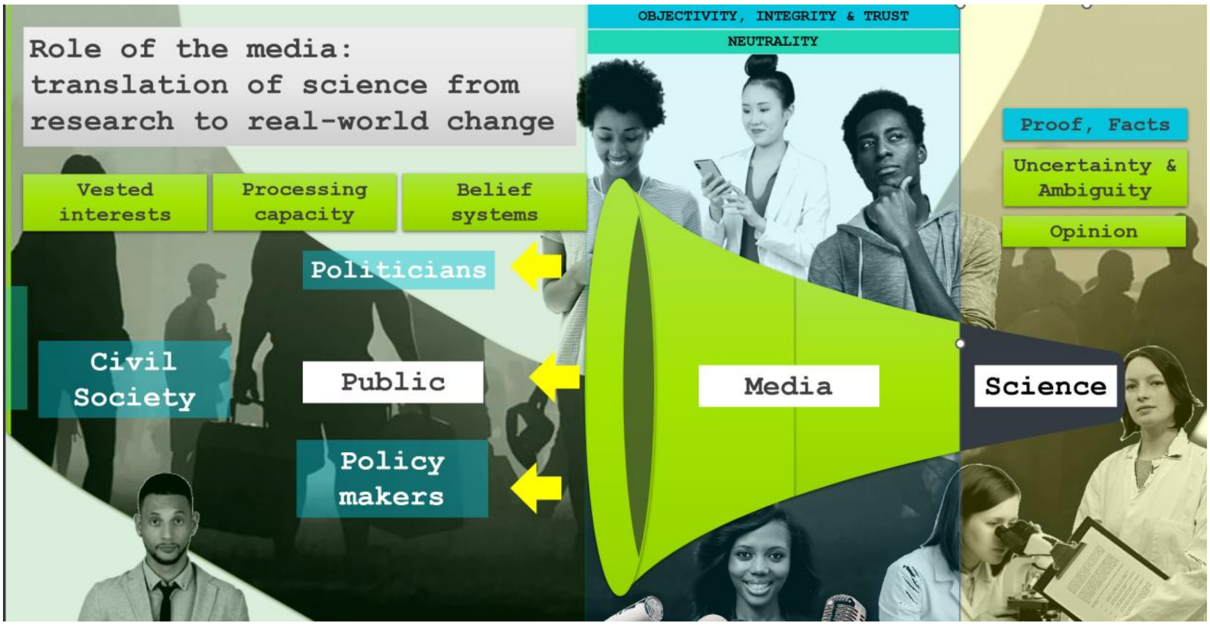
[2]See "Disaster Fighters".

Examinations Council should be involved in the development of specific qualifications relating to climate change, and also the inclusion of climate change and health content in examinable courses.

Build media and communications skills in climate change and health

Experts and advocates should create relationships with and build capacity among media practitioners so that they are well informed about the scientific evidence and able to foster attitudes of objectivity and neutrality. National and regional news agencies (e.g. the Caribbean Broadcasting Union) should be involved in capacity-building initiatives. Media practitioners and climate change and health advocates should be provided with skills in audience analyses and how to relay information in a digestible and relatable way. They should be trained to consider the vested interests, belief systems and processing capacity of different target audiences, all of which impact the effectiveness of media messages (Figure 1).

Figure 1: Translation of science from research to real-world change via the media



Source: Ewing-Chow (2021).

Media and communications training and tools should also be developed and made available to government and civil society stakeholders to enhance their impact. Education and mentorship opportunities should be made available to enable a wide range of communication strategies to be used, such as storytelling, videos, music and peer education. Information should be simplified in line with the capacities and interest of the audiences (Bailey, 2021; Ewing-Chow, 2021).

There is very little research in the region on the role of the media in communicating climate and health research and stimulating action at the personal, community or societal levels. Given that Caribbean media carry health stories extensively, and that climate change affects many aspects of health and well-being, it is a promising avenue for linking the two through programmes to train and sensitise health and environmental journalists together.

Create mechanisms for bottom-up as well as top-down learning

Learning should be bottom up as well as top down. This is in part an ethics issue, to ensure that social inclusion and the needs of vulnerable people are factored into climate change and health plans. It is also a matter of efficiency, as, in practice, policies are implemented at the local level and people on the ground will have expertise in the facilitating factors of and barriers to implementation (R4ACCHC, 2023). By sharing this expertise and advising governments and private developers, the efficiency and effectiveness of projects may be enhanced (Patterson-Waterston, 2021) while avoiding human rights infractions. Mechanisms for dialogue and mutual learning and cooperation must be devised as part of the capacity-building process, so that those in authority can learn from employees, customers and communities (Itoewaki, 2021; Lashley, 2021; Williams, 2021). Academics as well as government and private sector actors should be involved in seeking the views and expertise of community members.

Frame communication according to human and emotional interest, showing the impacts on health

Based on analysis of Loop Caribbean news articles relevant to climate change and health, Ewing-Chow (2021) made the following recommendations for climate change and health messaging to achieve change in attitudes and behaviours:

- **Frame the story from the perspective of health**: the way climate change has traditionally been framed – as an environmental problem – tends not to engage members of the public. By making the case that climate change is a major threat to people's health and well-being, advocates can engage a much broader cross-section of the public.
- **Connect with human emotions**: this can be done through an influencer model or through human interest stories.
- **Localise the issues**: to many people, the problem of climate change is global and abstract, while human health impacts are local and concrete. Including local examples of health and other human impacts of climate change can help mobilise interest and action.
- **Emphasise the immediate health benefits**, i.e. the "win–wins", associated with taking action: showing the health co-benefits of climate action is a powerful way to get people involved. Programmes and policies that make it easier for people to walk, cycle and take public transportation create important climate, health and quality-of-life benefits. Individuals embrace information about climate change that uses a health co-benefits frame because recommended behaviours are seen as benefiting them at the same time that specific messages about what they could do to mitigate climate change are conveyed.

Social media can provide important platforms for the communication of these types of information, given their focus on human and emotional interest content. Mobile phone chat groups can also provide important means for sharing this content. If combined with accessible information from health and disaster early warning systems as well as updates on response and recovery from extreme events, these media can play a critical role in mobilising the public to take action.

Build capacity among health and other professionals

Capacity-building and sensitisation training in climate and health is needed for practising healthcare professionals, public health officials and epidemiologists, undergraduate and post-graduate students and faculty in health sciences and medical schools.

Research has shown that health professionals are willing to become involved in climate change and health action but lack the appropriate knowledge and skills (Kotcher, 2021; Kotcher et al., 2021). In addition to health professionals, there is a need for training professionals concerned with the mental and social impacts of climate change, such as counsellors, psychologists and social workers (R4ACCHC, 2023). Recently, courses have been developed for Caribbean health professionals, such as the Caribbean Climate Change and Health Responder Course (Sorensen et al., 2023) and the Disaster-Related Psychological Trauma and Mental Health Training for Emergency Professionals course (Ocho et al., 2023). Online delivery modalities have facilitated a pan-Caribbean skills-building approach. This is especially valuable in helping overcome the human resource capacity constraints of individual Small Island Developing States and creating transnational networks. Existing training materials, courses and how-to guides can be further adapted to the Caribbean context (De Freitas, 2021).

There have been important Caribbean initiatives to build multisectoral leadership capacities via the One Health and Climate Change and Health Leadership Fellowship programmes. Small numbers of Caribbean professionals have been empowered through teaching and experiential learning to mediate and strategize between sectors to develop and implement plans to address climate change and health. These initiatives should continue, while evolving based on monitoring and evaluation of their processes and outcomes.

To create systemic change in health sector approaches, climate change must also be included in curricula for training health professionals, and their competencies in this area must be assessed as part of their qualifications. Institutional inertia in changing higher education curricula must be overcome through partnership between technical, health professional, student and advocacy organisations, and academic institutions. National and regional professional organisations, such as medical associations and the Regional Nursing Body, should be involved. There is a need to collaborate with accrediting bodies to establish formal qualifications and micro-credentialing schemes. UWI has a leadership role to play as a regional university, as do national tertiary-level training institutions. The Caribbean Accreditation Authority for Education in Medicine and Other Health Professions should include consideration of climate change in its accreditation programmes for medical, dental, veterinary and other health profession education.

Organisations can offer short courses to students while curriculum reform is underway and can complement formal teaching when curricula have been established (Nunes and Mundle, 2021). Likewise, technical, health professional, student and advocacy organisations should reach out to faculties beyond medicine/health sciences in higher education institutions so that they can infuse climate change considerations into teaching a wide range of other disciplines. For courses to have professional standing, there is a need to work with the councils/boards/associations that organise credits for continuing medical education, continuing professional development and technical and vocational education and training.

The “Research and surveillance capacity-strengthening needs” subsections of this report provide listings of the wide range of disciplines that should be involved in research and action. The Caribbean Field Epidemiology Training Program coordinated by the Caribbean Public Health Agency should include climate and health training. This should cover data collection, analysis and operational research, collaborative exercises across departments within and between ministries/agencies (such as the meteorological services and environmental management authorities), and how to communicate on climate and health to different audiences.

Implement institutional change management strategies

To effect the necessary changes, facilitating factors must be put in place throughout and between agencies (Oura and Stephen, 2021). Leaders and managers within agencies must be brought on board through collaboration and education. Policymakers, chief executive officers and managers should lead in establishing incentive structures for employees to engage in climate change and health action, including responsibilities for specific tasks in job descriptions (Kotcher et al., 2021). Feedback mechanisms from employees and customers should be instituted. Sustainable environmental standards should be developed and instituted at each agency (Williams, 2021).

Research gaps and how to address them

Conduct longitudinal and experimental studies of education, training and skills-building interventions

While important interventions have been established, we are a long way from having a precise idea of what works in the Caribbean context. The evaluation of the pilot Caribbean Climate Change and Health Responder Course is a step in the right direction, by measuring communication, engagement and application of knowledge before and after the course. However, it relied on self-reporting and perceptions of a limited range of questions. There is a need for careful documentation of education, training and skills-building exercises in terms of their objectives, methods, processes, outputs and expected outcomes and impact. Means to document, track and measure these should be put in place. Studies should be carried out to assess how trainees implement their learning when they return to their workplaces and communities, tracking progress and outcomes over the medium to long term. Facilitators of and barriers to this process should be identified along with strategies for how to address them.

There is also a need for experimental designs, so that the outcomes and impacts of each intervention can be measured through comparisons with control conditions. Unfortunately, the tradition of experimental studies on social and education interventions in the Caribbean is weak, and technical and financial assistance may be needed to support their further development.

Learn what works internationally and adapt it to the local context

Studies of education, training and skills-building interventions on climate change and health for specific professions and audiences should be systematically reviewed. Especially given the limited resources available in Small Island Developing States, it is critical to build on existing knowledge. The GCCHE at the Mailman School of Public Health, Columbia University, is a valuable resource, with over 200 universities included in its network.[3] The differences in context between the locations of existing studies and the Caribbean should be clearly identified so that appropriate adjustments can be made. Adjusted interventions should then be tested, as recommended above.

Conduct media and communications research

A combination of quantitative surveys, such as KAP studies, and qualitative research can be used in media and communication research. KAP studies should be conducted with the general population and targeted audiences for media and communications. Qualitative research is important to identify the skills required to implement capacity-building. Focus group discussions can be used to assess responses to messages and media used. The characteristics of effective human-interest stories should be identified (Bailey, 2021; Ewing-Chow, 2021).

An important topic for media and communications research is business advertising and public relations activities and how they affect perceptions of climate change and health and peoples' consumption. They may, for instance, promote the use of fossil fuel and derivative products (e.g. plastics) and processed foods and draw resources away from consumption patterns that have co-benefits for health and climate change (R4ACCHC, 2023).

Surveillance gaps and how to address them

Repeated knowledge, attitudes and practice studies

To assess the effectiveness of communications and other awareness- and skills-building interventions, a monitoring system is needed. Indicators of progress in such interventions should be standardised and KAP surveys repeated at regular intervals (R4ACCHC, 2023).

Monitor outputs of training and learning

From school classes and small workshops to full degree programmes, the outputs of awareness- and skills-building exercises should be documented and monitored. The numbers educated should be disaggregated by

[3]See Global Consortium on Climate and Health Education.

demographics and vulnerability factors. Time-bound target numbers should be specified, and progress monitored. Accompanying this, the inputs should be documented and monitored, such as numbers and job positions of educators, teaching staff to student ratios, and monetary and other resources used.

Research and surveillance capacity-strengthening needs

A robust evidence base is critical for communication with the public and key stakeholder groups such as healthcare professionals and government officials. Strong collaboration will need to be built between health and climate researchers, with accompanying joined-up surveillance and information systems. Early warning systems for health and disaster-related outcomes must be developed in a way that the information is accessible for key audiences. This requires strong collaboration between researchers and communication professionals.

Leadership, technical and financial resources are needed to conduct the necessary research and surveillance. Leaders of government, academic and other agencies commissioning and conducting research need to implement measures requiring documentation, monitoring and evaluation of awareness- and skills-building exercises. Government agencies should be integrally involved in reviewing the resulting documentation and research and using it to orient the design or modification of interventions.

Health professionals should be provided with training and facilities to conduct research on the effectiveness of their capacity-building strategies (R4ACCHC, 2023).

Technical cooperation may be needed in design and implementation of intervention studies, especially in experimental designs for behavioural interventions. Institutions within the Caribbean should continue to strengthen their cooperation and call on external assistance when needed.

Financial resources are needed, especially for any research involving face-to-face data collection. Lack of finance is a major constraint to the conduct of research and surveillance. Lack of continuity in funding is inimical to the necessary longitudinal research and surveillance systems. Caribbean leaders must advocate for the provision of additional and sustained research funding to support the needed research and surveillance.

Awareness and skills are needed across society to effect the necessary actions on climate change and health in the Caribbean. Robust research and surveillance are needed to support evidence-based action, efficiency and effectiveness.

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DOMAIN 3: MITIGATION ACTIONS AND HEALTH CO-BENEFITS

14. MARINE RESOURCES AND HEALTH

14.1. WHAT IS HAPPENING?

The ocean is of vital importance to the health of humanity, and especially to people of the Caribbean, 70% of whom live along coastlines (Gordon-Strachan, 2021; Headley, 2021). The composition and activity of the other components of the Earth system – atmosphere, geosphere, biosphere, cryosphere – are all influenced by the state of the ocean. Evolution and development have proceeded based on oceanic regularity. Climate change is disrupting regular and familiar patterns, with dire consequences for human health and the ecosystems on which health is built (Taylor, 2021). In this chapter, we outline ecosystem services and resources provided by the ocean, highlighting how they mitigate climate change and contribute to health and economic development. We then provide examples of how marine ecological disruption associated with climate change is affecting the conditions for health, and how coastal communities and economies are affected.

Ecosystem services and resources provided by oceans

The ocean covers 71% of the earth's surface, and 97% of the water on the planet is in the ocean (CARPHA, 2018; National Geographic, 2023). It is a complex ecosystem that provides services that are essential to sustain life on Earth. More than 25% of the carbon dioxide (CO_2) emitted into the atmosphere each year as a result of human activity is absorbed by the ocean, and the ocean is also the world's largest net supplier of oxygen. The ocean has been called the planet's main lung (Ocean and Climate Platform, 2022). As a vast "carbon sink", it naturally tends to mitigate the impact of CO_2 emissions on the climate. Coastal plants that surround parts of Caribbean coastlines – mangroves, plants living in salt marshes and seagrasses – store additional large quantities of carbon and protect coastlines from damaging waves (Mycoo et al., 2022; Storlazzi et al., 2021).

The ocean also stores most excess heat due to rising atmospheric greenhouse gas concentrations and provides breeze, making small tropical islands cooler than larger land masses in the tropics (Dubrow, 2021). Thus, the ocean provides a measure of protection from heat-related illness associated with climate change in Caribbean Small Island Developing States (SIDS). Sea bathing provides additional welcome relief from heat on hot days in the Caribbean.

Coral reefs have been referred to as "the rainforests of the sea". Ecosystems of unparalleled biodiversity, they cover less than 1% of the sea floor but are home to over 25% of all marine species. Sea creatures living around coral reefs are a primary source of protein for people in SIDS, and reefs provide a nursery habitat for many commercial species (Storlazzi et al., 2021). Animals living on coral reefs create unique chemicals that are not found on land. These chemicals are used to make important medicines and food supplements (Cousteau, n.d.). Coral reefs are also a major source of attraction for divers and tourists and provide mental health benefits through their beauty. The white and pink sandy beaches that attract tourists to some Caribbean SIDS are mostly composed of coral fragments. Ecosystem services provided by coral reefs are critical to economic livelihoods, well-being and health in SIDS (Storlazzi et al., 2021).

Coral reefs also play a critical role in coastal protection. It has been estimated that they dissipate wave energy coming towards coastlines by around 97% and are therefore especially important in protecting coastal communities and infrastructure from the effect of storms. Degraded, unhealthy coral reefs offer less protection from wave run-off and flooding of coastal areas than healthy coral reefs, whose vertical structures provide "hydrodynamic roughness", forming multiple barriers to waves. Combined with sea level rise, damage to coral reefs constitutes a severe threat to coastlines. Critical infrastructure, agriculture, freshwater supplies and habitats are under threat when corals are damaged, with severe impacts on physical and mental health (Dubrow, 2021; Storlazzi et al., 2021).

Seafood is an important part of a healthy diet. Fish are a major source of protein, and provide valuable dietary components including polyunsaturated fatty acids, iodine, selenium, tocopherols and vitamins A, B, D and K. Consumption of fish has beneficial effects on blood pressure, lipid profile and the inflammatory process. Fish consumption can assist in preventing noncommunicable diseases (NCDs), including cardiovascular diseases, cancer and diabetes (Headley, 2021).

Oceans are important in providing potential alternative sources of energy, contributing to climate change mitigation and improved air quality. Oceanic alternatives to fossil fuel use include offshore wind energy, floating solar energy, sea water air conditioning, ocean thermal energy conversion, tidal energy, wave energy, salt gradient energy and bioenergy (Allen et al., forthcoming; Giebel and Hasager, 2016; Gorjian, 2017). The Caribbean Community (CARICOM) has set a regional target of 47% renewable contribution to total electricity generation by 2027, and ocean energy is at the forefront of CARICOM discussions. A focus on marine renewable energy frees up significant land area for other initiatives, including agriculture and thus enhanced food security (Allen et al., forthcoming; Smith et al., 2013).

Climate change, the ocean and Caribbean health

Disruptions to the oceanic environment caused by climate change are interfering with the services the ocean provides to human health. These disruptions have been accompanied by pollution and overexploitation of marine resources, progressively damaging marine ecosystems (Ocean and Climate Platform, 2022). For example, it has been estimated that more than 80% of untreated wastewater is released into the ocean. This damages marine life and human health and represents a lost opportunity for reuse of water resources, which themselves are increasingly scarce because of climate change (Dubrow, 2021). See Chapter 3, “Water, sanitation and hygiene”.

The major physical and biogeochemical oceanic changes arising from rising greenhouse gas emissions and climate change are ocean warming, ocean acidification (caused by CO_2 emissions), deoxygenation and sea level rise (Headley, 2021). These have disastrous consequences, including increased intensity of tropical storms/hurricanes, storm surges, species loss, reduction in biodiversity, coastal flooding and shoreline retreat (Dubrow, 2021). Inland and coastal flooding are worsened by sea level rise, since excess water backs up and takes longer to flow into the ocean.

An estimated 22 million people in the Caribbean live below 6 m elevation; these areas are threatened with inundation, some even with eventual submergence (Mycoo et al., 2022). With much of the population, infrastructure and economic assets of Caribbean SIDS located in the low-elevation coastal zone of below 10 m elevation, oceanic changes will affect most of the Caribbean population quite profoundly (CARPHA, 2018; Gordon-Strachan, 2021; Hassan, 2021; Mycoo et al., 2022; R4ACCHC, 2022a). For instance, it is estimated that the sea levels around Jamaica will, by 2100, have risen between 0.18 m and 1.4 m above current levels, depending on the level of future greenhouse gas emissions (Climate Studies Group, 2012). This will retard coastal development and contribute to population displacement from coastal settlements (Climate Studies Group Mona, 2012). Changes in wave dynamics superimposed on sea level rise are predicted to increase coastal flooding significantly.

Severe coral bleaching, together with declines in coral abundance, have already been observed in Caribbean SIDS. It is projected that, once the temperature rise compared with the pre-industrial period reaches 1.5 °C, 70–90% of reef-building corals will be lost globally across small islands, with this figure rising to 99% with warming of 2 °C or more (Mycoo et al., 2022). Saltwater intrusion from sea level rise compromises both agriculture and water security. Storms can devastate plant and animal agriculture and can also damage fishing boats, equipment and fish stocks (Dubrow, 2021). Table 1 shows how the varied geographical characteristics of Caribbean SIDS are likely to influence specific vulnerabilities.

Table 1: CARICOM member states' geographical vulnerabilities to oceanic climate change

Geophysical setting	Key climate change vulnerabilities	CARICOM members
Coastal plains below 10 m	• Flooding from storms • Inundation from SLR • Saltwater intrusion of ground water • Erosion with loss of mangroves	Belize, Guyana, Suriname
Low-lying islands	• Inundation from SLR • Flooding from storms • Saltwater intrusion of ground water • Erosion with SLR and storms	The Bahamas, Barbuda, the Grenadines
Volcanic island coasts	• Beach erosion from SLR and storms • Landslides (locally) • Localised flooding from storms	Dominica, Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent
Varied geophysical characteristics	• Localised erosion by SLR and storms • Localised inundation from SLR • Localised flooding from storms • Localised saltwater intrusion of ground water	Antigua, the Bahamas, Haiti, Jamaica and Trinidad and Tobago

Note: SLR, sea level rise.
Source: Simpson et al. (2010).

Coastal threats: fisheries, food security, tourism, coral reefs and biodiversity

Fisheries and tourism make major contributions to Caribbean economies, health and wellbeing, and are fundamentally threatened by climate change through its devastating impact on marine environments (Headley, 2021; Oxenford et al., 2021a).

Ocean warming and acidification damage ocean ecosystems and marine life, threatening the food security of island nations and the viability of the fishing industry. In 2018, 3.3% of the working population in member countries of the Caribbean Regional Fisheries Mechanism (CRFM)[1] were employed in the fisheries sector, in

[1]Member states of the CRFM are Anguilla, Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago and Turks and Caicos.

fishing, processing, retailing, boat construction, net repairs or other activities. Fisheries are an important source of export revenue as well as income from sales within the region (Headley, 2021).

Coral reefs and shellfish are especially at risk (Dubrow, 2021). New studies have reported large reductions in the populations of some marine species, and it is predicted that, if warming exceeds 3 °C, some endemic species in insular biodiversity hotspots will become extinct (Mycoo et al., 2022). One of the threats to biodiversity associated with climate change is the incursion of invasive species such as the lionfish, which eats endemic species and has no natural predators (Albins and Hixon, 2013; Green et al., 2012; Norton and Norton, 2021). Species distributions are predicted to shift, with suitable habitats for a range of species projected to decline across most of the Caribbean region, resulting in substantial local loss of species, decline in fisheries catch potential and change in catch composition. Loss and damage from tropical cyclones will exacerbate these challenges. The short time frame over which these impacts are projected to occur poses substantial challenges to adaptation. Caribbean nations are therefore projected to suffer losses in economic well-being and health due to a reduction in the production and consumption of seafood (Headley, 2021).

More than 25% of the world's coral reefs have already been damaged beyond repair. Global stressors include increases in temperature and ocean acidification. Local stressors include land-based pollution, overfishing and mechanical damage. According to the Reefs at Risk Indicator, many of the Caribbean reefs are at very high risk (Burke et al., 2011; World Resources Institute, 2022). Forecasted reef degradation and sea level rise exacerbate the risks of flooding associated with climate change, increasing threats to coastal communities (Storlazzi et al., 2021).

Caribbean reliance on tourism as a major contributor to gross domestic product also underscores the importance of the ocean and coastlines to Caribbean lives and livelihoods (Gordon-Strachan, 2021). Tourism is threatened by destruction caused by hurricanes, by beach erosion due to sea level rise (R4ACCHC, 2022b) and by the ocean ecosystem degradation caused by warming oceans, ocean acidification and harmful algal blooms. Increased ocean temperatures can lead to the seaweed *Sargassum* overgrowing along the shoreline and washing up on beaches, which is likely to have an adverse impact on tourism (R4ACCHC, 2022c). The perception that the Caribbean is unsafe due to increasing potential hazards (e.g. hurricanes, Saharan dust) could make the Caribbean a less attractive tourism destination than other areas (Dubrow, 2021). Yet some tourist establishments contribute to the challenges by polluting the sea water and depleting the resources of coral reefs in an uncontrolled manner (R4ACCHC, 2022d), and marine and other forms of transport associated with tourism continue to be highly reliant on fossil fuels. The adverse effects of climate change on the tourism industry in the Caribbean, and the resulting loss of revenue, could lead to anxiety, depression and other mental health conditions among those affected.

Consequences of marine ecological disruption: harmful algal blooms

The warming ocean and warming freshwater lakes, combined with phosphorus and nitrogen from agricultural run-off (aggravated by extreme precipitation events), increase the risk of harmful algal blooms.

Overgrowth of different species of microalgae can result in excess production of an array of phycotoxins with various effects on the liver, skin and kidney, as well as the gastrointestinal, neurological and respiratory systems. Fish, shellfish and drinking water can become contaminated with phycotoxins, which cause a variety of human diseases including ciguatera fish poisoning, neurotoxic shellfish poisoning, paralytic shellfish poisoning, amnesic shellfish poisoning, diarrhetic shellfish poisoning and azaspiracid shellfish poisoning. Ciguatera fish poisoning, caused by a toxin that is produced by *Gambierdiscus toxicus* (a dinoflagellate) and which bioaccumulates in the large carnivorous fish that inhabit coral reefs, such as barracuda, grouper and mackerel, is the most common. Ocean acidification favours dinoflagellates. Since 2005, ciguatera poisoning resulting from the consumption of contaminated fish has accounted for the second largest number of laboratory-confirmed foodborne disease cases in the Member States of the Caribbean Public Health Association (CARPHA), behind *Salmonella* (CARPHA, 2018; Dubrow, 2021; Gordon-Strachan, 2021).

Fuelled by climate change and ocean enrichment, a new source of *Sargassum* seaweed – a macroalga – began to grow in the Equatorial Atlantic in 2011, and since then vast “golden tides” of the seaweed have been carried to the Lesser Antilles by ocean currents (Sargassum Information Hub, 2021). As a result, Caribbean coastlines have, year after year, been affected by accumulations of *Sargassum* on the seashore (see Figure 1), with major socioeconomic impacts, and *Sargassum* blooms are now considered another form of climate change-related disaster. In some countries, visitor rates have declined by as much as 30%. Additional massive costs are associated with beach clean-ups and at-sea management. Furthermore, *Sargassum* seaweed has a considerable impact on the fishing industry and reduces fish catches: mats of the seaweed impede access to fish, clog boat propellers, damage boats and fishing gear, and force fisherfolk to travel longer distances (Dubrow, 2021). Marine environments have been severely disrupted, with *Sargassum* smothering sea grass and corals, raising water temperature, depleting oxygen and releasing toxic gases. The damage that climate change causes to corals and the sea life they support has been aggravated by the *Sargassum* crisis (Dubrow, 2021; Gordon-Strachan, 2021; Oxenford et al., 2021a).

Figure 1: *Sargassum* on a beach in Barbados

Source: Oxenford et al. (2021a).

When *Sargassum* is trapped in wet environments and decomposes, it releases hydrogen sulphide and ammonia (Dubrow, 2021). Common symptoms of exposure to these toxic gases are respiratory problems, vomiting, rashes, headaches, dizziness, temporary loss of vision and asthma attacks. Medical practitioners in the French Caribbean islands of Guadeloupe and Martinique reported over 11,000 cases of these symptoms arising from *Sargassum* exposure in 2018 (Oxenford et al., 2021a).

Another health challenge is that *Sargassum*, like all ground seaweeds, absorbs heavy metals and pesticides as it passes through the sea. Of special concern is arsenic, one of the most toxic heavy metals, which has been found in most of the samples of *Sargassum* tested in the Caribbean in recent years. This poses significant concerns about potential poisoning, arising via several pathways (Oxenford et al., 2021b):

- Direct consumption of *Sargassum*-based products;
- Consumption of food products containing arsenic if *Sargassum* is used as fertiliser or animal feed;
- Consumption of fish and shellfish that have accumulated toxic leachates released into the nearshore;

- Direct exposure to toxic leachates that have entered the environment as a result of the use of inappropriate disposal methods.

The presence of *Sargassum* in the nearshore also presents a hazard to sea bathers: it may harbour stinging hydroids, which can inflict painful injuries, and it can make it difficult to swim, creating a risk of drowning (Oxenford et al., 2021a).

Research

The University of the West Indies (UWI) has facilities dedicated to marine research and teaching. The Centre for Marine Sciences at the Mona, Jamaica, campus has marine laboratories and conducts marine biological research, ecosystem studies, pollution monitoring and mitigation and coastline management studies. At the Centre for Resource Management and Environmental Studies at the Cave Hill Campus, there is a Coastal and Marine Resources Management team, which has conducted several research projects on climate changes impacts on reefs, fisheries and the *Sargassum* crisis. These institutions have increasingly explored the implications for health of damage to marine ecosystems associated with climate change.

Other institutions and projects focus mainly on the social and economic costs of oceanic changes and on enhancing the well-being of coastal communities. Their work, while not specifically addressing health outcomes and health systems strengthening, assists in understanding critical socioeconomic impacts of changes in the marine environment (see Box 1).

Box 1: Projects analysing the social and economic impacts for Caribbean people of changes in ocean environments associated with climate

As part of the Caribbean Regional Track of the Pilot Programme for Climate Resilience (PPCR), the Caribbean Regional Fisheries Mechanisms and the Mona Office for Research and Innovation have collaborated to conduct assessments of the impacts of climate change on fisheries. They have also worked to develop a monitoring system to track these impacts. Between January 2018 and April 2020, they worked with stakeholders in Dominica, Grenada, Haiti, Jamaica, Saint Lucia and Saint Vincent and the Grenadines to conduct the assessments. Impacts on the number and distribution of species were assessed. Economic assessments looked at impacts on communities and effects along the fisheries value chain. A data portal and a monitoring and evaluation framework were established, with adaptation planning guidance to assist in the response. Results were fed into a Fisheries Early Warning and Emergency Response (FEWER) system, which included access to information on fisheries-related threats and sources of support accessible on a web-based dashboard and via mobile phone. A poster series, educational slide deck and documentary video were developed to inform fisherfolk. Among other things, FEWER provides access to local ecological knowledge, weather alerts, emergency contacts and procedures, damage reporting and notifications of missing persons. These serve to reduce fishers' vulnerability and inform management decision-making (Headley, 2021).

The Climate Change Adaptation of the Eastern Caribbean Fisheries Sector Project (CC4FISH) of the Food and Agriculture Organization of the United Nations is a USD 5.5 million project in seven Eastern Caribbean countries with five regional partners. The project covers improving the fisheries sector, capacity building of fisherfolk, aquaculture and fisherfolk organisations, mainstreaming of climate change into fisheries plans, policies and legislation, and post-disaster needs assessments of the fisheries sector. The Centre for Marine Sciences, UWI, carries out studies of Caribbean marine environments, without an explicit health focus. Several Caribbean governments have established units responsible for coastal zone management (Allen, 2021; CARPHA, 2018).

The US Geological Service uses a combination of oceanographic, coastal engineering, ecological, geospatial, social and economic models in an **estimated damage function** to assess how coral reef degradation will impact coastal communities. There are three main components:

- Offshore hazards – waves and how they come to the shoreline;
- Ecosystem – how reefs, in current and predicted future scenarios, affect levels of flooding;
- Consequences – impacts on people, built infrastructure and associated costs.

The estimated damage function has been applied in the United States of America to estimate the numbers of people in different geographic areas who will be affected under predicted scenarios of damage to coral reefs arising from climate change, and the associated economic value of damage to public and private property and infrastructure. It was found that the numbers of people in vulnerable communities at risk (children, the elderly and low-income and minority people) are especially high in the United States island territories in the Caribbean (Puerto Rico and the United States Virgin Islands), as are the estimated values of damage to residential commercial, industrial, government and agricultural property and infrastructure. It was concluded that coastal communities in SIDS are at relatively high risk of increased flooding resulting from projected coral reef degradation due to climate change, especially the young, the old and those on low incomes or from minority groups (Storlazzi et al., 2021).

14.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Collaborate to protect marine and coastal environments

Education of the general population and coastal communities about the importance of marine conservation is needed to assist in motivating individual and community action. Local universities and other educational establishments can play important roles in providing the expertise and raising awareness. A wide range of communication and outreach methods may be needed (R4ACCHC, 2023). Chapter 13, "Awareness and skills-building", provides details of strategies that may be used, and Chapter 9, "Distribution, equity and justice in climate change and health", provides details of ways in which the resilience of vulnerable communities can be built in collaboration with these communities.

Stakeholders who are affected by damage to coastlines and reefs should come together with experts to develop solutions. For instance, to facilitate the protection of reefs and coastlines, affected communities, such as coastal residents, schoolchildren, fisherfolk, hotel owners and water sports operators, can collaborate with medical and other experts, such as professional divers, marine biologists, oceanographers and coastal zone management experts, to develop plans to protect ecosystems and reduce damage (Storlazzi et al., 2021).

Solutions include simple actions such as beach clean-ups (already popular among schools and community groups in the Caribbean) as well as strategies that require longer-term commitment and enforcement. These include strategies to reduce pollution flowing into the sea from both households and industry, including tourism and agriculture. Solid and liquid waste management should be a focus of particular concern (R4ACCHC, 2023). Government agencies need to be involved in supporting and enforcing the longer-term solutions and to collaborate with communities (Gordon-Strachan, 2021). These types of action do not themselves mitigate climate change, but they do reduce additional sources of damage to marine ecosystems and the coastal protection and resources they provide. Community involvement, however minor, can assist in increasing activism and participation in the larger struggles to protect marine environments and reduce the damaging effects of climate change on health.

Involve communities in developing strategies to mitigate climate change impacts on marine environments

Individuals and communities can contribute in small but important ways to mitigation by reducing fossil fuel use and choosing transport solutions with zero or reduced emissions, such as cycling and use of electric and hybrid vehicles. Although active transport methods, such as cycling or walking, have health co-benefits, it may be challenging to implement these methods on a mass scale, as exercising in conditions of high temperature, which already prevail, can cause heat-related illness. The use of low-carbon forms of energy for air and sea transport should also be supported. Planting and maintaining mangroves and seagrass around coastlines and increasing the number of plants and trees on land is another solution to increase absorption of emitted CO_2. Mangroves and seagrass can also help to mitigate effects of coastal storms and flooding.

To encourage individual and community action, children and adult communities should be educated about the gravity of the impacts of climate change on oceanic environments and therefore on Caribbean health (Ocean and Climate Platform, 2022; R4ACCHC, 2023). Campaigns should be conducted to increase popular support for mitigation action, also including sustainable oceanic energy development (Allen et al., forthcoming).

Involve communities in oceanic disaster preparedness strategies, including simulation exercises

Coastal protection is an important aspect of disaster prevention. It is increasingly important that measures to protect the coast be accompanied by preparedness activities to enable communities to prevent and respond to destruction of property, injury, illness and death resulting from massive waves and flooding from hurricanes and sea level rise (Harewood, 2021). It is important to focus especially on disadvantaged coastal communities such as people on low incomes and ethnic minorities with poor housing. Capacity-building among healthcare workers is an important complementary and supportive activity. Box 2 provides an example from the Caribbean coast of Nicaragua of how academic institutions collaborated with coastal populations to conduct disaster simulations and ensure access to health care (Mitchell et al., 2021).

Box 2: Collaboration between disadvantaged coastal communities and academic institutions to improve disaster preparedness and climate resilience on the Caribbean coast of Nicaragua

The Caribbean coast of Nicaragua is populated by several ethnic minority populations and is vulnerable to the impacts of climate change, especially hurricanes and flooding. Most economic activities are marine based.

The Bluefields Indian and Caribbean University (the only school of nursing on the Caribbean coast of Nicaragua) and the University of Virginia School of Nursing worked to develop faculty and student capacity for disaster preparedness specific to the health impacts of climate change. Through iterative case study development, faculty members in Nicaragua and in the United States of America collaboratively created simulations aimed at increasing student knowledge and community preparedness.

Beginning with case studies of historical natural disasters (Hurricane Joan in 1988, Hurricane Mitch in 1998, etc.), the academic team worked with local leaders to support and facilitate the integration of trained nurses into the disaster response team. They also developed locally responsive collaborations to build capacity in the coastal communities through (1) a series of workshops for 60 young Afro-descendant leaders on sexual and reproductive health, incorporating models of empowerment and history of the Caribbean coast; and (2) a community-based capacity-building response to climate change programme focused on the experiences and empowerment of Afro-descendant youth in the context of ongoing political autonomy initiatives. Simulations provided hands-on experiences for nurses and showed them how they would help community members during a disaster. The simulations were iteratively adapted to become more appropriate to local scenarios.

The collaborations strengthened the capacity of health systems, and the resilience and preparedness of professionals and laypersons, to respond to both the immediate and delayed consequences of climate change for coastal communities. The team concluded that the role of nurses is especially important in these systems.

Source: Mitchell et al. (2021).

Structural/governmental and private sector actions

Advocate at global and regional level for resources and measures to protect SIDS' marine environments and support implementation

Protection of marine resources in SIDS is an important dimension of global climate justice. The marine environments surrounding SIDS are profoundly affected by greenhouse gas emissions, the vast majority of which are from outside SIDS themselves. The impacts are compounded by various forms of pollution that are often beyond the control of Caribbean people. Politicians and civil society activists should draw attention to marine-related impacts on health and development. For example, they should highlight the commitment of countries who are major emitters and polluters to numerous global environmental conventions, including agreements pertinent to marine environments (R4ACCHC, 2023). These include:

UN environment agreements

- Convention on Biological Diversity;
- Convention on Migratory Species;
- Ramsar Convention on Wetlands;
- Convention on International Trade in Endangered Species;
- Stockholm Convention on Chemicals Management;
- Basel Convention on Hazardous Waste.

International Maritime Organization agreements

- International Convention for the Prevention of Pollution from ships (MARPOL);
- Ballast Water Convention;
- London Convention.

Global agreements and commitments

- Agenda 21;
- Barbados Small Island Developing States (SIDS) Programme of Action;
- Johannesburg Plan of Implementation;
- Rio+20;
- Samoa Outcome for Small Island Developing States;
- Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities;
- The United Nations Sustainable Development Goals (SDGs), especially SGD 14: "Life Below Water".

Caribbean leaders should also become involved in the Sustainable Oceans Initiative, which is associated with the Convention on Biological Diversity (Sustainable Ocean Initiative [www.cbd.int/soi]).

In 1986, Caribbean governments signed the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, or the Cartagena Convention, the first and only regional legally binding treaty of its kind. This treaty promotes the protection and development of the marine environment of the region and provides the legal framework for the Caribbean Environment Programme. It is supported by three technical agreements or protocols, on oil spills, specially protected areas and land-based sources of marine pollution. Implementation of the convention is supported by regional activity centres in Cuba, Curacao, Guadeloupe and Trinidad and Tobago. Governments should continue to uphold and support the implementation of the convention (Caribbean Environment Programme, n.d.).

The convention should also be collectively reviewed and updated at the regional level in view of the accelerating impact of climate change since it was first signed. Currently, its focus is largely limited to pollution. Contracting parties to the convention are also required to protect and preserve rare or fragile ecosystems and the habitats of depleted, threatened or endangered species. They must also develop technical and other guidelines for planning and carrying out environmental impact assessments for important development projects. The focus of legislation and activity should shift towards protection and preservation of biodiversity in the context of climate change, and addressing the causes and impact of threats such as hurricanes of increased intensity, storm surges, ocean acidification, sea level rise, sea surface temperature rise, coastal erosion, invasive species, and harmful algal blooms. It is especially critical to address issues of ocean governance in the context of development of blue economy initiatives,[2] which may be harmful unless environmental standards are imposed (R4ACCHC, 2023).

Laws against pollution of the ocean, to guard against the infringement of marine protected areas and to prevent overfishing must be put in place and enforced. To support this, the seriousness of the threat to human health and well-being posed by damage to marine environments must be communicated and included in the training and appraisal procedures for law enforcement agents. Action against those who violate these laws must be taken without fear or favour.

Address mental health impacts of damage to marine environments

People in SIDS, and especially those living along coastlines, are profoundly affected emotionally as well as physically by their oceanic environments. The ocean also has spiritual significance for some people (Gibson et al., 2020; Tiatia-Seath et al., 2018). Awareness of the impact of damage to marine environments should be addressed in training of mental health professionals and skills-building for community-based counsellors. Faith leaders should also be engaged in dialogue so that they understand and can respond to marine environmental issues with their congregations (R4ACCHC, 2023) (see Chapter 7, “Mental health”, and Chapter 13, “Awareness and skills-building”).

Engage in management of terrestrial, coastal and marine ecosystems

In SIDS, terrestrial, coastal and marine ecosystems are highly interconnected and interdependent, with each ecosystem contributing towards maintaining the health of the others. These ecosystems collectively provide protection from natural hazards to human populations living in SIDS. Reef-to-ridge ecosystem management involves improved land use as a driver of ecosystem health, including better management of forests, nutrients and wastewater upland catchments (Mycoo et al., 2022). Adaptation and mitigation actions by governments, civil society and the private sector can protect and restore ecosystems, with benefits for health. Table 2 provides examples of actions that can be taken in each type of ecosystem, with benefits for all three ecosystems and for human health.

[2] The blue economy is defined as comprising the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable (World Bank, 2017).

Table 2: Examples of ecological and health benefits of ecosystem adaptation and mitigation actions in SIDS

Type of ecosystem	Mitigation or adaptation action	Ecological benefits	Human health benefits
Terrestrial	Reforestation and planting of plants and trees, including on coastlines and beaches	• Reduction in erosion and landslides • Reduction in ocean run-off of pollutants • Preservation of biodiversity • Increased absorption of CO_2	• Reduction in infrastructure and building damage, injuries and deaths, including in coastal communities • Protection of coastal communities and food security through retention of biodiversity and coral reefs • Protection of food and water security through stabilisation of air, soil and water quality • Slowing of climate change impacts on health
	Reduction in the use of the ocean to deposit organic and inorganic waste	• Reduction in toxic algal blooms • Reduction in the global proliferation of *Sargassum* seaweed • Preservation of marine species • Protection of coral reefs and their ecosystems	• Reduction in poisoning from contaminated fish • Reduction in the risk of toxic fumes from rotting seaweed and arsenic poisoning from the unsafe use of *Sargassum* products • Protection of the livelihoods of those working in fishing and tourism • Protection of coastal communities and food security through retention of biodiversity and coral reefs • Preservation of opportunities to develop pharmaceutical and other products
Coastal	Mangrove, seagrass and beach vegetation planting	• Increased CO_2 absorption • Protection of coastlines	• Slowing of climate change impacts on health • Protection of coastal communities and food security through retention of biodiversity and coral reefs
Marine	Marine Protected Areas	• Reduces ecosystem exposure to human disturbance, increasing their resistance and resilience to climate events	• Protection of coastal communities and food security through retention of biodiversity and coral reefs • Enhances food security and assists sustainability of the fishing industry through replenishment of fish stocks

Sources: adapted from Headley (2021), Mycoo et al. (2022), Oxenford et al. (2021a) and Storlazzi et al. (2021).

Manage the consequences of sea level rise on human settlements and displacement

Caribbean coastal communities are under severe threat from sea level rise, with massive potential damage to housing, infrastructure, economic livelihoods, and physical and mental health. Without careful management, potential consequences include climate-induced displacement, migration and depopulation of Caribbean countries. *In situ* adaptation options include further coastal protection measures such as mangrove planting, ever-higher hard barriers such as sea walls and raising dwellings (e.g. on stilts). In the medium and longer term within countries, relocation inland or to other islands is likely to be necessary. Without management, this is likely to favour people with more resources to enable relocation, leaving poorer and marginalised communities to suffer more of the consequences of sea level rise. Governments can help support the relocation of households, with a focus on vulnerable populations. Wholesale relocation of communities is likely to be too expensive for Caribbean governments and will require some external support (Mycoo et al., 2022).

Climate-induced displacement and migration are likely outcomes of sea level rise. Options for management of these movements and for health systems responses are presented in Chapter 8, “Population displacement and migration”.

Implement sustainable and resilient fisheries strategies

Adaptation to climate change must be undertaken within the multifaceted context of fisheries. Relatedly, measures or actions to address climate change should complement overall governance for sustainable use of fisheries resources. Figure 2 shows various elements of climate change adaptation in fisheries. The ecosystem approach is integrated across coastal and marine areas and promotes conservation and the sustainable use of the ecosystem. Examples include the use of Marine Protected Areas, regulation and enforcement of regulations on fishing specific species and sizes of fish, coral reef conservation and selective breeding of fish and shellfish. Building livelihood resilience means addressing the human, physical, social and financial risks arising from both short-term events and long-term climate change. For example, climate change can alter fish stock distribution, while hurricanes can damage boats, equipment and other infrastructure necessary for fisheries. Sustainable economic production involves optimising fishing effort and improving fisheries management. Disaster risk reduction means adaptation to improve the sustainability of fisheries as part of food systems in the face of disasters, including severe weather events and oceanic events such as massive coastal incursions of *Sargassum* seaweed (Headley, 2021).

Figure 2: Elements of climate change adaptation in fisheries

Source: Caribbean Regional Fisheries Mechanism.

Assist in the transition to alternative livelihoods of people in traditional ocean-based occupations

As climate change advances, fisherfolk and others dependent for their livelihoods on the ocean will need to be provided with new skills and possibly helped to transition to alternative ways of making a living. Skills-building should include them in various aspects of marine conservation and development of the "blue economy", reaping benefits from the use and promotion of oceanic resources in sustainable ways. It may also be necessary to help some of those affected to transition to land-based occupations (R4ACCHC, 2023).

Act to reduce destruction of Caribbean reefs

Coral reefs must be preserved if the multiple services they provide are to be protected from further destruction. Although overall responsibility for climate change-related destruction lies with global producers of greenhouse gases, Caribbean governments and the private sector have critical roles to play. Risks to key economic sectors (tourism, fisheries), to biodiversity and to coastal communities must be reduced by focused attention on reef conservation (Storlazzi et al., 2021). Useful initiatives would include those aimed at the reduction of waste disposal and agricultural fertiliser run-off into the sea, the creation of Marine Protected Areas, the removal of *Sargassum* seaweed and the enforcement of regulations to prevent damage by overfishing, fishing boats, tourist vessels and commercial divers, as well as schemes to reproduce corals under laboratory conditions, to repopulate depleted reefs and to establish new coral colonies. Shifting to renewable marine and other energy sources helps make a macro-level contribution to coral reef conservation.

Research gaps and how to address them

Critically examine the legal framework on ocean conservation

Legal experts should critically examine the regional and international agreements and legislation in the light of the current and evolving threats from climate change. They should identify what regional treaties and agreements need to be developed and which existing ones need to be amended to identify and support the actions needed. Specific identification of relevant clauses is necessary for strategic enforcement (R4ACCHC, 2023).

Conduct research on opportunities for sustainable development of the blue economy

Research should be conducted with communities and government and private sector agencies on the potential for economic development based on alternative and sustainable use of the ocean environment. The level of understanding of the concept of the "blue economy" should be explored, along with ideas from stakeholders regarding how they can be involved in developing and implementing projects and entrepreneurship in environmentally sustainable ways with a view to conserving ocean environments. Technical experts on sustainable practices should be involved in this research and developing recommendations (R4ACCHC, 2023).

Conduct research on repurposing Sargassum

Attention is being paid by researchers and the private sector across the Caribbean regarding how to use the *Sargassum* crisis for the region's economic and social benefit as part of blue economy initiatives. Some of the options could directly benefit human health. The biosorption properties of living *Sargassum* can be used to clean contaminants from polluted water. *Sargassum* can be converted to activated carbon, which can be used in water and air purification systems. *Sargassum* also contains bioactive compounds with benefits for human health, including compounds with antiviral, anti-cancer and antioxidant properties (Dubrow, 2021; Oxenford et al., 2021a,b).

There is also potential for *Sargassum* to contribute to climate change mitigation, as it can be used in the manufacture of carbon-neutral biofuels and bioplastics. It can contribute to mitigation by carbon sequestration when it sinks to the ocean floor or is used on land in the form of activated carbon. Further research could identify opportunities for businesses in the region to develop and market new products, increasing economic livelihoods and thus mental well-being (Oxenford et al., 2021a).

Key challenges must be addressed to enable such research and associated economic and social benefits (Oxenford et al., 2021b):

- Better forecasting of *Sargassum* supply is needed.
- The chemical composition of *Sargassum* must be better understood, focusing on its arsenic content.
- Equipment must be improved and expanded for adequate harvesting, transport and storage.
- Safety standards should be developed to regulate *Sargassum* use.
- More funding and greater support for innovation are needed.

There are roles for research in addressing these challenges. For instance, meteorological and oceanographic researchers can contribute to better forecasting and development of *Sargassum* early warning systems.

Conduct research on responses of marine ecosystems to climate change

Food and water security, and security of other marine resources such as components of pharmaceuticals, are affected by marine ecosystem damage resulting from climate change. Research must be conducted to establish and monitor key ecosystem changes, including the effect of changes in ocean temperature, salinity and acidity on marine life, and differential effects of ocean warming and acidification on stocks and movement of various commercially important fish species by geographical area (Dubrow, 2021).

Conduct research to preserve marine food security and quality

The health benefits of eating fish and other seafood of various kinds available in the Caribbean context of climate change should be assessed. It is important to consider the health benefits by age group. Research should also be conducted into the feasibility and value of using aquaculture to counteract the loss of natural fisheries. Research is important to develop innovative fish products with improved nutritional value. The results can form the basis of nutrition-sensitive fisheries policies and nutrition education and awareness programmes (Dubrow, 2021).

Surveillance gaps and how to address them

Monitor key oceanic climate change drivers of ill-health and their consequences

Ocean warming, acidification, decreasing salinity, deoxygenation and rising sea levels must be continually monitored for the sake of the health of the ocean and Caribbean populations. The disastrous consequences of these climate-change-driven changes to the ocean, including increased intensity of tropical storms/hurricanes and storm surges, fish species loss, reduction in biodiversity, coastal flooding and shoreline retreat, should be monitored as well (Headley, 2021; Taylor, 2021). The health of coral reefs also should be monitored, and early warning systems for coral bleaching events developed (R4ACCHC, 2023).

Monitor the status of fisheries and marine ecosystems

To bolster sustainable fisheries strategies, data must be generated and monitoring systems established on the status of Caribbean fish stocks, marine ecosystems and the economic status of fisheries. Suitable approaches are exemplified by the joint project of the Caribbean Regional Track of the PPCR, the Caribbean Regional Fisheries Mechanisms and the Mona Office for Research and Innovation. These organisations together developed a monitoring system and collaborated with local communities to track the number and distribution of species and conducted economic assessments looking at impacts on communities and effects along the fisheries value chain. A data portal and a monitoring and evaluation framework were established.

Surveillance data can be used in early warning systems, such as the FEWER system under the same project, which included access to information on fisheries-related threats and sources of support accessible on a web-based dashboard and via mobile phone. The results can be presented to a variety of audiences, and using a range of communications products, to inform decision-making (see Box 1 in Section 14.1, "What is happening?").

Monitor harmful algal blooms

Research is needed to track harmful microalgal blooms, as well as *Sargassum* seaweed infestations, over time and space and to identify their climate and other determinants. Such research could inform harmful algal bloom and *Sargassum* seaweed early warning systems that ultimately could facilitate prevention microalgal bloom and prevention of *Sargassum* infestation occurrences (Dubrow, 2021; R4ACCHC, 2023).

Research and surveillance capacity-strengthening needs

A number of institutions in the Caribbean conduct research on and surveillance of oceanic environments and how they are impacted by climate change. These include several departments within the University of the West Indies, notably the Climate Studies Group, the Centre for Marine Sciences, the Centre for Resource Management and Environmental Studies and the Caribbean Institute for Meteorology and Hydrology, as well as other CARICOM institutions, such as the Caribbean Regional Fisheries Mechanism. The Instituto de Meteorología de la Republica de Cuba has compiled Caribbean data on sea level rise and sea surface temperatures (Climate

Studies Group Mona (editor), 2020), and has conducted important climate and health research (Linares-Vega and Ortiz-Bulto, 2021; Linares-Vega et al., 2020; Ortiz, 2021; Ortiz et al., 2015), although it is not clear whether this has included research into the connections between oceanic climate change phenomena and health. The Food and Agriculture Organization of the United Nations (FAO) has an ongoing project on Climate Change Adaptation in the Eastern Caribbean Fisheries Sector, which has included capacity-building in fisheries statistics, damage and loss assessment and vulnerability and capacity assessment (FAO, 2020).

Institutions with research capacity should collaborate with technical agencies concerned with ocean conservation and health, such as (R4ACCHC, 2023):

- The Institute of Marine Affairs, which is the only multidisciplinary coastal, marine and environmental organisation in the CARICOM region, and whose mandate is to collect, analyse and disseminate information relating to the economic, technological, environmental, social and legal developments in marine affairs and to formulate and implement specific programmes/projects;
- The Commonwealth Secretariat, which is in the process of developing strategic approaches to deal with ocean governance and the blue economy;
- Global organisations such as the United Nations Environment Programme (UNEP) and the United States National Oceanic and Atmospheric Administration;
- The UNEP Caribbean Regional Coordinating Unit and the secretariat to the Cartagena Convention and its protocols;
- The European Union–CARIFORUM Climate Change and Health Project;
- The Caribbean Public Health Agency;
- The Pan American Health Organization/World Health Organization.

Some of these institutions have begun to explore, but should deepen their focus on, the health outcomes of ocean-related climate change and research on suitable mitigation and adaptation strategies to strengthen marine ecosystems/resources and the resilience of coastal communities. More human resources and equipment for marine biology, oceanography, remote sensing and coastal resource management research are needed (R4ACCHC, 2023). Medical and nursing research must be conducted on health risks associated with marine environmental damage and how to treat associated health conditions. To build these resources, and especially to obtain the equipment needed for marine research, collaboration with external academic institutions and sponsors will be necessary.

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15. CLIMATE-FRIENDLY HEALTH-PROMOTING INFRASTRUCTURE

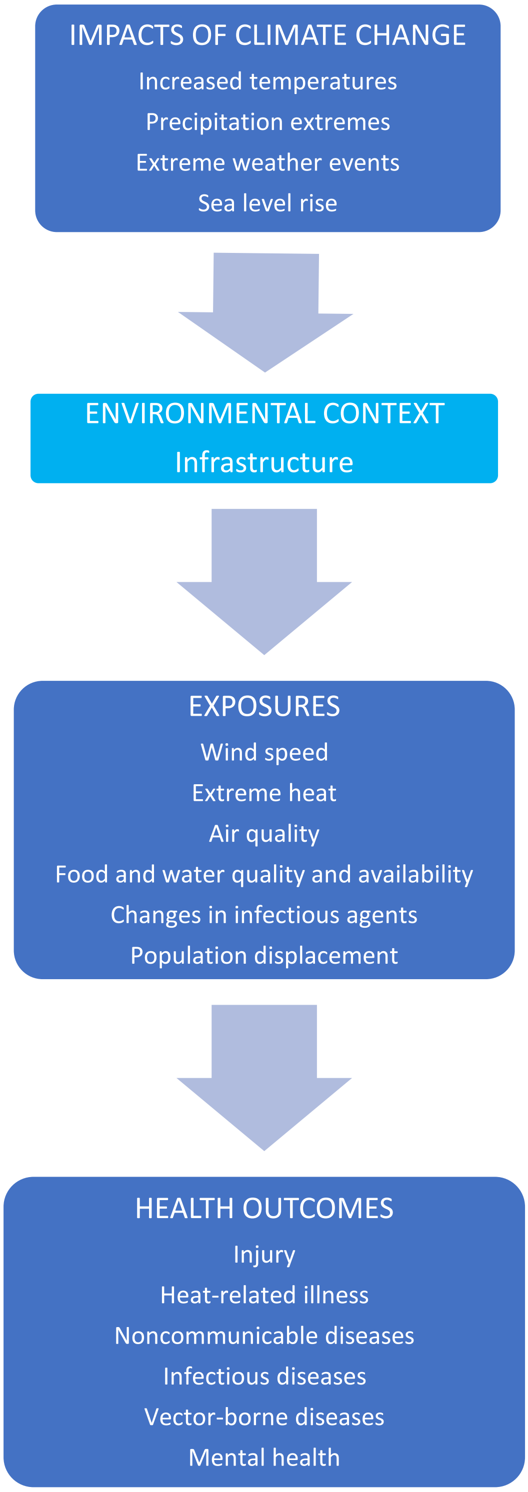
15.1. WHAT IS HAPPENING?

The condition and availability of infrastructure, such as buildings and physical structures for transport, water, sanitation, electricity, cooling and telecommunications systems, are critical determinants of public health. Climate change can cause infrastructural facilities to become severely damaged or be destroyed and fail to function, by driving extreme weather events, increased temperatures and sea level rise (Riley, 2021). Infrastructure is one of the major environmental mediating factors between climate drivers and exposure pathways that affect health outcomes, as illustrated in Figure 1. Infrastructure is generally constructed based on normative assumptions about weather, temperature and oceanic conditions, all of which are altered by climate change (Taylor, 2021).

The Intergovernmental Panel on Climate Change predicts with a high level of confidence that (1) the warming expected in small islands in the twenty-first century will further increase heat extremes and heat stress, (2) sea level will rise around small islands and, (3) coupled with storm surges and waves, sea level rise will exacerbate coastal inundation. Sea level rise likely will also cause shorelines to retreat on the sandy beaches of most small islands, and there are likely to be more intense, but generally fewer, tropical cyclones affecting small islands (Mycoo, 2021; Mycoo et al., 2022). For the Caribbean, a tendency towards a drier climate overall is expected but with more intense rainfall when it occurs (McLean et al., 2015). These impacts of climate change on small islands including those of the Caribbean should be considered in building and maintaining climate-resilient infrastructure in the interest of the health and well-being of Caribbean people. Unless infrastructure is suitably adapted, Caribbean people will suffer from the health consequences of heat stress (see Chapter 6, “Heat-related illness”) and various health consequences of damage to infrastructure associated with sea level rise, coastal inundation, saltwater intrusion into water supplies, flooding and extremely dry and extremely humid conditions (see Chapter 14, “Marine resources and health”; Chapter 12, “Agriculture and food safety and security”; and Chapter 3, “Water, sanitation and hygiene”). More intense tropical storms and hurricanes will cause additional injuries and deaths and will reduce access to health care, safe food and safe water (see Chapter 1, “Extreme weather events”).

Not only are infrastructural facilities vulnerable to climate change, but they also contribute substantially to it, since they consume vast amounts of energy in their construction and use. It has been estimated that infrastructure is responsible for 79% of all greenhouse gas emissions (UNOPS et al., 2021). Approximately one-quarter of CO_2 emissions come from the transport of people, goods and services (Gordon-Strachan, 2021), which is heavily dependent on road and other transport infrastructure.

Figure 1: The mediating role of infrastructure in pathways between climate change and health



Source: Adapted from USGCRP (2016).

Much essential infrastructure in the Caribbean is not built to climate-resilience standards (R4ACCHC, 2022a,b). Access to climate-resilient housing is especially scarce in low-income communities, with residents of these communities losing their accommodation and possessions when hurricanes strike. For example, housing damage in Dominica following Hurricane Maria amounted to 38% of all costs inflicted by the hurricane (Government of Dominica, 2017). In Chapter 3, "Water, sanitation and hygiene", Box 1 details what happened to Dominica's water and sanitation infrastructure as a result of Hurricane Maria. For example, the construction of water and sewage pipes across bridges resulted in loss of water and sanitation services for extended periods, as water from the hurricane cascaded down hillsides and broke both the pipes and the bridges (Allen et al., 2019; CARPHA, 2018; Dubrow, 2021). Figure 2 illustrates the difficulties that can be experienced in obtaining safe water and with recovery in general when infrastructure is destroyed by a hurricane.

Figure 2: Waste and sanitation hazards in Dominica following Hurricane Maria, September 2017

Source: International Medical Corps (https://internationalmedicalcorps.org/story/dominica-devastated-by-hurricane-maria-but-determined-to-rebuild).

In the Caribbean, 52% of the population lives in urban settings (World Bank, 2021), so it is important to consider how infrastructure in urban areas can affect health. An important risk factor for heat-related illness and illness related to poor air quality is the urban heat island effect. This is a phenomenon whereby urban areas experience higher air temperatures than the surrounding countryside and is due to urban construction and human activities. In urban areas, artificial surfaces such as roads and buildings absorb and re-emit more heat than the plants, soil and water they have replaced, which makes their surroundings warmer too. Dark-coloured roofs, for instance, absorb heat during the day and radiate it overnight. Heat from sunlight is compounded by heat from human activities such as power generation and the use of cars and air conditioning. The geometry of cities also contributes to heat island effects: narrow spaces between tall structures, known as urban canyons, can block wind and trap heat. The especially hot conditions during the day affect people's ability to work, both within and outside buildings, affect cognition and dispose people to heat-related illness. Built structures that become hot during the day retain heat throughout the night. The difference between urban and rural areas is even greater at night than during the day, preventing night-time relief from heat stress (Campbell-Lendrum and Corvalán, 2007; Gordon-Strachan, 2021; Gregory and Azarijafari, 2021; Yang et al., 2016). For more information, see Chapter 6, "Heat-related illness". The combination of buildings, dense populations and warm conditions in urban settings also provide ideal conditions for *Aedes aegypti*, the mosquito that is responsible for most cases of vector-borne diseases in the Caribbean (Henry and Mendonça, 2020). For more information, see Chapter 2, “Vulnerability to vector-borne diseases”.

The negative effects on human health of air pollution caused by transport and other forms of fossil fuel use is aggravated under the hotter urban conditions (Gordon-Strachan, 2021). For example, ground-level ozone is formed when vehicle and other fossil fuel and chemical emissions react in the presence of heat and sunlight. Inhaling ozone can cause coughing, shortness of breath, increased severity of asthma, bronchitis and other lung diseases, irritation and damage to airways, and premature death from lung diseases (United States Environmental Protection Agency, 2022). See Chapter 5, “Air quality”, for more information.

Much infrastructure in the Caribbean is dedicated to the use of private vehicular transport and does not encourage physical exercise. Many roads do not have sidewalks and there are very few cycle lanes. Little consideration has been given to protection from heat in the design of public parks and outdoor sport and recreational facilities. Infrastructural design may thus contribute to sedentary lifestyles and to the burden of noncommunicable diseases in the region. See Chapter 4, “Noncommunicable diseases and risk factors”, for more information.

Poor sanitation is another infrastructure-related factor that increases vulnerability to the impacts of climate change in urban areas. In Small Island Developing States, such as those of the Caribbean, the coastal locations of most cities creates an additional vulnerability, from sea level rise and storm surges (Campbell-Lendrum and Corvalán, 2007). See Chapter 14, “Marine resources and health”, for more information.

The climate resilience of health service infrastructure is of special concern. In the face of hurricanes, floods, extreme heat, and other climate hazards, health facility factors that are critical for maintaining sanitary and safe conditions for patients include the quality of building construction, facilities for solid and liquid waste disposal, water supply, electricity and refrigeration. Health facilities also have the opportunity to contribute to climate change mitigation through their choices of construction materials and energy options. These issues are considered in Chapter 16, “Smart health facilities”.

Little research has been dedicated to examining the effects of infrastructural design on health in the context of climate change in the Caribbean. Much of the information on which the current chapter is based was extrapolated from evidence on climate change conditions in the Caribbean and from general information on how health is affected by infrastructure as an environmental determinant, based on studies elsewhere (Allen, 2021). Caribbean urban planning and geography experts are, however, starting to consider how climate-friendly infrastructural design can contribute to Caribbean health (Mycoo, 2021; Sarjeant, 2021), as discussed in Section 15.2, "What should be done?” There is a need for the greater involvement of public health and medical experts in these research endeavours. A PhD study in Barbados is looking at community-level environmental features influencing walkability, individual walking behaviour and risk of noncommunicable diseases (Rocke, 2022). While monitoring and early warning systems are being developed for extreme temperatures, air quality, vector-borne diseases and extreme weather events, the data collected have not generally been used in combination with data on the presence of or condition of infrastructure to examine how these can moderate or aggravate impacts on health. Data are also lacking on how infrastructural risks to health are influenced by sociodemographic and socioeconomic status.

15.2. WHAT SHOULD BE DONE?

> As we seek to bridge the infrastructure gap and improve the quality of life of people everywhere, it is critical that we invest in sustainable infrastructure that adapts to future uncertain climate conditions; contributes to the decarbonization of the economy; protects biodiversity and minimizes pollution. Sustainable infrastructure is the only way we can ensure that people, nature and the environment thrive together.
>
> Inger Andersen, Executive Director of United Nations Environment Programme (UNEP), in UNOPS et al. (2021)

This quote from the Executive Director of UNEP highlights that, if appropriately designed, infrastructure can contribute to achieving the major environmental goals of climate change adaptation and mitigation, conservation of biodiversity and minimisation of pollution. All of these goals relate to health, so infrastructure has the potential to be a major contributor to improving public health, by creating health co-benefits. Moreover, infrastructure can prevent and reduce illness if health is considered in its design, i.e. if facilities are purposely built to prevent and reduce illness and promote health. Infrastructure can also contribute to health if the mitigation of climate change is considered in its design, i.e. by using sustainable materials and sources of energy. Studies calculating the cost savings from considering climate change adaptation and mitigation in infrastructural design have consistently shown that the benefits far outweigh the costs of such design (Campbell-Lendrum et al., 2009; Gordon-Strachan, 2021; Patterson-Waterston, 2021).

While the mitigation of and adaptation to climate change have become major considerations in infrastructural design globally, issues of health and equity are not so often factored into design. This means that, even when projects address environmental sustainability, opportunities to improve health are missed, and some people are left behind or disadvantaged. Health and equity should be considered alongside climate change adaptation and mitigation in cost–benefit analyses of different infrastructural options (Patterson-Waterston, 2021; R4ACCHC, 2022c). Many people in the Caribbean live in substandard housing with limited access to basic utilities. This must be addressed as part of overall infrastructural mitigation and adaptation strategies (Bouillon, 2012).

Individual and community actions and how to support them

Move decision-making on infrastructural projects closer to the communities affected

Since infrastructure is responsible for around 79% of all greenhouse gas emissions and around 88% of the costs of adaptation to climate change (UNOPS et al., 2021), decisions about infrastructure are both highly important and highly political. Moving towards environmental justice, health and equity requires involving affected communities in decision-making about where to place infrastructure and the characteristics of the infrastructure to be installed. Too often, corporate and narrow political interests are served by infrastructure projects, which line the pockets of a few, displacing and inflicting losses on vulnerable communities. Not only would the democratisation of decision-making improve environmental justice, but local, traditional and indigenous expertise may also be very useful in ensuring that appropriate technologies are used and applied to optimise conservation of the environment and health (Mycoo, 2021; Scobie et al., 2021). Technical experts and local community members should engage in mutual education and dialogue to optimise solutions.

A further advantage of sharing decision-making more equitably is that it can help to achieve national goals. While national policymakers set goals and targets relating to climate change, such as time-bound, specific targets for fossil fuel emission reductions, it is the people “on the ground” who make the millions of decisions on consumption and production that determine whether or not these goals and targets are achieved. If local stakeholders have a say in decisions about infrastructure, it is more likely to be designed and built in harmony with their own goals and objectives, and their actions are likely to support the overall goals of the infrastructural project (Scobie et al., 2021). If environmental goals are accepted by all sides, a virtual cycle of mutually supportive action is created. Better communication by and coordinated education and support between the national and local levels of government can help to multiply achievements at both levels (Patterson-Waterston, 2021). In health systems, involvement of front-line service providers and patient advocates can assist in designing health infrastructure to optimise human and planetary health. In the words of Caribbean urban planner, Renelle Sarjeant, "People already seem to want green environments. They need to decide how and be supported" (Sarjeant, 2021).

Mechanisms for community consultation and involvement need to be established and supported by government, especially local authorities, given that they are responsible for local infrastructural development. "Town hall" meetings and committees can involve experts and developers in presenting information to local stakeholders and in receiving their feedback on local impacts and solutions. Environmental impact assessments should involve local stakeholders in highlighting potential challenges and solutions. Environmental laws should be strictly enforced. See Chapter 9, "Distribution, equity and justice in climate change and health", for further information on methods for involving communities.

Involve communities in developing "blue–green" infrastructure in the public realm

The public realm consists of the shared outdoor spaces that are open and accessible to the public. Increasing the numbers of plants (green) and water features (blue) in the public realm combats the urban heat island effect, reduces CO_2 emissions and pollution, and provides a pleasant environment, improving physical and mental health. Including greenery in children's play areas, for instance, has been shown to improve their immunity (Mycoo, 2021). Plants and access to green spaces can be incorporated into the design of buildings (e.g. through rooftop gardens, green walls), transport hubs, schools, health centres, etc. Further blue–green options include urban agriculture; permeable pavements, to improve drainage and water conservation; the use of aquatic plants in water channels; and the creation of detention ponds, to control flood and stormwater (Sarjeant, 2021). The numbers of blue–green parks and other recreational facilities in urban environments can be increased (R4ACCHC, 2022d). Maintaining and planting trees on hillsides are important measures for preventing landslides and infrastructural damage. Preventing the increasing numbers of bush/forest fires is also important for stabilising slopes and preventing landslides.

Involving the public in designing, constructing and maintaining these spaces enhances community engagement, sustainability, responsiveness to needs and access to environmental justice (Sarjeant, 2021). To enable this, community outreach is needed, along with information, education and communication on ways that community members can become involved, providing details on the practical steps they can take and tools they can use. Participatory processes can enhance effectiveness and efficiency of actions by communities, but investment is needed in equipment and materials for communities to use. The engagement of influencers such as faith leaders, community leaders and celebrities is important in motivating communities to get involved (R4ACCHC, 2023). Governments and the private sector should involve local communities in environmental planning and in the development of health- and well-being-oriented solutions. At times, action by government against property developers may be needed to achieve equitable and sustainable infrastructure. The value added by developing sustainable infrastructure should be emphasised in communication by civil society to the government and private sector (R4ACCHC, 2023). Tools such as Greenkeeper, an online tool that estimates the economic value of the ecosystem services provided by existing and potential urban green spaces (Patterson-Waterston, 2021), can help in motivating change.

It is also important to build on existing good practices in the Caribbean. Some Caribbean cities, such as Havana, Cuba, have multiple green spaces, such as squares and parks, in which plants are well maintained and continuously planted, and which people attend when they have opportunities for relaxation and leisure time. These spaces provide carbon sequestration services, improve local air quality, provide shade from the sun, help to manage groundwater infiltration and reduce flooding (Mycoo, 2021).

The development of blue–green infrastructure is one of several nature-based solutions that can complement and reinforce each other in facilitating climate change mitigation and adaptation, thereby improving health (Mycoo, 2021). Other nature-based solutions include ecosystem protection, support for rebuilding ecosystems and the restoration of natural resources (Sarjeant, 2021). Installing infrastructure for rainwater harvesting is also a nature-based solution (Gordon-Strachan, 2021; R4ACCHC, 2022c). Individuals and communities can become involved and take leadership roles in implementing all of these solutions. Governments and the private sector should collaborate to support these efforts.

Individuals and communities also need to desist from actions that worsen climate change risks, e.g. dumping litter, plastic waste and even old appliances into rivers and drains, which can become blocked, exacerbating flooding and providing mosquito-breeding sites (see Chapter 2, "Vulnerability to vector-borne diseases", and Chapter 3, "Water, sanitation and hygiene").

Strengthen the climate resilience of homes

Homeowners can contribute to their own safety and health by constructing, maintaining, retrofitting and repairing their homes, to ensure that they meet climate-resilience standards. This includes using special materials and building techniques to hurricane-proof homes. The capacity of water pipes and electricity wires to withstand hurricanes, floods, drought and extreme heat should also be addressed. The installation of solar panels and rainwater-harvesting facilities can help to mitigate climate change and its effects. Painting roofs white or with heat-reflective paints can increase the reflection of the sun's heat, reducing indoor air temperatures on hot days and reducing the load on air-conditioning systems (Pearce, 2018). Houses and surrounding land should be designed to minimise pools of stagnant water where mosquitoes can breed. To facilitate the implementation of these measures, education, information and advice should be provided using various information tools, media and face-to-face interaction, to enable people to contribute to making infrastructural changes, monetarily and in kind. It would also be helpful to have a checklist for the safety and greenness of homes/houses, adapted to the Caribbean situation, that people can refer to. For example, the "Climate change preparedness and resiliency checklist" (U.S. Climate Resilience Toolkit, 2021) developed in the United States of America could be adapted for use in the Caribbean.

It would be useful to provide information on traditional Caribbean construction methods designed to cool indoor environments, which consume less energy than some conventional methods (R4ACCHC, 2023). Consumers and homeowners should be educated on the importance of demanding more climate-friendly products and services from the private sector. Suppliers such as hardware and paint stores can be encouraged to learn about and stock heat-reflective paints.

These solutions are not available – or are available only minimally – to those who do not own their homes or cannot afford the expenses involved in converting their homes. Governments and landlords have responsibilities to climate-proof buildings or to provide the resources and expertise needed for this to be done. Building codes and their enforcement should be reviewed and will need to be adjusted to ensure compliance with evolving climate-resilience standards.

Structural/governmental and private sector actions

Form multisectoral partnerships for sustainable infrastructural development, including with the health sector

This recommendation is complementary to those above concerning community involvement and moving decision-making closer to affected communities. Governments should actively form partnerships with affected communities as well as with a range of different types of agencies that have a critical influence on infrastructural development and health. Stakeholders include central government, local government, property owners, planners and designers, private developers, small and medium-sized enterprises, community groups, healthcare providers and health researchers (Sarjeant, 2021). Within government, the agencies responsible for environmental management, health, transport, urban and coastal development and planning, marine resources and agriculture should be involved in such partnerships (Gordon-Strachan, 2021). Partners should work together to identify funding streams, including existing climate change-related financing, to support the development of infrastructure that supports both health and climate resilience (R4ACCHC, 2023).

A strong framework of regulation is needed for new developments, and this can be better implemented if strong collaboration and planning mechanisms are in place (Campbell-Lendrum and Corvalán, 2007; Sarjent, 2021). More active input is needed from the health sector, to ensure that development and health policies contribute to following a preventive approach to local and global environmental sustainability, urban population health and health equity (Campbell-Lendrum and Corvalán, 2007).

There is also a need to develop alliances to focus on the maintenance and upgrading of existing infrastructure in the Caribbean, much of which is old and therefore requires considerable investment. The health and economic benefits of this investment must be stressed to government agencies, the private sector and civil society.

It is important to network internationally. Given the high level of urbanisation in the Caribbean, it would be helpful for local and national governments to connect with people involved in the global movement to create greener and healthier cities. For example, the C40 Cities organisation is a global network of mayors taking action to confront climate change and thereby enhance well-being (C40 Cities, 2022). The Caribbean Association of Local Government Authorities involves mayors in global initiatives such as the Compact of Mayors, a cooperative effort among mayors and city officials to pledge to reduce greenhouse gas emissions, track progress and prepare for the impacts of climate change (R4ACCHC, 2022a).

Adapt infrastructure and building codes to the characteristics of climate change in the Caribbean

As mentioned earlier in this chapter in Section 15.1, "What is happening?", the predicted characteristics of climate change in the Caribbean include increased warming, an overall drier climate interspersed with more intense rainfall, more intense tropical cyclones and sea level rise. Adapting to each of these characteristics requires engineering and infrastructural solutions (Mycoo, 2021; Mycoo et al., 2022). Cooling services are needed as part of infrastructural design, to prevent heat-related illness. See Chapter 6, "Heat-related illness", for details about heat-related illness and recommendations for addressing it. Buildings and other infrastructure must be constructed to withstand ever hotter and drier conditions without cracking, melting or crumbling. Risks of landslides resulting from successive droughts and extremely wet conditions must be considered. Much critical infrastructure is found around coastlines, and this infrastructure must be strengthened and/or relocated to address the risks associated with sea level rise, coastal inundation and saltwater intrusion into water supplies (see Chapter 14, "Marine resources and health", and Chapter 3, "Water, sanitation and hygiene", for more information on the health consequences of these risks and recommendations for addressing them). Infrastructure in general must be constructed to withstand more intense tropical storms and hurricanes (see Chapter 1, "Extreme weather events").

All these considerations should form the basis of revising building codes and other requirements for obtaining permission to install or make major modifications to infrastructure (Gordon-Strachan, 2021; R4ACCHC, 2023). Insurance companies can get involved by providing incentives to build infrastructure that meets climate-resilience standards by adjusting their premium levels according to adherence to building codes, as has been done in Dominica (R4ACCHC, 2023). Building contractors should be targeted with information, education and communication products (R4ACCHC, 2023). The Pan American Health Organization recently concluded its "Smart Health Care Facilities in the Caribbean" project. As part of this project, a toolkit was developed for retrofitting and/or building health facilities that are both green and safe, thus making them “smart”. This toolkit can be adapted to ensure that buildings are environmentally resilient to climate disasters. See Chapter 16, “Smart health facilities”, for more information.

Governments and the private sector need access to scientific information on how to construct and maintain climate-resilient infrastructure. The Caribbean needs to strengthen its research capacity, and particularly its research in engineering and related fields, and to develop appropriate means of communicating the information collected from such research (R4ACCHC, 2023).

Draw inspiration from traditional Caribbean infrastructural design for climate resilience

In the past, Caribbean people have developed infrastructure appropriate to the tropical climate, but there appears to have been a move away from appropriate architecture over the course of the twentieth century and into the current century. This has coincided with an acceleration of climate change and has aggravated the negative effects of climate change on public health (Mycoo, 2021).

Figure 3 provides some examples of traditional and new housing features in the Caribbean. Traditional features to address the hot climate prioritised methods to maximise ventilation and shade. Traditional housing in flood plains, especially in Guyana and Trinidad and Tobago, was often constructed on stilts, so that water could flow underneath without damage to property. Outside the rainy season, the area under the house provided additional shade and living space.

Some of the newer housing developments in the Caribbean are inappropriate for the local climate, since they are based on designs and have used materials imported from more temperate countries, often contributing to the urban heat island effect (R4ACCHC, 2022d). Current designs favour enclosed spaces and the use of fossil fuel-powered air conditioning for cooling (Gordon-Strachan, 2021). Such developments in lower income communities sometimes render inhabitants extremely vulnerable to flooding and are maladapted to the increasingly hot conditions being experienced (R4ACCHC, 2023). The role of property developers and politicians in constructing and allowing such developments to be constructed, respectively, must be challenged. There is a need to widen drains and adopt other flood mitigation measures, especially given the slower run-off of floodwaters because of sea level rise. The health consequences of flooding are presented in Chapter 3, “Water, sanitation and hygiene”, and those of increased temperatures are presented in Chapter 6, “Heat-related illness”.

Promote blue–green infrastructural policies and plans

To achieve the health outcomes of blue–green infrastructure outlined above, governments should integrate the creation of blue–green infrastructure into spatial and sectoral plans and policies. Public–private partnerships are critical, along with the allocation of finance and incentivisation mechanisms. A variety of agents should be made aware of the importance of blue–green infrastructure and become involved in these partnerships, including sectoral agencies, line ministries, physical and urban planners, architects, engineers, landscape architects, mayors, communities and neighbourhoods (Sarjeant, 2021). Dominica has made climate resilience a central goal of national development policy, aiming to become a climate-resilient nation (Government of Dominica, 2012). For this purpose, it has established a coordinating agency, the Climate Resilience Execution Agency for Dominica (CREAD, 2019). Moreover, Saint Lucia’s National Adaptation Plan 2018–2028 includes plans for green roofs, urban afforestation, natural buffers and green spaces (Mycoo, 2021).

Figure 3: Climate change adaptation features of old and new architectural styles in the Caribbean

Traditional architectural features

Adaptation to heat

– Jalousie windows
– Verandahs
– Porticos
– Gable windows
– Short piers for air flow

Source: Photo of a house in Trinidad and Tobago by James Hospedales.

Adaptation to flooding

Elevation of the house on stilts

Source: Photo of a house in Trinidad and Tobago by James Hospedales.

Typical housing construction in the twenty-first century for low-income neighbourhoods in the Caribbean

– Bungalows built on flat land, including floodplains
– Small windows with little natural ventilation

Source: Trinidad Express Newspapers (2018) (https://trinidadexpress.com/news/local/national-disaster-declared/article_16ff68d4-d47a-11e8-9e2f-e3a80bd3c43c.html).

Provide infrastructural support for green mobility and exercise

Green mobility refers to options for movement or transport that do not damage the natural environment, such as walking or cycling. Green mobility options can also reduce the environmental damage and decline in air quality associated with transport, for example by shifting towards sustainable energy sources and providing shaded bus stops and sustainably cooled transport hubs to encourage public transport use. Green mobility that involves a physical exercise component is often termed “active transport”. This mitigates climate change by reducing the use of automobiles and has health co-benefits such as reducing the incidence of and morbidity associated with noncommunicable diseases (Campbell-Lendrum and Corvalán, 2007; Gordon-Strachan, 2021; R4ACCHC, 2022e).

Green mobility should be supported and the benefits to health therefore promoted by infrastructural design. The number, and blue–green characteristics, of parks and other recreational facilities enabling exercise should be increased. The number of footpaths and cycle lanes should be increased, and they should be provided with shade, ideally using plants, to help prevent heat-related illness (R4ACCHC, 2022e; Rocke, 2022). Duties and taxes should be removed from bicycles and e-bikes to provide an incentive for their use. Compact urban design can reduce travel distances and commuting times, contributing to green mobility. The number of electric vehicle charging stations, of which there are few in the Caribbean, should be increased (Sarjeant, 2021). The availability of exercise equipment and number of sports fields should continue to be increased, with attention being paid to their installation in low-income and marginalised communities. Moreover, these facilities must be properly maintained and repaired on an ongoing basis.

Invest in sustainable energy infrastructure

Since infrastructure itself is responsible for over three-quarters of greenhouse gas emissions, it is critically important for new infrastructural developments to include means of manufacturing energy from sustainable, renewable, nonpolluting sources. These forms of energy should be used to power other forms of infrastructure (Campbell-Lendrum and Corvalán, 2007).

The Eastern Caribbean Central Bank provides a model, having established a solar farm on its premises (R4ACCHC, 2022b). The project involved installing solar panels in a series of canopies over the bank’s car park at its headquarters in Basseterre, Saint Kitts and Nevis, resulting in the largest solar-powered generator on the island. It is also thought to be the largest solar-powered system in the Eastern Caribbean operated by any entity other than a power company (Eastern Caribbean Central Bank, 2022). Chapter 5, “Air quality”, and Chapter 14, “Marine resources and health”, provide further details of options related to energy infrastructure for mitigating climate change with health co-benefits.

To encourage the greater adoption of sustainable energy infrastructure by households and businesses, governments should offer more incentives such as tax breaks, and cost–benefit analysis and other relevant data should be provided to consumers (R4ACCHC, 2022d,g). Utility companies can assist by providing easily accessible information to consumers, to enable them to monitor their energy use, and by communicating with consumers about the importance of conservation in the context of climate change.

Reduce, reuse, recycle

Infrastructure should support a reduction in environment-damaging production and consumption in the Caribbean. New developments should incorporate facilities for collecting and processing materials for recycling. Facilities should be properly maintained and repaired rather than replaced, once they can meet environmental standards. Compact design should be a principle for designing infrastructure.

Requirements on water-harvesting facilities are included in the building codes of countries such as Antigua and Barbuda. Other Caribbean countries should include these requirements too, as climate change continues to exacerbate water stress in this region. The management and recycling of wastewater should also be included as part of the greening of urban spaces. The regional adoption of integrated water resource management (IWRM) plans is actively being discussed by Caribbean stakeholders and is at the nexus of climate change and water security. Several Caribbean countries, including the Bahamas, Barbados, Guyana, Jamaica, and Trinidad and Tobago, have drafted/developed IWRM plans. However, IWRM has not been fully integrated into legal and policy frameworks (Gordon-Strachan, 2021).

Include infrastructure in disaster preparedness and response, and build back better following extreme events

As part of disaster preparedness and response, and in the aftermath of extreme events, it is critically important to ensure the resilience of infrastructure. This means ensuring that structural integrity and strength are sufficient to withstand more intense wind and hydraulic forces. This is especially important for health facilities; storage facilities for emergency medical, food and water supplies; and hurricane shelters. See Chapter 16, "Smart health facilities", for further details. Water, sewage and solid waste infrastructure should receive special attention in disaster preparedness and response. Safeguarding infrastructure is one of the five pillars of the Caribbean Resilience Framework, developed by the Caribbean Disaster and Emergency Management Agency and its partners in 2018 (Riley, 2021). Design should also be sensitive to important social vulnerabilities that arise from disasters. For instance, shelters should be designed with separate areas and entrances for men and women, to prevent violence against women from occurring.

Research gaps and how to address them

Build the Caribbean body of knowledge on the role of infrastructure in reducing or amplifying the impacts of climate change on health

Developing science-driven policy on infrastructure, climate change and health is critical. Robust research is needed to measure the effect of different types of infrastructure in mediating the impacts of climate change on health. Such empirical evidence can provide cogent arguments for investment and the allocation of resources (Allen, 2021; Mycoo, 2021).

There is a need to identify the health impacts of the various types of infrastructural projects implemented in the Caribbean, and how these impacts vary according to climatic conditions (Allen, 2021). Longitudinal studies are needed, including those that map environmental, climatic and health conditions before and after project implementation and at determined intervals thereafter. Impacts should be disaggregated according to the sociodemographic characteristics of affected communities and geographical areas. Projects with varying levels of incorporation of "blue–green" features can be compared with each other in terms of performance and with the performance of "baseline" or status quo infrastructure (Sarjeant, 2021).

Health impact assessments and environmental impact assessments should be systematically conducted for infrastructure projects. Data from these should be collated in repositories to enable systematic learning from the limitations of previous projects and how these were resolved.

The geographical vulnerabilities of each Caribbean state should be measured and monitored, such as the percentage of the population living along coastlines; the topography (e.g. percentages of flat and mountainous terrain); geographical distances from other land masses and commercial centres (degree of isolation); and the availability of transport, communication infrastructure, healthcare equipment, supplies and specialised healthcare workers (Allen et al., 2021; Holdschlag and Ratter, 2012). This would provide important contextual information to inform the development of climate-resilient infrastructure (Allen, 2021).

Results from such studies should be combined with economic data to conduct cost–benefit analyses that incorporate subpopulation impacts (Gordon-Strachan, 2021; Patterson-Waterston, 2021; Sarjeant, 2021). Such cost–benefit analyses are critical to inform decisions to enhance health equity and environmental justice.

Identify health hazard hotspots and opportunities for infrastructural adaptation

Researchers in disciplines including medicine, public health, geography and meteorology can help to identify geographical areas with concentrations of people living with health conditions associated with climate change and to examine the infrastructural and other environmental conditions under which people are living in these areas. The environmental conditions identified can be compared with those in areas with lower levels of ill health, to identify infrastructural risk factors and make recommendations for adaptation (Sarjeant, 2021). The use of geographic information system technology can assist with this. Location-specific economic values of health and the social and environmental costs and benefits of different infrastructural options can be calculated (Patterson-Waterston, 2021). Opportunities for transforming/retrofitting Caribbean urban, rural and coastal spaces should be identified with the assistance of engineers, architects and environmental health specialists. An important area to focus on is possibilities for IWRM. See Chapter 3, "Water, sanitation and hygiene", for further information on IWRM (Gordon-Strachan, 2021; Mycoo et al., 2022).

Identify financial mechanisms to support climate- and health-friendly infrastructural development

Given that it has been estimated that 88% of all climate change adaptation costs involve infrastructural adaptation (UNOPS et al., 2021), it is critical to consider how the costs of climate- and health-friendly infrastructure will be met (Sarjeant, 2021). Economists and public health experts should collaborate to quantify the costs of climate-friendly investment options and seek sources of funding for these. Economic research can also help in the design of appropriate financial mechanisms for Caribbean conditions. Chapter 17, "Funding streams for climate and health action", provides a further analysis of this.

Critically examine the framework of laws and regulations concerning infrastructure through a climate and health lens

Lawyers, structural and mechanical engineers, and public health specialists should examine environmental and building codes, laws and regulations to assess the extent to which they promote climate change mitigation and adaptation and prevent further climate change-related damage (Gordon-Strachan, 2021). Health considerations should be foremost in recommending changes to the legislation and enforcement mechanisms.

Examine the climate resilience of infrastructural solutions developed by Caribbean people

As outlined above, there may be things to learn from traditional Caribbean architecture in terms of climate adaptation. Research should be conducted on how traditional infrastructural solutions to climate challenges affect health and how they can be updated to benefit health, for example by reducing indoor air temperatures or the impact of recurrent floods in some areas. Resources should be dedicated to research and development by Caribbean engineers and designers, to enable them to adapt infrastructure to local conditions (R4ACCHC, 2022b). Using renewable energy for air conditioning, in instances where it must be used to mitigate the effects of heat on health, is also an important topic for research (Allen, 2021; Gordon-Strachan, 2021).

Conduct research on infrastructural options for promoting green mobility and exercise

Replacing vehicular with active transport such as walking and cycling may not be straightforward in the Caribbean, as the hot conditions create risks of heat-related illness and there are concerns about security and safety and harassment, especially among women and girls. Research should be conducted into the efficacy of infrastructural solutions (Gordon-Strachan, 2021) such as walkways and cycle paths shaded by greenery or artificial canopies, ventilation and cooling options. A current PhD project is looking at the walkability of public spaces in Barbados to promote exercise and prevent noncommunicable diseases (Rocke, 2022).

Conduct research on how to connect health specialists with other experts and officials to build a multisectoral approach

Research on institutional structures and processes for infrastructural projects should be conducted to assess ways in which public health and medical experts can contribute to infrastructural design. Once ways of engaging health workers are established, they can be communicated to students undertaking health-related tertiary education courses, hospital rotations, etc. A suggested research question is: "How can we connect the health sector with the planning departments and authorities in Caribbean countries with respect to urban greening, including promoting walking paths and biking lanes?" (Gordon-Strachan, 2021).

Surveillance gaps and how to address them

Develop and use measures of equity and health impact for infrastructural assessment and monitoring

The benefits and costs of infrastructural projects are not evenly distributed. Methodologies should be developed to measure differential impacts, according to demographic and socioeconomic factors, and the extent to which these impacts are concentrated in certain communities. Impacts on groups known to be vulnerable to the health effects of climate change should be assessed and monitored. For example, a scoring system was developed to assess the impact of Belize's nationally determined contributions on vulnerable groups, including women, indigenous people and people with disabilities (Patterson-Waterston, 2021). Various indicators of benefits and costs could be measured, including new employment and skills, as well as health status.

To integrate health data into such assessments, special efforts to strengthen health surveillance will need to be made. Electronic information systems should be strengthened to facilitate these kinds of surveillance approaches.

Strengthen information systems that monitor energy and water consumption and promote the use of the information generated

Utility companies should continue to strengthen information systems to monitor the consumption of energy and water. Communication campaigns should promote the use of the information collected to guide consumption decisions and promote conservation among individual consumers, businesses and government agencies. The information should be made available and readily accessible, for example via smartphone apps.

Develop integrated surveillance systems that monitor weather, health and emissions of greenhouse gases and other air pollutants

In evaluating the health dimensions of infrastructure, it is necessary to have access to weather, health and emissions data simultaneously. Strengthening and integrating these types of data is very important (Gordon-Strachan, 2021).

Develop and use tools to assess the environmental and health benefits of infrastructure

Metrics for the assessment of the health and social impacts of climate change-responsive projects are being developed globally. These can be adopted and possibly adapted to the Caribbean context (Gordon-Strachan, 2021). These metrics include:

- The Health Economic Assessment Tool (HEAT) for walking and cycling (WHO, 2021);
- The GreenUr green urban spaces and health tool, which uses geographic information systems to measure the availability and accessibility of green space and its health effects (WHO, 2022);

- Greenkeeper, an online tool that estimates the economic value of the ecosystem services provided by existing and potential urban green spaces (Patterson-Waterston, 2021).

The Caribbean Public Health Agency has developed an innovative framework for the monitoring and surveillance of integrated solid waste management in the Caribbean, with the aim of building resilience to climate change. Poor solid waste management in the context of climate change can exacerbate health challenges related to dust, bioaerosols, vermin and contaminated water or food, including infections, chronic diseases, acute poisoning and injuries. The monitoring and surveillance framework was designed for solid waste disposal facilities. It includes indicators under the broad headings of planning, implementation, evaluation and improvement, to assess whether or not key steps have been taken in the project management cycle that are consistent with the achievement of public health objectives. Assessments of environmental and social impacts are included among the planning indicators (Newton-James and Ivanova, 2021).

Research and surveillance capacity-strengthening needs

Developing suitable infrastructure to help address climate and health requires a wide range of scientific and creative skills, including in disciplines such as engineering, architecture, physics, chemistry, biology, medical science and public health. Social scientists, including economists and urban planners, are needed to plan projects and assess social and economic challenges, and to help develop social inclusion strategies and resource mobilisation. Experts in information technology, remote sensing and geographic information systems are also needed (Allen, 2021; Gordon-Strachan, 2021).

Intergovernmental agencies make an important contribution to operational research, complementing that of academic institutions. For instance, the health subcommittee of the Caribbean Disaster and Emergency Management Agency's Coordination and Harmonization Council has the key function of identifying challenges and gaps in the health sector regarding the implementation of health disaster risk reduction actions (Riley, 2021).

Major challenges in strengthening research and surveillance capacity in the Caribbean are the scale and cost of infrastructural projects and therefore the power of governments and large corporations in determining whether or not they go ahead. Resources are needed from donors to scale up research and make use of all available datasets and technologies, to establish infrastructure that truly serves the interest of Caribbean health. Public–private partnerships can assist considerably if they are truly oriented towards achieving better health outcomes by strengthening infrastructural responses to climate change in the region.

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16. SMART HEALTH FACILITIES

16.1. WHAT IS HAPPENING?

Climate change has the potential to have devasting health impacts across the Caribbean Small Island Developing States (SIDS) (CARPHA, 2017; EarthMedic/EarthNurse Foundation for Planetary Health et al., 2021; R4ACCHC, 2022a) (see Chapters 1, "Health impacts of extreme weather events", 2, "Vulnerability to vector-borne diseases", 3, "Water, sanitation and hygiene", 4, "Noncommunicable diseases and risk factors", 5, "Air quality", 6, "Heat-related illness ", 7, "Mental health", 8, "Population displacement and migration', 9, "Distribution, equity and justice in climate change and health", 12, "Agriculture and food safety and security", and 14, Marine resources and health"). Given the ever-increasing impacts of climate change on health, it is vital to have resilient health facilities capable of functioning during and after extreme weather events and designed to function in environmentally sustainable ways.

A major source of concern is the resilience of health facilities to natural disasters, of which hurricanes are one type. In the Americas, 61% of the impact on health facilities is caused by earthquakes, 17% by hurricanes, 14% by floods and 8% by other health emergencies (Buter, 2021). In 2010 Hurricane Tomas caused USD 2 million in damages to health facilities in Saint Lucia (ECLAC, 2011), and in 2017 the estimated damage to health infrastructure in Dominica after Hurricanes Irma and Maria was USD 10.3 million (Ministry of Health and the Environment, 2017). When 38 hospitals in the English-speaking Caribbean were assessed using the Hospital Safety Index (HSI; see Box 1), it was found that 82% of them could resist a disaster but the equipment and critical services were at risk, and 18% could not resist a disaster in that the lives and safety of occupants were deemed at risk in the event of a disaster (PAHO, 2017). In Latin America and the Caribbean 67% of hospitals are in areas assessed to be at high risk of natural disaster (PAHO, 2017). This is especially important, because 70% of health ministries' budgets are spent on hospitals.

Health systems globally are estimated to contribute some 5% of global greenhouse gas emissions, more than the total greenhouse gas emissions of Japan or Brazil, especially through energy use (Karliner et al., 2019). Health facilities use large amounts of energy. This contributes to greenhouse gas emissions and is excessively costly because Caribbean energy prices are among the highest in the world (PAHO, 2013). It is prudent to try to reduce this expenditure and use the resources instead to improve the health systems. Smart facilities focus on improving resilience, strengthening structural and operational aspects and using green technologies. Energy improvements include solar panel installations, electric storage batteries and low-consumption electrical systems. In addition to reducing energy consumption, these improvements reduce the health sector's carbon footprint and give hospitals energy autonomy, allowing them to continue running during and after emergencies and disasters.

Smart health facilities must be safe and green; they must link their structural and operational safety with green interventions at a reasonable cost–benefit ratio (see Figure 1). Other ways to be more environmentally friendly and sustainable include using eco-friendly flooring, paints, furniture and furnishings; using less paper; recycling; generating less waste; disposing of waste (solid and liquid) and pharmaceuticals properly; using environmentally benign chemicals; and sourcing more locally and sustainably produced food (PAHO, 2017, n.d.).

Figure 1: Elements of a smart health facility

RESILIENCY SAFE	SUSTAINABILITY SMART	ENVIRONMENTALLY SOUND GREEN
• Sound roof & foundation • Improved security & signage • Secured equipment & fuel storage • Protected & efficient doors and windows • Good drainage • Back-up power • Water reserve • Disaster management plans • Comprehensive maintenance planning • Disability access	• Reduced downtime • Resilient structure • Reduced operating cost • Improved safety • Satisfied patients & staff • Environmentally sound operations • Improved emergency care & services for the community	• Water efficiency • Water minimisation & management • Pollution reduction • Rain water harvesting • Alternative power using renewable energy • Efficient lighting & cooling • Improved indoor air quality

Source: Reproduced from PAHO (n.d.). This is an adaptation of an original work by the Pan American Health Organization (PAHO). Views and opinions expressed in the adaptation are the sole responsibility of the author(s) of the adaptation and are not endorsed by PAHO.

The Foreign, Commonwealth and Development Office of the United Kingdom Government (FCDO)[1] funded the Smart Health Care Facilities in the Caribbean (SHCFC) project: phase 1 (2012–2014) and phase 2 (2015–2022). This project was implemented by the Pan American Health Organization (PAHO) in collaboration with the ministries of health in target countries (Hassan, 2021; PAHO, n.d.). The overall aim of the project was to provide safer, greener healthcare facilities that could deliver care in times of disaster. It was implemented in seven countries: initially in two countries (Saint Kitts and Nevis and Saint Vincent and the Grenadines) and then expanded to another five countries (Belize, Dominica, Grenada, Guyana and Jamaica). The project had four main outputs (Hassan, 2021; PAHO, 2017, n.d.):

1. Assessing the disaster safety and water and energy consumption of health facilities;
2. Implementing standards in selected health facilities in Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia and Saint Vincent and the Grenadines;
3. Developing national and regional capacity to promote climate-smart health facility standards for health workers and users of the facilities; other sectors and climate change platforms or programmes; technical stakeholders (construction, engineering, architects, etc.) and the media;
4. Improving accounts of reconciliation and transparency in financial reporting and implementing risk management.

Phase I introduced the concept "safe + green = smart" (Figure 1) and developed a smart toolkit with resources for identifying and implementing practical and measurable smart building design, operations and maintenance solutions for the Caribbean. This phase retrofitted health facilities in Saint Vincent (Georgetown Hospital) and Saint Kitts (Pogson Medical Centre) (Buter, 2021; PAHO, 2017, n.d.). Retrofitting included replacing windows to

[1]The FCDO was formerly called the United Kingdom Department for International Development.

combat higher wind speeds, strengthening roofs to accommodate solar panels, and improving natural lighting, ventilation, fire safety and emergency exits. Following the completion of the retrofit at the Georgetown Hospital, electricity consumption decreased by approximately 58% and that of the Pogson Medical Centre by 50% (Buter, 2021).

The toolkit provides guidelines for assessing, designing, and adapting or building new health facilities. It incorporates climate-smart and safety standards and includes three main sections: the HSI (see Box 1), the Baseline Assessment Tool (BAT) and the Green Guide. Annexes provide additional information that will assist in guiding health officials and health facility administrators in achieving smart health facilities[2] (PAHO, 2017, n.d.).

- HSI: the index is used to assess a health facility and determine whether it is disaster resilient and can continue to operate during a climate-related disaster based on structural, non-structural and functional factors. A health facility is scored on the level of safety in 145 areas. Based on the index score, the health facility is placed into one of three categories (PAHO, 2017):
    - Category A: a facility that is deemed able to protect the lives of its occupants and is likely to continue functioning in disaster situations.
    - Category B: a facility that can resist a disaster but in which equipment and critical services are at risk.
    - Category C: a facility where the lives and safety of occupants are deemed at risk during disasters.
- BAT: the tool is used to collect baseline information to assist in decision-making when retrofitting a health facility. Users of the tool need specialised structural and electrical engineering knowledge. The data gathered include energy and waste consumption; indoor environmental quality; building components; the results of an occupant survey; and local land use zoning regulations.
- Green Guide: the guide is a checklist that health facility operators can use to minimise their contribution to climate change. It identifies areas that can conserve energy, cut costs, increase operational efficiency and reduce the health facility's carbon footprint. The checklist has a maximum score of 100, with 70 being the minimum total score needed to achieve certification.

For a health facility to be considered "gold standard", it needs to achieve a combination of scores from the HSI and the Green Guide, which has been set at A/70 (PAHO, 2017).

Phase 2 of the SHCFC project assessed additional health facilities in Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia and Saint Vincent and the Grenadines; built national and regional capacity to use and apply the smart toolkit; and retrofitted at least one health facility in each of the participating countries. This led to enhanced safety standards, reduced downtime and damage to health facilities from natural disasters, and lower operating costs due to savings on water and electricity (Baron, 2021; Buter, 2021). See Box 1 for a case study of smart adaptation and mitigation strategies at health facilities in Saint Lucia. Training in water and energy conservation and contingency planning has resulted in new habits and staff better prepared for emergencies. Data collected in the community surrounding the Vieux-Fort Wellness Centre has demonstrated desirable changes in knowledge, attitudes and practices (Harvey, 2021).

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[2]Annexes include "Sustainable construction: designing for the future", "Model policy for smart health facilities", "Green checklist and field guide", "Cost-effectiveness analysis: the Retrofitting Economic Support Tool (REST)", "Water conservation plan template and posters" and "Energy conservation plan template and posters".

Box 1: Smart adaptation and mitigation strategies and challenges at health facilities in Saint Lucia

In Saint Lucia three health facilities – Comfort Bay Senior Citizens Home, Vieux-Fort Wellness Centre and New Beginnings Transit Home – were retrofitted to A/70 standard. Twelve smaller facilities were also upgraded to an increased level of resilience and greenness. The following are some of the adaptation and mitigation strategies used:

- Adaptation to hurricanes: focusing on wind resistance, use of locally made timber shutters, as well as imported hurricane-rated aluminium shutters.
- Adaptation to drought and heavy rainfall: use of rainwater harvesting in response to drought and to direct and control the runoff of heavy rainfall. The runoff can be treated and used for clinical, sanitary and laundry purposes. A combination of gravity-fed and pumped systems was used.
- Adaptation to high temperatures: use of ventilation and solar-powered fans, as well as shading from photovoltaic panels.
- Mitigation: water and electricity consumption was reduced, with the reduction in electricity use being more marked when using solar photovoltaic systems.
- Mitigation: use of a specific budget for preventive maintenance.

Source: Harvey (2021).

Smart standards are being increasingly used in the Caribbean. Apart from the FCDO, other financial partners (e.g. World Bank, International Development Bank, European Union) have provided loans or grants for new builds or retrofits of health facilities. These projects have been implemented in the original seven countries of the project and also across the region in the Bahamas, the British Virgin Islands, Haiti, Montserrat, Sint Maarten and Suriname, for example. Box 2 presents a case study from the British Virgin Islands.

It should be noted that the Caribbean region's building codes are rather general. In the absence of national or regional policy to adopt smart building codes for health facilities, there is the risk that the implementation of smart builds or upgrades will be sporadic and subject to local capacity and willingness of governments (Julian Murray Consulting, 2022). Furthermore, as climate change advances and brings more powerful storms and floods, building codes need to be updated to match.

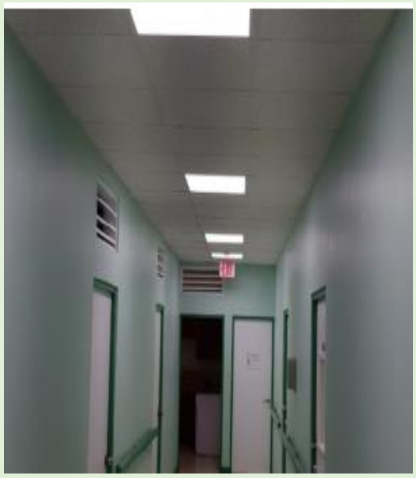
Box 2: Case study on climate-smart renovation of the Adina Donovan Home for the Elderly after Hurricane Irma in 2017

The Adina Donovan Home for the Elderly in Tortola, British Virgin Islands, was substantially damaged by Hurricane Irma in 2017. The home sustained severe damage to its roof, windows, hurricane shutters and metal doors (including the front doors). Parts of the electrical system were broken, including exterior lighting fixtures, junction boxes, switches and outlets, and air conditioners and their switches. The perimeter fence was also destroyed by the high winds. The home had 18 occupants, and since it was one of only two care homes for older people on the island, getting it fully functional again was a matter of urgency. The Government of the British Virgin Islands with technical assistance from PAHO and funding from the United Kingdom Department for International Development used the PAHO smart toolkit to build back greener, smarter, and more resilient and sustainable. The following are some of the smart changes made to the home:

- Changes were made to ramps and louvered windows were included to allow safer movement of the residents and workers while also improving lighting.
- The roof was strengthened, and its slope increased. This was to improve its aerodynamic properties in anticipation of hurricanes with very high wind speeds in the future. Guttering was added to the roof that would direct captured rainwater into a cistern.
- The waterproof part of the roof was painted white (see image A below). This was to assist in reflecting light and heat off the roof, thus keeping it cooler and reducing heat transfer into the facility. Insulation sheets were also used on the new roof.
- A solar photovoltaic system was added to the front of the building and its panels placed on the roof (see image B below). The facility's energy consumption was reduced by approximately 20–30% by this system.
- LED bulbs were used throughout the facility to reduce energy and operating costs (see image C below).
- Inverter-type split air-conditioning units were added in some areas. These result in more energy-efficient cooling and thus reduced energy consumption. They also assist in improving indoor environmental quality.
- The kitchen was upgraded with a new energy-efficient refrigerator and a stove and oven combination.
- Low-flow toilets and aerated taps were added. These will assist in reducing water consumption and operating costs.

A: Roof painted white

B: Solar panels on roof



C: Use of LED bulbs

Source: Government of the British Virgin Islands et al. (2020); photos: copyright © Pan American Health Organization, 2020.

An evaluation report of the SHCFC project was released in December 2022. The following are the highlights of the findings (Julian Murray Consulting, 2022):

- The vulnerability of the target health facilities was substantially reduced.
- The project tested and proved a new model that added climate change adaptation and mitigation (green) to the established foundation of safety (safe). A new gold standard, A/70, for certifying resilience in health facilities was established.
- Public and government officials' knowledge increased but did not always translate into action. For example, it was found that some skills were gained, but it was not certain that enough of the correct people were trained to build a critical mass to ensure self-sustaining transformational change. Despite overt support from regional governments for smart facilities, there were instances in which they did not honour their commitments, for instance to purchase specific equipment or infrastructure to complement that provided by the funding partner, or to keep commitments on a timely basis.
- The project represented good value for money.
- Modest operating efficiencies were achieved, including increased energy and water conservation in retrofitted facilities.
- The British Virgin Island's system of smart accreditation for schools provides a viable model that could be replicated in the education and health sectors throughout the Caribbean region.
- Smart standards are being increasingly used in the region, but this is mostly as a result of the commitment of individuals rather than being underpinned by building or health regulations.
- The need for ongoing preventive maintenance of smart buildings remains a risk for their sustainability.

By June 2022, 415 Caribbean health facilities had been assessed using the smart toolkit; this has created an important database that can be used as a guide for future decision-making and to attract funding. Fifty-four facilities had been retrofitted and another six were in the pre-retrofit construction phase (i.e. the design stage). A total of 1,215 people had been trained in the use of the toolkit, the principles of conservation of water and energy, maintenance and contingency planning. Information about the project and its results have been communicated on social media, at conferences, on billboards and banners and through press releases. This has facilitated the implementation of the smart standards, attracted other financial partners (e.g. World Bank, International Development Bank and European Union) and promoted their use in other sectors (e.g. schools and a courthouse in the British Virgin Islands). The project resulted in approximately 500,000 people having access to more resilient health facilities during times of disaster (Buter, 2021; Julian Murray Consulting, 2022).

Important factors in the project's success and for the future of smart health facility projects include preventive maintenance and the use of "check consultants". Preventive maintenance helps ensure the success and sustainability of a smart health facility. The check consultants are a group of regional construction, structural, mechanical, electrical and plumbing engineers, architects and quantity surveyors who were used as and when needed. Check consultants were used at all stages of assessment and design to assist in troubleshooting and quality assurance. They were also used at the beginning of the project in the development of the toolkit and as trainers and at the end of the project for final validation of the quality of the work (Buter, 2021; Julian Murray Consulting, 2022). Box 3 lists the factors important in facilitating the SHCFC project. It has also been suggested that disaster management simulations are necessary to keep health facilities smart (R4ACCHC, 2023a).

Box 3: Facilitators of the implementation of the SHCFC project

- Preventive maintenance and use of check consultants;
- Strong, clearly understandable and measurable goals, e.g. attaining a resilience gold standard rating of A/70;
- Strong desire on the part of ministries of health and facility managers for upgrading;
- PAHO's capacity to conceptualise and implement a project of this scale and complexity, its strong relationships with national governments and the personal leadership skills of the project coordinator;
- Use of local experts and companies;
- A single project implementation unit based in Barbados, with local coordinators in each country;
- Good teamwork between the project implementation unit, local coordinators, ministry of health focal points and health facility managers and between PAHO and the FCDO;
- Adaptation strategies such as adjusting the HSI checklist for application to small and medium-sized facilities and adjusting design plans (e.g. focusing on use of space) and timelines (for delays in the arrival of raw materials) to account for the impacts of COVID-19.

Source: Julian Murray Consulting (2022).

A vision for scaling up the number of smart health facilities from 50 to 500 by 2030 has been articulated and proposes an expanded multi-stakeholder initiative including France, the Kingdom of the Netherlands, the United Kingdom and the United States of America, as countries that have dependent territories in the Caribbean region (Hospedales and van Alphen, 2022).

Apart from the PAHO smart toolkit, other initiatives that can be useful for Caribbean efforts to develop climate-smart health facilities and systems include the report *Delivering a Net Zero National Health Service* (NHS England and NHS Improvement, n.d.); and the work of Health Care Without Harm (Karliner et al., 2019), which aims to reduce the environmental footprint of health care. For primary care facilities, Greener Practice (United Kingdom) (Greener Practice, n.d.) and My Green Doctor (United States of America) (My Green Doctor, n.d.) are also useful free resources. The Aga Khan Development Network carbon calculator is a useful free tool for calculating and tracking the carbon footprint of healthcare operations (Aga Khan Development Network, 2021).

16.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Build awareness of the advantages of smart health facilities

For there to be uptake of smart (green + safe) health facilities, there needs to be increased awareness of the impact of climate change on health and health facilities and of the advantages of having smart health facilities. This need for awareness applies not only to the public but also to health facilities' managers, public and private, healthcare professionals, and the ministries responsible for urban planning, the environment and health. Social media, conferences, billboards and banners, and press releases were used to communicate the work and results of the SHCFC project. This had the added benefit of attracting financial partners to implement additional Caribbean projects, not only in the health sector, using the smart standards (Buter, 2021; Julian Murray Consulting, 2022; R4ACCHC, 2023a). Figure 2 shows a health centre in Saint Vincent and the Grenadines with a sign indicating to the public that it is a smart health centre. By building awareness, at individual, household and community levels, of the benefits of smart health facilities, it is hoped that smart standards will be used in developing structures other than health facilities. This is already being done in Saint Vincent and the Grenadines (R4ACCHC, 2023a,b).

Figure 2: Sign outside Barrouallie Smart Health Centre, Saint Vincent and the Grenadines

Source: PAHO et al. (2021); copyright © Pan American Health Organization, 2021.

Encourage health clinic attendance in the early morning and early evening

One of the impacts of climate change has been an increase in air temperature (see Chapter 6, "Heat-related illness"). Health clinics and hospitals should offer and encourage early morning (between 7:00 and 9:00 a.m.) and early evening (between 5:00 and 6:00 p.m.) appointments in addition to retaining the option to visit in between these times. Having fewer people at a health facility during the hottest time of the day can reduce the energy needed for cooling rooms.

Structural/governmental and private sector actions

Integrate smart standards in national and regional policies and guidelines

The goal that all health facilities should achieve the A/70 standard should be adopted. Smart standards (safe + green) must include preventive maintenance) and should be included in national and regional policies, strategies and codes relating to health, climate change and disaster risk reduction. This could include the adoption of a national smart health facilities policy[3] (PAHO, 2013) and the 2017 Smart Technical Standards for Retrofitting as part of the PAHO Smart Hospital Facilities Toolkit (PAHO, 2017). Other channels include the development of national health action plans and Caribbean comprehensive disaster management targets (Drewry, 2021; Drewry and Oura, 2022; Julian Murray Consulting, 2022; R4ACCHC, 2023a).

Scale up the PAHO Smart Health Care Facilities in the Caribbean project

The 2012–2022 SHCFC project should be scaled up, building on the lessons learned. Some recommendations include (Hassan, 2021; Julian Murray Consulting, 2022; R4ACCHC, 2022b):

- Ensure that national governments have a dedicated unit with the capacity and authority to identify target facilities and to provide technical support for their retrofitting.
- Implement smart projects where feasible. Ideally projects require a committed government, a project management team with relevant technical expertise, a local project implementation unit with delegated authority to make substantive decisions and a flexible donor.
- Be flexible with timelines – sometimes there are setbacks, e.g. COVID-19 or even climate change disasters. Consultations, verification of building ownership, quality design and construction, and behaviour change also take time.
- Create a regional network of check consultants, ensuring that additional consultants are continually added to the network to ensure its sustainability.
- Pay attention to maintenance – prevention is cheaper and greener than cure – think about it from the start. Understand that maintenance is ongoing. Establish national standards for maintenance with practical, affordable and independent means of verification. Develop the capacity and a culture for maintenance. Ensure that facility managers "own" the newly retrofitted health facility, and therefore they will be more inclined to ensure its upkeep. Guarantee preventive maintenance by creating a system of responsibilities, resources and technical support that is controlled by the health facility manager.
- Use local resources with a focus on design quality.
- Promote wider use of photovoltaic systems with batteries in facilities where smart retrofits are being done.

Include smart standards in regional and national building codes

National building codes remain general, are rarely built into national standards, have no established inspection system and are generally not enforceable. The British Virgin Islands and Montserrat appear to be the only countries that have adopted smart standards in health and other sector regulations. Belize, Jamaica, Saint Lucia and Saint Vincent and the Grenadines have not fully adopted smart standards through changes in existing regulations, but they have included them in the terms of reference for new buildings or retrofitting projects in the health sector. Smart awareness and understanding have grown within the Caribbean engineering community through the check consultants and regional engineering bodies (Julian Murray Consulting, 2022; R4ACCHC, 2023a). Climate and health nongovernmental organisations and civil society organisations and health

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[3]A national smart health facilities policy would be built on the principles of the SHCFC project – where smart = safe + green. Smart health facilities policies should also include strategies for preventive maintenance. A national policy would build on existing initiatives that ministries of health are already undertaking to make health facilities resilient to disasters and to contribute to national governments' priorities in disaster risk reduction and in adaptation and mitigation to climate change. Such a policy would provide a legislative framework that would earmark specific human, technical and financial resources to achieve its goal of smart health facilities (PAHO, 2013).

professional associations should strongly advocate climate-resilient health systems, including smart health facilities, as they would benefit staff and patient safety and well-being.

Accredit smart healthcare facilities

PAHO has a hospital accreditation process across Latin America and the Caribbean. Several countries are seeking international accreditation for their health facilities, which will assist in strengthening public and tourist confidence in national health systems. Smart healthcare accreditation ensures that the healthcare facilities are maintained to the A/70 standard. Belize and Jamaica are in the process of deciding upon a national smart accreditation process. The British Virgin Islands is the only Caribbean entity that has a smart accreditation system, but it is in the education sector. Its system of smart accreditation for schools provides a viable model that could be replicated in the education and health sectors throughout the Caribbean (Julian Murray Consulting, 2022; R4ACCHC, 2023a).

Train health professionals in adopting climate-responsive practices

Staff of health facilities need to be properly trained if the facilities themselves are to be truly smart – it is not just a matter of infrastructure, medical equipment, supplies and energy use. This means that climate change impacts on health must be built into the training curricula of all health professionals. See Chapter 13, “Awareness- and skills-building”. As facilities are built and upgraded to smart standards, there should be a similar upgrading of staff skills, with special training of all staff categories (including allied health professionals, administrative and transport staff as well as medical staff) and integration of standards into job descriptions and responsibilities. Training should include disaster management, simulations, energy conservation and other environmentally sustainable practices. For example, anaesthetists could be trained in how to reduce their use of anaesthetic gases that also are greenhouse gases without compromising patient safety (R4ACCHC, 2023a).

Research gaps and how to address them

Determine the cost–benefit and cost-effectiveness of the regional Smart Health Care Facilities in the Caribbean project and of other national new build and retrofitted health facilities

Undertaking cost–benefit and cost-effectiveness analyses of retrofitting health facilities is key and will provide data that can be used in designing work to retrofit additional health facilities and in building a case for support from donors and lenders. This information should be disseminated to policymakers in the ministries responsible for health, the environment and urban planning (Hassan, 2021; R4ACCHC, 2022b, 2023a). The proposed research questions are as follows (Hassan, 2021):

- What is the cost-effectiveness and cost–benefit of the SHCFC project, as a whole and broken down by health facility, in each of the participating countries?
- How well do smart health facilities stand up to extreme climate events compared with facilities not designed and built or retrofitted to smart standards?
- What is needed to scale up the smart health facilities initiative in the Caribbean?
- How do we ensure sustainable funding for new build or retrofitted smart facilities if the initial funding is foreign based?
- How do we engage the private sector in funding smart facilities? Are there any private hospital associations and medical associations such as the Caribbean College of Family Physicians, with which governments can partner?

Determine the barriers to increasing government leadership and participation in implementing smart health facilities

To scale up the implementation of smart health facilities throughout the Caribbean, the government has an important role in providing leadership and financial support. This is a step towards addressing many of the research gaps and actions required (R4ACCHC, 2023a). Some research questions include (Hassan, 2021):

- How do we strengthen the capacity among government leaders to understand climate change and its impact on health and the urgency of addressing the issue. How do we identify and empower champions to help achieve this?
- How do we promote the importance of understanding that smart health facility policy development and implementation is a critical part of building resilient health systems?

Conduct studies that will enable certification of local materials

In Saint Lucia, locally sourced timber shutters have been used in buildings to protect windows that had breeze block openings with fixed wooden louvres and/or glazed windows. However, the locally made timber shutters had not been tested to international standards to certify their wind resistance. Therefore, the Vieux-Fort Wellness Centre used imported aluminium shutters that had an international wind resistance certification but were probably more costly (Harvey, 2021). Research needs to be conducted to allow certification of locally sourced-products.

Understand the challenges of preventive maintenance

It is important to understand how maintenance can be better addressed rather than waiting for problems to occur. Research questions could include (Julian Murray Consulting, 2022; R4ACCHC, 2023a):

- How can the value for money of preventive maintenance be measured and demonstrated? This would assist in building a case for donors and governments to take maintenance more seriously.
- What are the challenges of preventive maintenance, and are there innovative ways to address these challenges?

Invest in development of efficient plumbing system options suitable for Caribbean water supplies and pressure

Conservation of water and efficient water systems are required, e.g. water-efficient taps and toilets. Low-flow plumbing fixtures are water-saving devices designed to save water, energy and money. They were used in the retrofitting of health facilities in Saint Lucia. However, since the water supply was neither consistent nor of high enough pressure to effectively run such plumbing fixtures, many proved to be unsuitable. Investigations are needed to adapt existing low-flow plumbing technology to conditions such as those found in Saint Lucia and, potentially, the rest of the Caribbean, where there are also challenges of inconsistent water supply and low pressure (Harvey, 2021). Consideration should be given to ways of managing and possibly integrating different sources of water, such as that from mains, rainwater harvesting and wells (R4ACCHC, 2023a).

Investigate the effectiveness of alternative cooling and ventilation systems

If ventilation is modified and additional cooling features are included in health centre designs, their effectiveness should be monitored for any new challenges that might arise. For instance, in the Vieux-Fort Wellness centre in Saint Lucia, solar-powered fans and shading from the photovoltaic panels did not achieve the level of cooling required in the ceiling space. It was also found that a temperature differential between air-conditioned rooms and rooms with natural ventilation and fans resulted in moisture-related problems on the wall between the two kinds of room. These types of challenges need investigation (Harvey, 2021). The issue of air quality and increasing levels of Saharan dust also needs to be researched to determine if air filtration needs to be part of ventilation systems for health facilities.

Additional research questions

The following research questions arise from the recommendations above:

- How can awareness be built about the advantages of smart health facilities among the general public, health facility managers, healthcare professionals and the ministries responsible for health, the environment and urban planning?
- Have smart standards been incorporated into national and regional policies and building codes?
- How can building codes be modified to ensure resilience to the wind speeds typical of category 5 hurricanes (R4ACCHC, 2022c)?
- Since the PAHO SHCFC project ended in 2022, how many additional health facilities have been retrofitted, newly built or started, but not yet completed, using the smart standards?

Surveillance gaps and how to address them

Monitor and evaluate preventive maintenance

Plans for maintenance of health facilities to climate-resilient standards should be developed and should be accompanied by monitoring and evaluation systems to ensure their sustainability and suggest areas for improvement. The maintenance plan must have a clear set of guidelines, practices, scheduled timelines, checklists, means of verification and indicators through which it is clear who is accountable for what aspects of maintenance (with incentives and consequences), and what sorts of operational maintenance need to be carried out by whom and how regularly (Julian Murray Consulting, 2022).

Monitor the efficiency of the smart healthcare facilities

The challenges faced in the Caribbean in implementing smart health facility models may be distinct from those faced in other parts of the world. A repository of structural, mechanical, electrical and plumbing problems that have occurred when using green technology (e.g. photovoltaic systems) in health facilities should be developed, including information on how they were overcome. Also included in the repository should be a cost of initial output and cost of specific repairs. Reports should be generated for use by other health facilities to inform their design and to aid troubleshooting. Ideally, data would be aggregated not only at national level but also at regional level so that countries can learn from each other's experiences. This information could be presented and discussed at national and regional meetings of professional bodies, including those of engineers (R4ACCHC, 2023a).

Research and surveillance capacity-strengthening needs

To address the research and surveillance needed to ensure the implementation of smart health facilities, capacity must be built in implementation science and research, impact evaluation, and qualitative and mixed methods research. The following additional specialist expertise is required:

- Structural, mechanical, electrical and plumbing engineering;
- Quantity surveying;
- Architecture;
- Cost–benefit and cost-effectiveness analysis.

There is also a need for enhanced information technology infrastructure and expertise, along with surveillance expertise, to build the databases needed for sharing information. Communications specialists with writing skills are needed to make technical reports accessible to decision-makers. The involvement of medical associations and healthcare facility managers and administrators will be important in future research and action (R4ACCHC, 2023a).

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DOMAIN 4: RESOURCES AND ENGAGEMENT FOR CLIMATE CHANGE AND HEALTH ACTION

17. FUNDING STREAMS FOR CLIMATE AND HEALTH ACTION

17.1. WHAT IS HAPPENING?

> The Ministry of Health does not have a budget for climate change and health. Funding has to be sourced externally, through projects, writing proposals, through PAHO and other agencies.
>
> Interviewee from the health ministry of an unnamed Caribbean island, in Allen et al. (2021)

Funding for climate change and health action and research in Caribbean countries is often highly dependent on external sources, as indicated by the stakeholder quoted above. This is partly because of the limited finances of Small Island Developing States (SIDS), which are highly vulnerable to climate change-related shocks such as hurricanes. Traditional patterns of dependency on metropolitan countries may also play a role. Funding appears to be mainly grant funding, i.e. not national government funding, and therefore not sustainable. This funding is tied to governments' political will and awareness of the issues, as well as what international donors are willing to fund (Allen et al., 2021). This chapter will focus on financing for health programming; funding for research is covered in Chapter 11, "Research and surveillance in climate and health".

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change estimates that in 2050 adaptation costs in developing countries will be USD 70–100 billion annually (AF, n.d,; Cissé et al., 2022). The World Health Organization (WHO) has identified financial constraints as a major barrier to the implementation of health adaptation priorities (Watts et al., 2021). The participation of the global health sector in international climate financing mechanisms has been limited. In the 2020 Adaptation Fund (AF) database, the majority of projects were focused on indirect benefits to the health system, such as enhanced disaster preparedness and food security; none were explicitly aimed at strengthening health systems and none were directed through ministries of health (Cissé et al., 2022).

The Caribbean region, with its high levels of indebtedness, economies that are highly sensitive to climate variability and change, and human and financial resource constraints, is at risk of falling into greater poverty if climate change adaptation and mitigation measures are not put in place. The challenges faced by the Caribbean are profound and require funding from a variety of sources at national, regional and international levels from the private and public sectors (CCCCC, 2012). Caribbean countries and regional institutions have collaborated to call for greater assistance from developed countries and for solidarity within the region in providing assistance to countries and communities in need. The Caribbean Community (CARICOM) and individual ministers and heads of state continue to advocate at international meetings for the necessary funding for reconstruction, building back better, adaptation and mitigation (CARPHA, 2018).

Dominica provides an example of the financial challenges facing Caribbean SIDS in becoming climate resilient. After Hurricane Maria devasted Dominica in 2017, Prime Minister Roosevelt Skerrit addressed the 72nd United Nations General Assembly and declared the national situation an "international humanitarian emergency". In his speech, he vowed to rebuild Dominica as the first climate-resilient nation by 2030. The cost of Dominica's Climate Resilience and Recovery Plan (CRRP) is estimated at XCD 8.2–9.8 billion.[1] As of 2021, Dominica had invested approximately XCD 1.7 billion on critical infrastructure and other projects since Hurricane Maria. Hence, the remaining financing gap is estimated at about XCD 6.5–8.1 billion. Based on current government capital expenditure and assuming steady revenues and expenditure, the expected financing gap in delivering the CRRP by 2030 is XCD 2.5–3.5 billion. The CRRP includes the construction of well-planned and durable

[1] XCD: Eastern Caribbean dollar.

infrastructure, including roads and bridges, water and sanitation facilities, power supplies and health facilities. The targets for 2030 include 100% of primary roads and bridges open within three days of the passing of a major weather event; at least 60% of water/sanitation facilities operating within seven days; at least 90% of power coverage restored within three days; and no more than 5% of healthcare facilities severely damaged or destroyed by an extreme weather event (this will include using smart health facility concepts; see Chapter 16, “Smart health facilities”) (Baron, 2021; Government of the Commonwealth of Dominica, 2020).

A variety of multilateral and bilateral funding sources are available. As well as the sources presented below, there are opportunities for funding by individual countries through bilateral arrangements, with details available from the United Nations Framework Convention on Climate Change (UNFCCC) (2018a).

Adaptation Fund

Since 2010, the AF has committed USD 998 million to projects and programmes. This funding covers 100 countries, including 15 SIDS and 30 least developed countries, serving about 38 million total beneficiaries. The AF also pioneered the Direct Access system, empowering countries to access funding and develop projects directly through accredited national implementing entities (AF, n.d.). The fund is financed in part by governments and private donors and also a 2% share of proceeds of certified emission reductions (CERs) issued under the Kyoto Protocol’s Clean Development Mechanism (CDM) projects. The World Bank serves as trustee (World Bank, 2023). The CDM allows emission-reduction projects in developing countries to earn CER credits, each equivalent to one tonne of CO_2. These CERs can be traded and sold, and used by industrialised countries to meet a part of their emission reduction targets under the Kyoto Protocol (AF, n.d.; UNFCCC, 2018b). Activities funded by the AF include training people in climate resilience measures, developing early warning systems, and measures to restore or preserve natural habitats. In 2019, the main areas of investment were food security, agriculture, water management, rural development, and coastal zone management (AF,2021).

Countries directly receiving funds from the AF through national implementing entities include Antigua and Barbuda, Belize, Cuba, Dominica, the Dominican Republic, Jamaica, Saint Lucia and Trinidad and Tobago. The projects funded are not directly related to health adaptation but involve aspects such as resilience to flooding, coastal rehabilitation, innovative technologies for improved food security and safety, and marine conservation (AF, 2023). For example, Cuba’s project involved coastal management to reduce flooding through recovery of coastal ecosystems and forests; 21,500 people directly benefited from reduced coastal flooding (at least 45% of them women) (AF, 2021).

Climate Investment Funds

Founded in 2008, the Climate Investment Funds (CIF) represents one of the first global efforts to invest in a dedicated climate finance vehicle. It was created following the recognition that there was a need to deliver climate-smart investment at scale. The CIF supports developing and emerging economies in shifting to climate-resilient and low-carbon development. Since it was established, it has channelled over USD 10 billion from governments and the private sector in 15 donor countries to support more than 370 projects in 72 countries. The resources are held in trust by the World Bank and disbursed as grants, highly concessional loans and risk mitigation instruments to recipient countries through multilateral development banks (MDBs): the Inter-American Development Bank and the World Bank in the case of the Caribbean. The CIF benefits from the MDBs’ ability to leverage funding, mobilise other actors and harmonise policy support (CARPHA, 2018; Climate Investment Funds, 2023a, 2023b).

The CIF consists of two main funds: the Strategic Climate Fund and the Clean Technology Fund. The Strategic Climate Fund finances new approaches or scales up activities through the Pilot Programme for Climate Resilience (PPCR), the Scaling Up Renewable Energies Programme in Low Income Countries, and the Forest Investment

Programme. Other programmes include the Global Climate Action programmes; Nature, People and Climate; and Renewable Energy Integration (Climate Investment Funds, 2023c,d).

Ongoing Caribbean projects under the PPCR are not directly related to health systems and services, but relate to aspects of agriculture, infrastructure and urban flooding. For example, Saint Lucia's project to support climate-resilient investments in the agriculture sector included providing small to medium-sized loans to farmers, farmers' associations, distributors/wholesalers and processing companies in Saint Lucia; this was approved in 2017 with CIF funding of USD 0.80 million (Climate Investment Funds, 2023e). Also in 2017, Haiti's project for municipal development and urban resilience was approved with CIF funding of USD 7 million. One of its key objectives was to reduce climate risks and urban flooding in the city of Cap-Haïtien (Climate Investment Funds, 2023f).

Green Climate Fund

The Green Climate Fund (GCF), the world's largest climate fund, was established in 2010 as a dedicated financing vehicle for developing countries, serving as the financial mechanism of the UNFCCC and the Paris Agreement. Since the approval of the first funded project in 2015, GCF has built a portfolio of over 100 projects (Green Climate Fund, 2023a).

The GCF aims to ensure that at least 50% of adaptation funding is allocated to particularly vulnerable countries, including least developed countries, SIDS and African states. Developing countries appoint a national designated authority, which acts as the interface between their government and the GCF, and must approve all GCF project activities within the country. This country-driven approach ensures the GCF's activities operate in harmony with national priorities (CARPHA, 2018).

The initial mobilisation phase of the GCF (2014) raised USD 10.3 billion from 49 contributor countries, regions and cities. The first replenishment phase, GCF-1 (2020–2023 period), has received pledges from 34 contributors totalling USD 10 billion. The second replenishment phase, GCF-2 (2024–2027 period), is still in the planning and consultation stage. The World Bank acts as a trustee for the GCF; its functions include the receipt, holding and investment of financial contributions from contributors, the transfer of financial resources as instructed by the GCF and the preparation of summary financial reports (Green Climate Fund, 2023c).

The Caribbean region's engagement with the GCF is gaining traction, as several countries have benefited from the GCF Readiness and Preparatory Support Programme, which is designed to support countries' engagement with the GCF, to develop climate change projects and to enhance country ownership. To date, almost all CARICOM Member States have had a Readiness Project approved by the GCF, with most of them partnering with entities accredited by the GCF. There are two regional entities accredited by the GCF, the Caribbean Community Climate Change Centre (CCCCC) and the Caribbean Development Bank (CDB) (CARPHA, 2018).

Antigua and Barbuda, the Bahamas, Barbados, Belize, Cuba, Dominica, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname and, Trinidad and Tobago have received funding for national projects (Green Climate Fund, 2023c).

Global Environment Facility

The Global Environment Facility (GEF) supports developing countries' work to address the world's most pressing environmental issues. Their work is focused on five areas – biodiversity loss, chemicals and waste, climate change, international waters and land degradation – and they take an integrated approach to support more sustainable food systems, forest management and cities (Global Environment Facility, 2023a). Both developed and developing countries are or have been donors to the GEF Trust Fund. Since its inception, the GEF has received contributions from 40 donor countries. In the beginning, countries implemented activities with the assistance of the World Bank, the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). Today, 185 countries and 18 agencies including civil society organisations, indigenous people and the private sector have benefited from GEF support (Global Environment Facility, 2023b).

The Special Climate Change Fund (SCCF) of the GEF was established to support adaptation and technology transfer in all developing country parties to the UNFCCC. The SCCF supports both long-term and short-term adaptation activities in water resource management, land management, agriculture, health, infrastructure development, fragile ecosystems, including mountainous ecosystems, and integrated coastal zone management (Global Environment Facility, 2023c).

One of GEF's projects, the Pilot Program on Climate Change Adaptation to Protect Human Health (2010–2014), was funded by the SCCF and jointly implemented by the WHO and UNDP. This global pilot project was designed to increase the adaptive capacity of national health system institutions, including field practitioners, to prepare for, respond to and recover from the health risks of climate variability and change. The project covered seven countries: Barbados, Bhutan, China, Fiji, Jordan, Kenya and Uzbekistan. Total funding for the project was USD 21.1 million, with USD 4.5 million from the GEF SCCF; co-financing made up additional funding (Ebi, 2015). See Box 1 for more details of the Barbados project.

Box 1: Pilot Programme on Climate Change Adaptation to Protect Human Health – Barbados

The specific objective: to strengthen national adaptive capacity to address health issues related to climate change-attributable water scarcity.

All **project outcomes** dealt with wastewater reuse, and the project developed and implemented country-specific outputs in relation to the following defined outcomes.

- Outcome 1: Policies and programmes are implemented to ensure health risks do not increase as a result of using treated wastewater to recharge aquifers and for irrigation.
- Outcome 2: Capacity is strengthened on climate change and health, and public acceptance of the use of treated wastewater for nonpotable use is increased.
- Outcome 3: The public stores water safely to prevent the breeding of *Aedes aegypti* mosquitoes.

Lessons learned included:

- The development of water quality standards for the use of treated wastewater improved water quality and safety. Improved practices for the storage of rainwater prevented the breeding of *Aedes aegypti*, thus decreasing the incidence of dengue fever.
- Adequate support is needed, both technical and administrative, to scale up the project.
- Health can be a powerful driver of change in relation to climate change issues.
- The public is aware of climate change, but not of its implications on health, so awareness-raising and education is critical for building resilient communities.
- The poster competition implemented in schools attracted a lot of interest and participation from students.
- There should be continuous dialogue with policymakers, and it is important to communicate the results of the project in a relevant way to inform policymaking.
- More technical guidance should be provided at the initial stages of project implementation.

Key products included:

- Young citizens – students' workbook and notebook on piloting climate change adaptation to protect human health;
- Rainwater storage practices – guidelines for public health safety and protection, Barbados' adaptation to climate-driven health risks, climate change adaption to protect human health, adapted from WHO;
- Guidelines for the safe use of wastewater, excreta and greywater. Early communication and alert system for water quality, adapted from WHO.

Source: WHO (2015).

Antigua and Barbuda, the Bahamas, Barbados, Belize, Cuba, Dominica, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname and Trinidad and Tobago have received GEF funding for national projects (Global Environment Facility, 2023d).

Caribbean Development Bank

The CDB has a long history of supporting disaster risk reduction programmes in the Caribbean. The vision of the bank's Climate Resilience Strategy 2019–2024 is of climate-resilient, sustainable development in Borrowing Member Countries through enhanced and sustained climate actions. The CDB's work has four main priorities (CDB, 2018):

- Scaling up climate resilience actions in climate-vulnerable sectors;

- Mobilising concessionary resources;
- Supporting an enabling environment for climate action;
- Operationalising the strategy in concert with CDB.

The CDB has two major climate change projects:

- The Community Disaster Risk Reduction Fund (CDRRF). The CDRRF is a multi-donor trust fund managed by the CDB, with contributions from the Government of Canada, the European Union and the CDB. CDRRF finances community-driven projects, selected through a competitive process, that are aimed at reducing the impacts of natural hazards and climate change. These projects support farmers, fisherfolk, small-business owners and employees, and young people and the elderly in these communities through infrastructure improvements, hazard and vulnerability assessments and training initiatives. Currently, the CDRRF finances and supports eight projects in four countries – Belize, the British Virgin Islands, Jamaica and Saint Vincent and the Grenadines (CDB, 2023a).
- The Climate Action for Resilience Enhancement (CARE) Programme. Launched in February 2022, CARE is a five-year, EUR 14 million initiative to establish disaster risk management and climate resilient-building projects in the CDB's Borrowing Member Countries. The programme is funded by grant financing from the European Union through the 11th European Development Fund's Intra-African Caribbean Pacific–European Union Natural Disaster Risk Reduction Programme and is implemented by the CDB. The CARE Programme focuses on improving disaster risk management and climate change adaptation governance in the CDB's Borrowing Member Countries and strengthening their evidence-based planning, decision-making and financial response. It also seeks to strengthen community infrastructure and livelihood resilience to climate change effects and natural hazards (CDB, 2023b).

Commonwealth Secretariat: Commonwealth Climate Finance Access Hub

The Commonwealth Climate Finance Access Hub is helping to release vital finance to Commonwealth nations; beneficiaries include Antigua and Barbuda, Barbados and Jamaica. As of July 2021, 32 projects in 6 countries have been mobilised through support from the hub, with funds totalling USD 44.1 million. A further USD 762 million worth of projects are in the pipeline (Scotland, 2021).

Financial sector – banking and insurance

Globally, it is estimated that there will be 250,000 additional deaths per year due to climate change between 2030 and 2050. The direct costs of these deaths is estimated at USD 2–4 billion per year on average from 2030. This will lead to losses to the insurance sector because insurers will have to pay more claims. Only about 30% of the Caribbean public has health insurance, which places a burden on the general public through higher taxes. Over time, fewer and fewer people will be covered as global warming causes an increase in insurance claims and costs. The financial sector is the custodian of national and regional savings, and therefore has the potential to invest those savings to promote growth in the national and regional economies, i.e. invest in ventures such as eco-tourism, renewable energy and other eco-friendly businesses that combat climate change and produce health co-benefits. The financial services industry is also the custodian of large amounts of data and has access to reinsurers, whose job it is to better predict the future through research. Financial services have also invested heavily in data science capabilities (Tewari, 2021).

Republic Financial Holdings Limited (RFHL), headquartered in Trinidad and Tobago, is the registered owner of all the banks in the Republic Group in the Caribbean.[2] RFHL signed the Global Principles for Responsible Banking and joined the Net-Zero Banking Alliance as a founding member in 2020, and it was the only signatory in the English-speaking Caribbean. This was in line with the bank's commitment to achieve net-zero greenhouse gas emissions in its financing activities by 2050. One of its objectives is to discover areas of positive impact that link to the United Nations Sustainable Development Goals. RFHL has committed funds to help mitigate the effects of climate change and construct climate-resilient infrastructure throughout all territories where its banks are located (Republic Bank, 2023a). See Box 2 for some examples of RFHL's work (Republic Bank, 2023b).

Even though RFHL's work does not directly fund health-related climate change projects, its pledge is to increase access to funds to (Republic Bank, 2023a):

- Make electric vehicles accessible to more people.
- Support the development of renewable energy and related technologies, as well as the transition away from fossil fuels and towards more environmentally friendly energy sources.
- Provide loans that contribute to energy efficiency and fund construction projects that deploy climate-resilient technology.
- Support initiatives and projects that support environmental sustainability, renewable energy projects, green initiatives and the blue economy in a socially minded and just manner.
- Build all its new properties in accordance with Leadership in Energy and Environmental Design (LEED) Certified Standards by 2025, and make its existing properties more environmentally friendly and energy efficient.

[2] Caribbean RFHL banks are in Anguilla, Barbados, the British Virgin Islands, Cayman Islands, Grenada, Guyana, Saint Lucia, Saint Maarten, Suriname, and Trinidad and Tobago.

Box 2: Case study – Republic Bank of Trinidad and Tobago

In May 2022, RFHL partnered with Caribbean Bottlers Trinidad and Tobago Limited (Coca-Cola) and Blue Waters Products Limited to embark on the "Every Bottle Back" pilot project, which saw over 200 eco-bins placed around Port of Spain and at other locations, such as the bank's branches and units, to encourage the deposit of plastic bottles to be exported and recycled. Between May and August 2022 over 350 000 bottles were collected – about 14 000 pounds in weight. The pilot programme has the ultimate goal of establishing a plastic bottle recycling plant in Trinidad.

RFHL is also providing loans and investments that enable the sale of electric and hybrid cars; loans that are aligned to the promotion of clean fuels, renewable energy and technology that can contribute to an improvement in energy efficiency; and loans for construction that deploys climate-resilient technologies. In addition, RFHL has transitioned from printed to digital statements for its retail customers.

Source: Republic Bank (2023b).

Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) was established in 2007 as the first multi-country risk pool in the world. In 2014, it was registered as a Segregated Portfolio Company (SPC) to allow for new products and to expand its geographical reach. CCRIF SPC is a not-for-profit pooling facility that offers insurance in times of devastating tropical cyclones/hurricanes, earthquakes and excess rainfall events, providing quick, short-term finances. The company is owned, operated and registered in the Caribbean and offers policies to Caribbean and

Central American governments and two utility companies.[3] The CCRIF SPC also has an aggregated deductible cover (ADC) policy feature for tropical cyclone and earthquakes. The ADC was designed to be akin to a dedicated reserve fund providing a minimum payment for events that are not of a sufficient scale to trigger a policy payment (CCRIF SPC, 2023).

In July 2019, the facility, in collaboration with the World Bank and the United States State Department, introduced cover for the fisheries sector for two member countries: Saint Lucia and Grenada. In October 2020, the CCRIF SPC introduced cover for electric utilities in Anguilla (ANGLEC) and Saint Lucia (LUCELEC). The facility helps to mitigate the short-term cash flow problems that small developing economies suffer after major natural disasters. CCRIF SPC's parametric insurance mechanism allows it to provide rapid payouts to help members finance their initial disaster response and maintain basic government functions after a catastrophic event (CCRIF SPC, 2023).

The CCRIF SPC operates through a Multi-Donor Trust Fund (MDTF) under the leadership of the World Bank, and currently channels funds from various donors, including Canada, through Global Affairs Canada; the United States of America, through the Department of the Treasury; the European Union, through the European Commission; and Germany, through the Federal Ministry for Economic Cooperation and Development and KfW – Germany's main development bank. The CBD has supplied additional financing, with resources provided by Mexico; the Government of Ireland; and the European Union through its Regional Resilience Building Facility managed by the Global Facility for Disaster Reduction and Recovery and the World Bank (CCRIF SPC, 2023).

From 2007 to 2022, CCRIF SPC made 54 payouts to 16 member governments totalling approximately USD 269 million. Of this amount, USD 144 million was for tropical cyclones/hurricanes; USD 49 million for earthquakes and USD 66 million for excess rainfall. The largest Caribbean payouts[4] were USD 40 million to Haiti following an earthquake (2021); USD 20.4 million to Haiti after Hurricane Matthew (2016); USD 19.2 million to Dominica after Hurricane Maria (2017); and USD 13.6 million to Turks and Caicos after Hurricane Irma (2015). The most recent Caribbean payouts were USD 8.2 million to Trinidad and Tobago for rainfall events (2022). In addition, the CCRIF SPC has made 23 payments totalling approximately USD 3.2 million under member governments' ADC (CCRIF SPC, 2023).

Research and surveillance

Globally, the *Lancet* Countdown on Health and Climate Change continues to monitor the economic impact of climate change and the financing of health adaptation and mitigation measures (Romanello et al., 2022). There are several policy frameworks and action plans calling for increased solicitation of financing, e.g. The *Lancet* Countdown on Health and Climate Change: Policy brief for Small Island Developing States (Parker et al., 2022)

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[3]Nineteen Caribbean governments are currently CCRIF SPC members: Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Sint Maarten, Saint Vincent and the Grenadines, Trinidad and Tobago and Turks and Caicos Islands. Three Central American governments are currently members of the facility: Guatemala, Nicaragua and Panama. Two electric utility companies are currently members of the facility: the Anguilla Electric Company Limited (ANGLEC) and St. Lucia Electricity Services Limited (LUCELEC).

[4]Payouts are short-term liquidity that are made to the insured government, rapidly, after a disaster. Payouts are calculated based on models incorporating hazard levels such as wind, storm surge and waves for hurricanes and ground shaking for earthquakes. There is no need for a loss adjuster to survey the area or country to determine loss, a process that could take months or even years. Payments are made against a claims process in which proof must be provided demonstrating damage caused and receipts paid or estimates for replacement/repair. For traditional insurance payments, the loss adjuster visits the disaster area and, for example, determines the cost of repair relative to the original replacement cost for a building. Payment is dependent on the total amount of cover bought by the government and the deductible selected. For details see www.ccrif.org/frequently-asked-questions.

and the Caribbean Action Plan on Health and Climate Change (CAPHCC). The CAPHCC includes proposed actions to increase financing for climate change and health, along with indicators of progress (PAHO, 2019). Proposed actions include the creation of fund and project management functions for climate change projects and programmes within ministries of health; increased national budgets for climate change and health; and strengthening of national capacities to negotiate for climate change and health financing. Indicators of progress include the number of countries with climate change and health projects funded by main international funding mechanisms and development partners, and the proportion of national budgets allocated for climate change and health.

Studies have estimated the financial impact of climate-related events in the Caribbean. For example, in 2010, Hurricane Tomas was estimated to have caused USD 5.6 million worth of damage in Saint Lucia (ECLAC, 2011), and, in 2017, the estimated damage to health infrastructure in Dominica after Hurricanes Irma and Maria was USD 10.3 million (Ministry of Health and the Environment, 2017). See Chapter 16, “Smart health facilities”.

Following Hurricane Dorian in 2019, food security was threatened in the Bahamas (R4ACCHC, 2022). In Jamaica, Hurricane Sandy in 2012 resulted in agricultural losses of over JMD 4 billion, with 40,000 farmers affected (Bedasse, 2018). See Chapter 12, “Agriculture and food safety and security”.

17.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Increase community organisations' access to funding

Civil society organisations (CSOs) play a vital role in both climate change adaptation and mitigation, particularly through projects that improve health outcomes. In the Caribbean there is usually very little government funding available to them, and, where there is funding, it is often very difficult to access. Funding should be increased, application processes should be made simpler and grant assessors should be educated on climate change mitigation and adaptation processes (Jaramogi, 2021; R4ACCHC, 2023a). Innovative funding mechanisms, e.g. payment-in-advance initiatives, should be made available to CSOs. Grant proposal writers within community organisations should be trained in grant writing and project management; where community organisations do not have the capacity for in-house training, technical support should be made available to assist with proposal writing and support should be given for the implementation of projects, especially larger ones (R4ACCHC, 2023a).

Structural/governmental and private sector actions

Include climate change considerations in disaster management plans

Incorporating climate change and health considerations into disaster reduction and management strategies could improve funding opportunities and increase potential funding streams (Aitsi-Selmi et al., 2015). This can be done at both the regional and national level.

Advocate at the international level for more funding for Caribbean SIDS

> Less than 2% of climate change funding has gone to health projects, while SIDS have received only 2% of climate change adaptation funding.
>
> Dr Carissa Etienne, former director of PAHO (Etienne, 2021)

The challenges faced by the Caribbean are profound, and require funding from a variety of sources at national, regional and international levels from the private and public sector (CCCCC, 2012). Under Article 9 of the 2015 UNFCCC Paris Agreement, it is stated that "developed countries will provide financial resources to assist developing countries with respect to both mitigation and adaptation" activities (UN, 2015, p. 13). Advocacy from governments is needed to secure funding and support for health-related Caribbean adaptation and mitigation measures from developed countries, who have the greatest historical responsibility for climate change (Dubrow, 2021; Ortiz, 2021). Caribbean countries are relatively small and have limited resources, and therefore need to seek funding collectively through regional bodies such as the CCCCC, the Caribbean Public Health Agency (CARPHA) and the University of the West Indies. The creation of a specific regional entity for the sole purpose of mobilising funding across a range of priorities would be helpful; such a regional funding entity would not only seek funding for climate and health adaptation strategies, but could also finance innovative ways to boost agriculture and reduce the region's dependency on food imports (R4ACCHC, 2023b). Specialised funding streams should be developed for SIDS, focusing on addressing determinants of health and strengthening health systems.

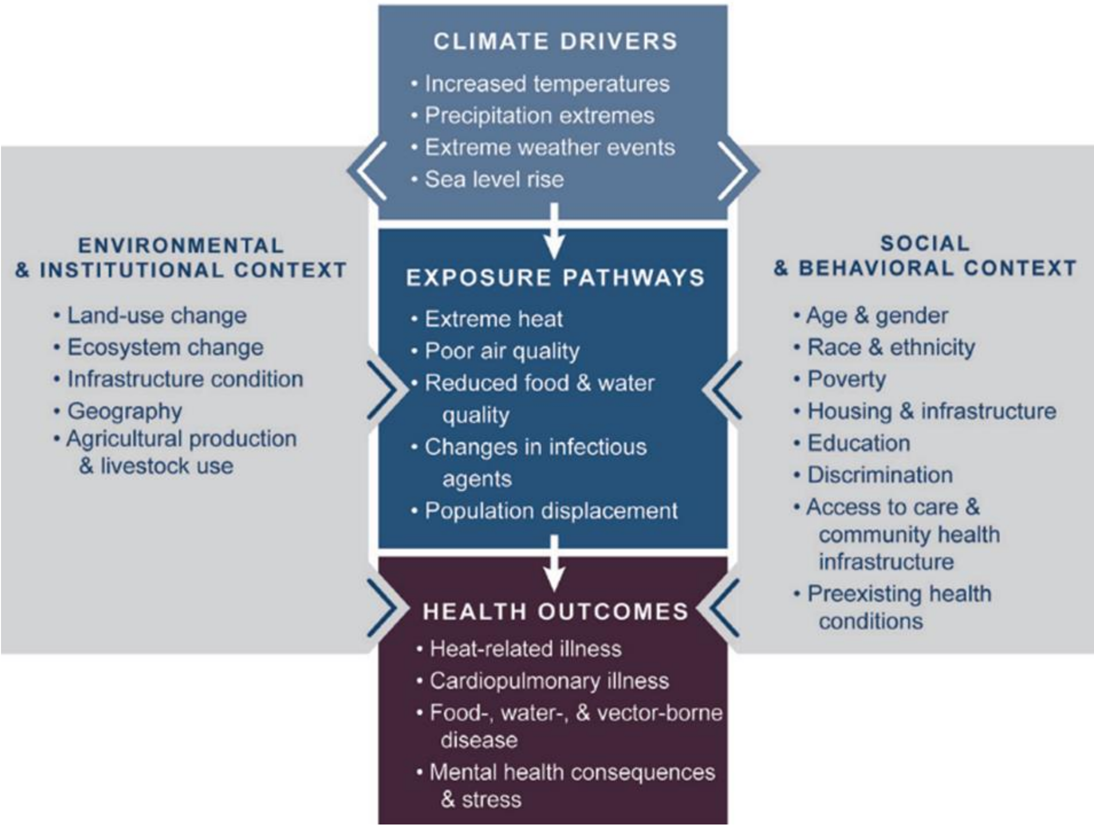
Encourage more public–private funding and partnerships

RFHL is strengthening its focus on climate change financing (Republic Bank, 2023a); other financial institutions should do the same. Collaborations between financial and commercial institutions, governments and technical agencies can be fruitful. For example, the Caribbean Hotel and Tourism Association has collaborated with CARPHA to strengthen its sustainable tourism and health initiatives. More collaborations such as these are needed to help build climate resilience throughout health services and systems, including health facilities.

Increase health policymakers' knowledge on climate change processes

With respect to allocation of funds for climate change and health efforts, policymakers need to better understand the linkages between climate change and population health and the contextual factors that affect those linkages. They need to understand what the climate drivers are, the environmental and institutional context, the social and behavioural context, and the exposure pathways that result in climate change-induced health outcomes (R4ACCHC, 2023a) (see Figure 2).

Figure 2: Framework used to understand climate change impacts, exposure and vulnerability



Source: USGCRP (2016) (https://health2016.globalchange.gov/).

Create a database of available funding relevant to Small Island Developing States and the Caribbean

Organisations need to know where they can access funding and for what specific purpose. Creating a database of the different funders (international, regional and national) will help organisations access funding (R4ACCHC, 2023a). Table 1 shows that lack of knowledge of funding opportunities is a barrier to accessing funding.

Train national and regional experts in grant writing

For a grant proposal to be successful, it must be written according to the donor's specifications. As with policymakers, grant writers need to be familiar with the climate change processes that increase vulnerability to health-related impacts. Expertise needs to be gained in writing such proposals. Table 1 shows that lack of capacity to prepare proposals is a barrier to accessing funding.

Table 1: Some challenges to accessing international funding in eight Caribbean countries[a]

Caribbean countries	AT	BAH	DOM	DR	GRN	GUY	JAM	SLU	TNT
Lack of information on the opportunities	✓		✓	✓	✓		✓		✓
Lack of connection by health actors with	✓		✓	✓		✓	✓		
Lack of success in submitted applications								✓	
Lack of country eligibility		✓			✓			✓	✓
Lack of capacity to prepare country	✓				✓	✓	✓	✓	

[a]As assessed in their Health and Climate Change Country Profile.

Notes: AT, Antigua and Barbuda; BAH, the Bahamas; DOM, Dominica; DR, the Dominican Republic; GRN, Grenada; GUY, Guyana; JAM, Jamaica; SLU, Saint Lucia; TT, Trinidad and Tobago.

Source: WHO and UNFCCC (2020a–f; 2021a–c).

Advocate for funding eligibility criteria to be based on country vulnerability rather than economic classification

There are disparities in access to funding between countries, even within the Caribbean. Countries across the region are classified differently by donors. For example, those classified as “high-income” countries, such as Barbados and Trinidad and Tobago, may not get funding, whereas Jamaica, classified as an “upper-middle-income” country, may receive funding. Most of the Eastern Caribbean countries have challenges in accessing funding because of their income level classification, despite their high degree of vulnerability. It can be challenging to acquire grants or loans for regional projects because of the mix of country income levels within the Caribbean (Allen et al., 2021; Harewood, 2021). This influences the rate of success of applications (Table 1).

Research gaps and how to address them

Determine how to generate sustainable funding streams and mechanisms to support policy and programme implementation to address the effects of climate change on health

Government financing for the climate change and health agenda is critical. In the short term this may need to come from outside organisations, e.g. the GCF. It is critically important to build health economics and financial modelling into programmes to understand the costs and benefits of mitigation and adaptation policies, and hopefully show long-term cost savings that can help sustain such programmes in the future. Some questions include (Hassan, 2021a):

- What is the role of public–private partnerships in developing and supporting funding?
- How can we measure the long-term returns on investment for private entities?
- How are upwards and downwards accountability aligned to create and secure access to funding for climate change and health?
- How can governments support a leadership structure (e.g. a coordinating centre similar to the National Institutes of Health) that can bring together individual grantees to develop common assessment tools, standards and indicators tailored to the Caribbean?

Conduct cost–benefit and cost-effectiveness analyses to understand the financial implications of regional initiatives and action plans

Understanding the financial implications of programmes to build climate-resilient health systems and services is critical for sustainability. There is a need for both cost–benefit and cost-effectiveness analyses to understand the short- and longer-term implications of climate-resilient health systems. Examples of questions could include (Campbell-Lendrum et al., 2009; Hassan, 2021b; R4ACCHC, 2023a):

- Has the EU/CARIFORUM Climate Change and Health Project: Strengthening Climate Resilient Health Systems in the Caribbean been cost-effective?
- How do we ensure sustainable funding for the programmes within the EU/CARIFORUM Climate Change and Health Project: Strengthening Climate Resilient Health Systems in the Caribbean (for example, the Climate Change Leadership Programme) if initial funding is foreign based (Oura, 2021)?
- What additional funding would be needed for climate change and health to support the data generated by the Caribbean Action Plan on Health and Climate Change?

Community climate and health projects should also be evaluated in terms of cost–benefit, cost-effectiveness and lessons learned (R4ACCHC, 2023a).

Determine the effectiveness of actions at the individual, community, structural/government and private sector levels

Climate change and health actions should be evaluated to ensure cost-effectiveness, efficiency and value for money. Process, impact, cost–benefit and/or cost-effectiveness evaluations may be conducted. Determining the barriers to and facilitators of implementing a suggested action would also be helpful in determining the limitations and challenges, and recommendations for the way forward. Research questions could include:

- How many CSOs were trained in proposal writing?
- At how many international meetings did Caribbean leaders call for increased international climate funding for Caribbean SIDS?
- What was the increase in public–private funding arrangements for climate change-related health adaptation and mitigation projects?
- How many health policymakers were trained in climate change impacts, exposure and vulnerability?
  - How was the increase in knowledge brought about? What was the cost of each training initiative?
  - How many countries have created a database of available funding?
- What steps were taken to adjust funding eligibility criteria at the Caribbean level to prevent exclusion of certain countries based on international economic classification?

Surveillance gaps and how to address them

Monitor national, regional and international funding received by countries

Budget allocation data are available but not always accessible. There are national-level budgets related to adaptation, but they may not be titled “adaptation”. Relationships would need to be strengthened with ministries of finance to be able to identify the funds allocated to adaptation measures. A major challenge is that ministries and programmes operate largely in silos, so it may be necessary to seek data from several agencies. Furthermore, identification of funding received for health adaptation in particular may be especially challenging. Capacity for analysis needs to be strengthened, especially since analysis is concentrated among a few people with many responsibilities. Funds are needed to ensure that research and analyses take place (Allen et al., 2021). It is important to monitor the funding expenditure to enable effective evaluation (R4ACCHC, 2023a).

Research and surveillance capacity-strengthening needs

To strengthen research and surveillance, resources must be dedicated to research and surveillance on climate change and health in Caribbean SIDS (Allen et al., 2021). This means dedicating funding to staff, equipment and institution-building, as discussed in Chapter 11, “Research and surveillance systems”. These resources should come from within and outside the region.

Capacity must be built in implementation science and implementation research, impact evaluation, qualitative and mixed methods research, and advanced statistical methodologies. The following additional expertise is required:

- Proposal writing;
- Economics and finance;
- Management and business;
- Budget analyses.

Statisticians and communications specialists with writing skills are needed to make technical reports accessible to decision-makers.

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18. GOVERNMENT ENGAGEMENT IN HEALTH AND CLIMATE CHANGE

18.1. WHAT IS HAPPENING?

Leadership and governance constitute one of the 10 building blocks of the World Health Organization (WHO)'s Operational Framework for Building Climate Resilient Health Systems. Addressing the impact of climate change on health takes political will and leadership, and requires collaboration across the entire health system, including health policy and health finance; training of health professionals; facilities management and services delivery; health information systems; water, sanitation and hygiene; vector control and procurement of medicines and diagnostics. Leadership and governance also involve the assessment, monitoring, regulation and management of climate-related health risks in non-health sectors such as urban planning, public and private works, water supply, food and agriculture, energy, transport and disaster management. It is critical that political leaders and decision-makers ensure adequate coordination and access to the necessary funding if health risks due to climate change are to be minimised (CARPHA, 2018; Hassan, 2021; Shumake-Guillemot et al., 2015; see also Chapter 17, "Funding streams").

In this chapter, we analyse the international and regional context in which governments must take action to address climate change and health.

Global policies and frameworks

Climate change and Small Island Developing States

Global strategies and agreements on climate change mention specific vulnerabilities of Small Island Developing States (SIDS) and recommend capacity-building, financial and technical assistance, and transfer of technological innovations. In 1992, at the Rio Earth Summit, SIDS were recognised as having particular social, economic and environmental vulnerabilities. These were acknowledged in formulating Agenda 21, the non-binding action plan for sustainable development that was a result of the Rio Earth Summit (United Nations Sustainable Development, 1992). In 1994, with the Barbados Programme of Action (BPOA), specific actions were agreed upon to enable SIDS to achieve sustainable development, and in 2005 the Mauritius Strategy sought to address gaps in the BPOA. In September 2014, the SAMOA (SIDS Accelerated Modalities of Action) Pathway, prescribed at the Third International Conference on Small Island Developing States held in Apia, Samoa, recognised and addressed the challenges presented to SIDS by climate change, including issues related to economic development, sea level rise (SLR) and food management (CARPHA, 2018 UNGA, 1994, 2014; UN-OHRLLS, 2015).

Climate change and health in small island developing states

In 2015, three global initiatives were developed to provide guidance and support on how to develop the world in a sustainable way, taking into consideration health implications of global warming and climate change. These were the United Nations Sustainable Development Goals (SDGs) (UNDP, 2015), the Paris Agreement on Climate Change (UNFCCC, 2019) and the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNGA, 2015).

The SDGs include four goals specifically, yet separately, relating to health and the environment (UNDP, 2015):

- SDG 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture";
- SDG 3: "Ensure healthy lives and promote wellbeing for all at all ages";
- SDG 6: "Ensure availability and sustainable management of water and sanitation for all";
- SDG 13: "Take urgent action to combat climate change and its impacts";

- SDG 14: "Conserve and sustainably use the oceans, seas, and marine resources for sustainable development";
- SDG 15: "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss".

To optimise effectiveness in reducing health-related impacts of climate change, these goals, together with the remaining 11 SDGs, must be implemented in totality. This is because action to attain other SDGs, such as reducing poverty (SDG 1) and affordable and clean energy (SDG 7) (among others) are essential components of climate change adaptation and mitigation with positive impacts on health.

The Paris Agreement mentions health only in its preamble, counting it among human rights and equity considerations that should be integrated into action:

> Acknowledging that climate change is a common concern of humankind, Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on human rights, the right to health, the rights of indigenous peoples, local communities, migrants, children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity.
>
> UNFCCC (2019)

Thus, it is imperative when implementing this agreement that the health of all populations is protected from climate hazards, that climate action maximises health benefits to all, and that there is equitable treatment of vulnerable populations (*Lancet* Countdown on Health, 2022; see also Chapter 9, "Distribution, equity and justice in climate change and health").

The Sendai Framework aims to achieve the following:

> The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.
>
> UNGA (2015)

Relative to the Paris agreement on climate change, it makes substantial reference to health, as shown in Box 1.

Box 1: Notable text on health in the Sendai Framework

Article 17

To attain the expected outcome, the following goal must be pursued: Prevent new and reduce existing disaster risk through the implementation of integrated and inclusive economic, structural, legal, social, **health,** cultural, educational, environmental, technological, political and institutional measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience.

Article 18

One of the seven global targets is:

(d) Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them **health** and educational facilities, including through developing their resilience by 2030.

Article 19

Two of the guiding principles are:

(c) Managing the risk of disasters is aimed at protecting persons and their property, **health,** livelihoods and productive assets, as well as cultural and environmental assets, while promoting and protecting all human rights, including the right to development.

and

(h) The development, strengthening and implementation of relevant policies, plans, practices and mechanisms needed to achieve coherence, as appropriate, across sustainable development and growth, food security, **health** and safety, climate change and variability, environmental management and disaster risk reduction agendas. Disaster risk reduction is essential to achieve sustainable development.

Article 24

Priority 1: Understanding disaster risk at national and local levels:

(d) To systematically evaluate, record, share and publicly account for disaster losses and understand the economic, social, **health**, education, environmental and cultural heritage impacts, as appropriate, in the context of event specific hazard-exposure and vulnerability information.

Article 27

Priority 2: Strengthening disaster risk governance to manage disasters at the national and local levels:

(b) To adopt and implement national and local disaster risk reduction strategies and plans, across different timescales, with targets, indicators and time frames, aimed at preventing the creation of risk, the reduction of existing risk and the strengthening of economic, social, **health** and environmental resilience [... and] (d) To encourage the establishment of necessary mechanisms and incentives to ensure high levels of compliance with the existing safety-enhancing provisions of sectoral laws and regulations, including those addressing land use and urban planning, building codes, environmental and resource management and **health** and safety standards, and update them, where needed, to ensure an adequate focus on disaster risk management.

Article 28

Priority 2: Strengthening disaster risk governance to manage disasters at the global and regional levels:

(b) To foster collaboration across global and regional mechanisms and institutions for the implementation and coherence of instruments and tools relevant to disaster risk reduction, such as for climate change, biodiversity, sustainable development, poverty eradication, environment, agriculture, **health**, food and nutrition and others, as appropriate.

Article 30

Priority 3: Investing in disaster risk reduction for resilience at the national and local levels:

(i) To enhance the resilience of national **health** systems, including by integrating disaster risk management into primary, secondary and tertiary **health** care, especially at the local level; developing the capacity of **health** workers in understanding disaster risk and applying and implementing disaster risk reduction approaches in **health** work; promoting and enhancing the training capacities in the field of **disaster medicine**; and supporting and training community **health** groups in disaster risk reduction approaches in **health** programmes, in collaboration with other sectors, as well as in the implementation of the International **Health** Regulations (2005) of the World Health Organization; (j) To strengthen the design and implementation of inclusive policies and social safety-net mechanisms, including through community involvement, integrated with livelihood enhancement programmes, and access to basic **health-care services**, including maternal, newborn and child health, sexual and reproductive health, food security and nutrition, housing and education, towards the eradication of poverty, to find durable solutions in the post-disaster phase and to empower and assist people disproportionately affected by disasters; (k) People with **life-threatening and chronic disease**, due to their particular needs, should be included in the *design of policies and plans to manage their risks before, during and after disasters, including having access to* ***life-saving services****.*

Article 31

Priority 3: Investing in disaster risk reduction for resilience at the global and regional levels:

(e) To enhance cooperation between **health** authorities and other relevant stakeholders to strengthen country capacity for disaster risk management for **health**, the implementation of the International Health Regulations (2005) and the building of resilient health systems.

Article 33

Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction at national and local levels:

(c) To promote the resilience of new and existing critical infrastructure, including water, transportation and telecommunications infrastructure, educational facilities, **hospitals and other health facilities,** to ensure that they remain safe, effective and operational during and after disasters in order to provide **live-saving** and essential services.

and

(o) To enhance recovery schemes to provide **psychosocial support and mental health** services for all people in need.

Sources: CARPHA (2018); UNGA (2015).

Thus, international agreements provide greater support for the integration of health into disaster preparedness and management than into the management of other environmental determinants of health affected by climate change.

In response to concerns expressed by SIDS' ministers of health to the WHO Director-General on the negative impact of climate change on health, the sustainable development of their countries, and their achievement of the SDGs, WHO launched the Special Initiative on Climate Change and Health in SIDS in November 2017 at the 23rd Session of the Conference of the Parties (COP23) held in Bonn, Germany (PAHO, 2018a).

The vision of the Special Initiative is:

> By 2030, all health systems in SIDS are resilient to climate variability and change, and countries around the world are reducing carbon emissions both to protect the most vulnerable from climate risks, and to gain the health co-benefits of mitigation policies.
>
> PAHO (2018a).

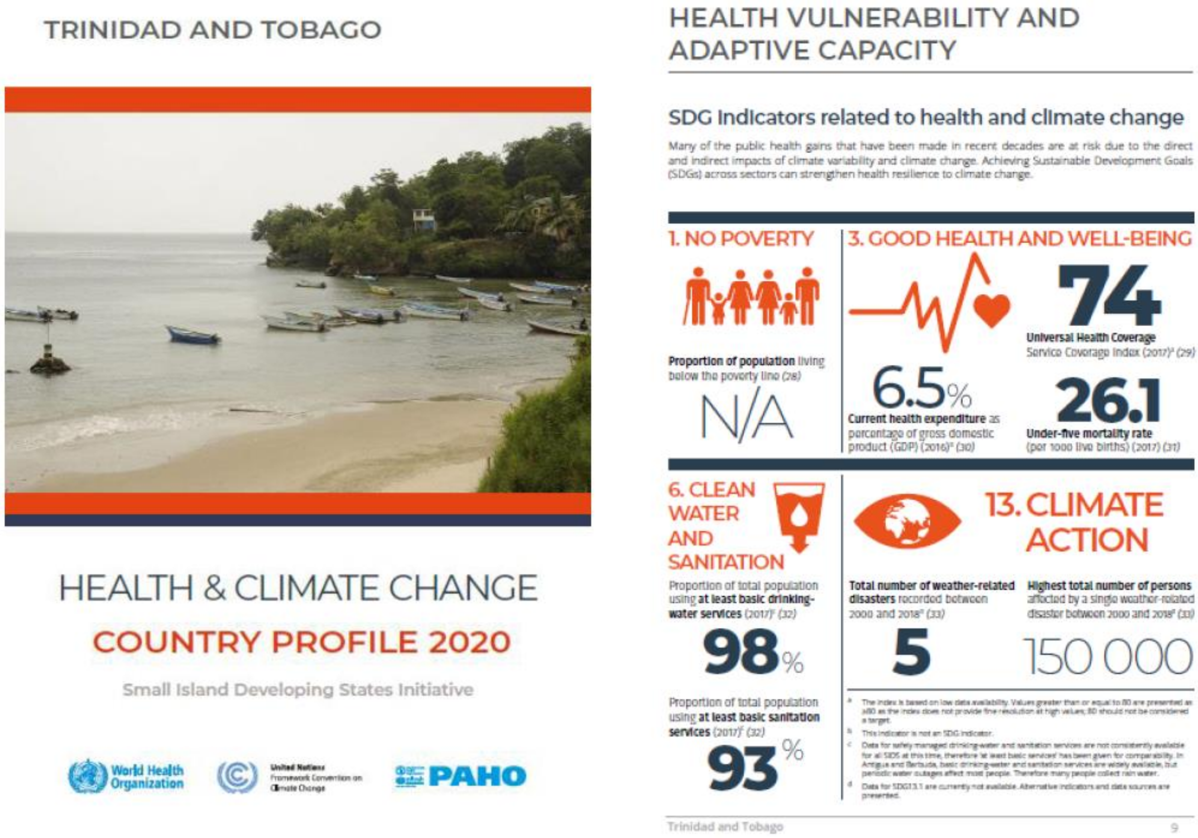
The Initiative includes four interlinked components: empowerment, evidence, implementation and resources.

- Empowerment – supporting health leadership in SIDS to engage nationally and internationally;
- Evidence – building the business case for investment;
- Implementation – preparedness for climate risks, and health promoting mitigation policies;
- Resources – facilitating access to climate and health finance.

The objective of the Third Global Conference on Health and Climate Change: Special Focus on SIDS was to develop regional action plans to address health and climate change priorities in SIDS, under the four components of the special initiative. To facilitate the participation of the geographically dispersed SIDS, the conference was held in three locations: in Fiji, in March 2018, for SIDS in the Western Pacific and African regions; in Mauritius, in March 2018, for SIDS in the South-East Asia region; and in Grenada, in October 2018, for the Caribbean region. Input and consultation with countries at the Grenada conference led to the Caribbean Action Plan on Health and Climate Change 2019–2030 (see below) (PAHO, 2018b).

As part of the WHO and United Nations Framework Convention on Climate Change (UNFCCC) Health and Climate Change Country Profile Project, nine Caribbean countries have prepared profiles – Antigua and Barbuda, the Bahamas, Dominica, the Dominican Republic, Grenada, Guyana, Jamaica, Saint Lucia and Trinidad and Tobago. These profiles provide country-specific estimates of current and future climate hazards and the expected burden of climate change on human health, identify opportunities for health co-benefits from climate mitigation actions, and track current policy responses at the national level. Figure 1 for a summary of the Trinidad and Tobago Country Profile (PAHO and UNFCCC, n.d.).

Figure 1: WHO and UNFCCC Health and Climate Change Country Profile for Trinidad and Tobago



Source: WHO and UNFCC (2020), under licence CC BY-NC-SA 3.0 IGO.

Caribbean government and regional agency responses to climate and health

Caribbean leaders have been extensively involved in highlighting the impacts of climate change on their countries. An important instance was the work of Caribbean leaders and experts in highlighting the importance of the 1.5 °C climate change target that was incorporated into the Paris Agreement (Caribbean Development Bank and CCCCC, 2016).

Caribbean regional agencies (see Box 2) have developed climate and health frameworks and projects using international and regional funding. These agencies all deliver high-level expertise.

Box 2: Caribbean agencies involved in climate and health mitigation and adaptation implementation and/or research

- Association of Caribbean States (ACS): acs-aec.org.
- Caribbean Agricultural Research and Development Institute (CARDI): cardi.org.
- Caribbean Catastrophic Risk Insurance Facility (CCRIF): ccrif.org.
- Caribbean Community Climate Change Centre (CCCC): caribbeanclimate.bz.
- Caribbean Disaster Emergency Management Agency (CDEMA): cdema.org.
- Caribbean Institute for Meteorology and Hydrology (CIMH): cimh.edu.bb.
- Caribbean Meteorological Organization (CMO): cmo.org.tt.
- Caribbean Public Health Agency, Environmental Health and Sustainable Development (CARPHA EHSD): carpha.org.
- Caribbean Regional Climate Centre (CRCC): rcc.cimh.edu.bb.
- Centre for Resource Management and Environmental Studies (CERMES): cavehill.uwi.edu/cermes/home.aspx.
- Implementation Agency for Crime and Security (IMPACS): caricomimpacs.org.
- Organisation of Eastern Caribbean States (OECS): oecs.org.
- Regional Coordinating Mechanism on Health Security (RCMHS): new.carpha.org.
- University of the West Indies (UWI), including the Climate Studies Group mona.uwi.edu/physics/climate-studies), the Caribbean Institute for Health Research (uwi.edu/caihr), the Caribbean Institute for Meteorology and Hydrology, the Centre for Marine Sciences (mona.uwi.edu/cms), the Centre for Environmental Management (uwi.edu/cem) and the Center for Resource Management and Environmental Studies (cavehill.uwi.edu/cermes/home.aspx).
- Windward Islands Research and Education Foundation (WINDREF): windref.gd.

Caribbean governments have developed regional frameworks on climate adaptation and mitigation strategies from those relating to SIDS at the global level. These frameworks have assisted Caribbean governments in developing strategic policies and initiatives and obtaining funding to supplement their own in implementing adaptation and mitigation initiatives (CARPHA, 2018), as outlined in the subsections below.

Liliendaal Declaration 2009

The Liliendaal Declaration affirmed the importance of a common Caribbean regional approach to address the threats and challenges of climate change and the roles of Caribbean agencies. It set out the responsibilities of countries outside the Caribbean to mitigate climate change as well as responsibilities of states within the Caribbean region. Declarations made at Liliendaal included (CCCCC, 2012, Annex 6):

- That all parties to the UNFCCC should work with an increased sense of urgency and purpose towards long-term stabilisation of atmospheric greenhouse gas (GHG) concentrations at levels which will ensure that global average surface temperature increases will be limited to below 1.5 °C of preindustrial levels and that global GHG emissions should peak by 2015.
- Adaptation and capacity-building must be prioritized, and a formal and well-financed framework must be established within and outside the UNFCCC to address the immediate and urgent, as well as long-term, adaptation needs of vulnerable countries, particularly the SIDS and the least developed countries.
- There is a need for financial support to SIDS to enhance their capacities to respond to the challenges brought on by climate change and to access the technologies that will be required to undertake needed mitigation actions and to adapt to the adverse impacts of climate change.

- The parties recognised the need for energy efficiency and conservation and for increased technical and financial support for the development of renewable energy in the Caribbean.
- The parties pledged their commitment to providing more effective preparedness for response to natural disasters through the development of better risk assessment and material coordination along with the streamlining of risk reduction initiatives.
- Support was expressed for the streamlining of all climate change funding mechanisms, including the recommendation that the Global Environment Facility include the vulnerability index in its formulae in order to better facilitate SIDS' access to financial resources; and for exploring mechanisms to support the Caribbean Community (CARICOM) adaptation programmes.
- The parties resolved to strengthen educational institutions to provide training, education and research and development programmes in climate change and disaster risk management, notably in health.
- The parties resolved to institute a comprehensive programme of public awareness and education to promote a better understanding of climate change, its impacts and adaptation and mitigation measures.

Caribbean Regional Framework for Achieving Development Resilient to Climate Change (2009–2015)

This framework and its associated implementation plan were prepared by the Caribbean Community Climate Change Centre (CCCCC) on behalf of the CARICOM heads of state.

The vision of this framework was to achieve a "regional society and economy that is resilient to a changing climate" (CCCCC, 2009). It includes five strategies to support the development of climate change mitigation and adaptation projects across the region. Health is specifically acknowledged as one of the major climate-sensitive sectors (the last strategy, below). The strategies are (CCCCC, 2009):

- Promoting actions to reduce GHG emissions through energy reduction and conservation, and switching to renewable and cleaner sources of energy;
- Promoting actions to minimise the effects of GHG emissions through initiatives and measures designed to reduce the vulnerability of natural and human systems to the effects of climate change (e.g. flood defences, and changing land use patterns);
- Promoting the development and implementation of educational and public awareness programmes as well as public access to information and citizen participation across the Caribbean region;
- Building the CCCCC's organisational capacity to manage adaptation to climate change, through training of scientific, technical and managerial personnel; institutional strengthening; providing systematic long-term technical assistance; and strengthening information support capacity that allows the CCCCC to effectively support the Member States; and
- Promoting the dissemination of successful adaptation experiences to address the impacts of climate change on (1) water supply; (2) coastal and marine ecosystems; (3) tourism; (4) coastal infrastructure; and (5) health, which combined represent the largest threats to the well-being of the CARICOM countries.

In 2012, an implementation plan was developed for this framework: Delivering Transformational Change 2011–2021. The plan involved establishing how regional and national bodies would work together; securing investment to support the action plan; proposing a monitoring and evaluation system; and obtaining buy-in from governments and funders across the region (CCCCC, 2012).

Caribbean Cooperation in Health IV, 2016–2025

The **Caribbean Cooperation in Health IV (CCH IV)** builds on a history of cooperation within the Caribbean and its predecessor plans, CCH I (1986–1995), CCH II (1997–2005) and CCH III (2007–2015). CCH IV provides a framework for CARICOM Member States to address common regional health and development issues, through cooperation, collaboration and collective action. The focus of CCH IV is that of a multisectoral approach and production of Regional Public Goods (RPGs) which will address the health and development challenges of the Caribbean countries. The mission of CCH IV is, "to build the capacity of countries to improve the conditions for health for all, especially among vulnerable groups, and to develop and maintain cost-effective and efficient health systems" (CARICOM, 2016, p. 12). CCH IV has five strategic priority areas (CARICOM, 2016):

- Health systems for universal access to health and universal health coverage;
- Safe, resilient, health-promoting environments;
- Health and well-being of Caribbean people throughout the life course;
- Data and evidence for decision-making and accountability;
- Partnership and resource mobilisation for health.

Strategic priority area 2 and its strategic outcome is the area most closely aligned with climate and health. However, addressing the other areas and outcomes will also assist in reducing climate-related health impacts.

Caribbean Action Plan on Health and Climate Change 2019–2023

The Caribbean Action Plan aims to protect the health of Caribbean SIDS populations from the adverse effects of climate variability by developing climate-resilient health systems, by increasing awareness and mainstreaming funding opportunities to support countries, and by promoting intersectoral mitigation actions in the health sector. It corresponds to the Caribbean part of the WHO Special Initiative on Climate Change and Health in Small Island Developing States.

According to the 2017 PAHO Country Survey on Health and Climate Change, which informed the Caribbean Action Plan, ministries of health raised the following priority actions that should be addressed to best tackle climate change and health challenges:

- Prioritise health issues in the climate change agenda, and in the preparation of reports, plans and other national documents.
- Increase the number of staff trained in and dedicated to health and climate change issues.
- Increase national and health sector budget allocations for climate change actions and programmes.
- Receive support for navigating the complex processes to access international and bilateral funds.
- Increase and improve data generation and results sharing, to support national and regional evidence-based interventions.

For each strategic line of action of the SIDS Initiative (Empowerment, Evidence, Implementation and Resources – see above), this Action Plan proposes actions to be taken at national/local and regional/global levels, and indicators to monitor implementation in Caribbean countries and territories.

Caribbean Public Health Law Forum

The Caribbean Public Health Law Forum was established in 2021 by the Pan American Health Organization (PAHO) and the Caribbean Court of Justice Academy for Law. This is a virtual network which brings together Caribbean professionals from health and law from ministries responsible for both health and legal affairs in nine CARICOM Member States and all five of the CARICOM Associate Member States. The purpose is to consider effective use of law to address shared public health concerns in the Caribbean, e.g. noncommunicable diseases and their risk factors (Anderson, 2021; PAHO, 2021).

Health National Adaptation Plans

The PAHO/WHO has been supporting regional initiatives and actions on climate change and health. PAHO, jointly with other regional technical agencies, has been providing capacity-building and technical support for multi-hazard early warning systems (warning, for example, of climate-related disasters, heatwaves, climate-sensitive diseases, severe droughts and floods), the Smart Health Facilities Initiative (see Chapter 16, "Smart health facilities"), and for the preparation of vulnerability assessments and Health National Adaptation Plans (H-NAPs) (CARPHA, 2018; PAHO, 2019).

H-NAPs help ensure the safety and health of the population pre and post disaster. Ministries responsible for health will need to collaborate closely with other ministries and agencies to address a wide range of issues relevant to climate and health, including but not restricted to public utilities, works, transport, security and education. To assist with the implementation of the Caribbean Action Plan on Health and Climate Change, the EU/CARIFORUM project Strengthening Climate Resilient Health Systems, launched in 2020, has as one of its core outputs the development of H-NAPs (Drewry, 2021; Drewry and Oura, 2022). H-NAPs are to provide an analysis of health systems vulnerabilities and opportunities for action to address the health impacts of climate change, as part of the national adaptation process. These plans can be used by the Green Climate Fund (GCF) and other donors, to demonstrate priorities for investments and as part of the country investment programming (Buss, 2022). PAHO/WHO has prepared guidelines to assist countries in preparing their H-NAPs and related documents such as the Country Profile (see above). As part of the development of H-NAPs, research is being undertaken on climate and health that can provide information to engage policymakers as advocates. (R4ACCHC, 2023a). As of November 2022, Cuba had completed an H-NAP; Grenada had prepared a draft; the Bahamas, Belize, Haiti and Jamaica were in the midst of writing drafts; and Barbados, the Dominican Republic, Guyana, and Saint Vincent and the Grenadines had initiated the process of writing a draft (Buss, 2022). See Box 3 for examples of the contents of the Cuban H-NAP.

Often, there is a bifurcation at the international level regarding treaties on the environment and those on health. In the Caribbean there is a similar pattern, with the Liliendaal Declaration and the **Caribbean Regional Framework for Achieving Development Resilient to Climate Change** referring mainly to climate mitigation and adaptation strategies. CCH IV does address climate and health and the Caribbean Action Plan on Health and Climate Change is fully focused on the issue.

Box 3: Case study: Cuba's Health National Adaptation Plan

Some of the work proposed in the Cuba's H-NAP includes the following:

- Continue developing the baseline in health, with particular reference to those diseases and disease-causing agents that are linked to climate variability and change.
- Establish the current distribution and burden of diseases and disease-causing agents that are linked to climate variability and change and determine recent trends in disease incidence and virus abundance, including other viruses (e.g. SARS-CoV-2).
- Develop information systems that allow environmental health diagnoses to be established.
- Develop public health action plans based on early warning systems that allow the identification of risk situations before they occur.
- Develop specific surveillance and control programmes for disease-causing agents and diseases related to climate variability and change.

Source: Duran (2021).

International treaty implementation at the national level

In the Caribbean, there has been excellent uptake of international health and climate change agreements and treaties in terms of countries signing up to them. However there has been an implementation deficit. The process of transposing international treaties into domestic law in the Caribbean is often difficult; it is rare to have dedicated climate change legislation in the region. The treaties, even though ratified, do not have the weight of law. To have legal force they must be transposed into domestic law by an act of parliament, but the number of Caribbean countries that have done so is much lower than the number that have signed up to such treaties. In addition, many Caribbean states lack the management, administrative and human resources necessary to enforce such a law (Anderson, 2021).

As seen above, the more prominent international climate change conventions[1] make little or no specific mention of health; they are focused on the environment and, in particular, climate change. Since Caribbean countries are responsible for developing their own regional policies from international ones, it is argued that they can use the "right to health" and human rights[2] arguments to develop their own policies and frameworks. Notably, the British Virgin Islands, the Cayman Islands, Guyana and Jamaica have recently made some progress in terms of provision for health and the environment in their constitutions. This makes it easier for countries to develop laws on what is required to ensure that there is support between a healthy environment and the right to health (see Box 4) (Anderson, 2021; Brathwaite and Mendoza, 2021).

Box 4: Examples of constitutional provisions on health and the environment

Guyana (1980), Article 149J (1): "Everyone has the right to an environment that is not harmful to his health or wellbeing".

Jamaica (1962) (Charter of Rights, 2013), s 13 (3) (1): "the right to enjoy a healthy and productive environment free from threat of injury…"

Cayman Islands (2009), S 18 (1): "Government shall … foster and protect an environment that is not harmful to the health or well-being of present and future generations…"

British Virgin Islands (2007), Article 29: "Every person has the right to an environment that is generally not harmful to his or her health or well-being…"

Source: Anderson (2021).

There has also been recent judicial decision-making, with the courts increasingly recognising the linkages between climate change and health. In 2021, the United Nations Environmental Programme noted a doubling of climate litigation between 2017, when there were 884 cases in 24 countries, and 2020, when there were 1550 cases from 38 countries. In most cases, the complaint was violation of climate rights, with the justification being that climate change compromises fundamental human rights including the right to life, health, food and water. In Trinidad and Tobago, there have been two cases of note: *Soodeen v Attorney General of Trinidad and Tobago* (1997) and *Fishermen & Friends of the Sea v EMA & Atlantic LNG* (2004) (Anderson, 2021).

The Commonwealth Secretariat

The Commonwealth includes 12 Caribbean countries.[3] In February 2022, the Commonwealth Secretariat and the WHO signed a memorandum of understanding in which they agreed to work together to strengthen the exchange of information on seven priority areas (WHO, 2022):

- Promoting universal health coverage and primary health care;

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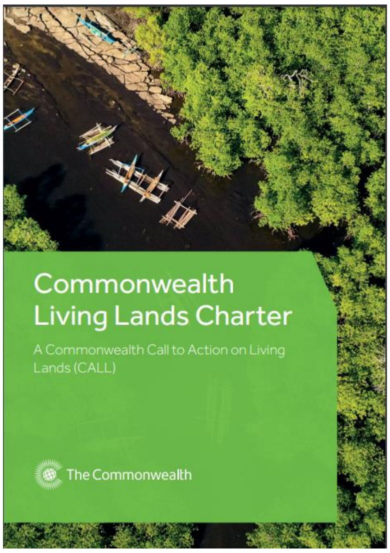
[1]All 15 CARICOM Member States have accepted the UN Convention on Climate Change (1992), the UNFCCC Kyoto Protocol (1997) and the Paris Declaration (2015) (Anderson, 2021).

[2]All 15 CARICOM member states have accepted the Universal Declaration of Human Rights (1948), the International Covenant on Civil and Political Rights (1966) and the International Covenant on Economic, Social and Cultural Rights (1966); all except Montserrat have accepted the San Salvador Protocol (1988), which focuses on human rights rather than the environment (Anderson, 2021).

[3]Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Saint Lucia, Saint Kitts and Nevis, Saint Vincent and the Grenadines, and Trinidad and Tobago.

- Strengthening global health security;
- Promoting healthy environments;
- Promoting the health of vulnerable groups;
- Transforming lifelong learning for health impact;
- Building a data partnership;
- Creating space for innovation and exchange of knowledge.

Figure 2: The Commonwealth Living Lands Charter: A Commonwealth Call to Action on Living Lands (CALL)



Source: Commonwealth Secretariat (2022).

The Commonwealth Secretariat, as part of its plan for a green recovery after COVID-19, is working to encourage greater use of off-grid clean energy as a more sustainable solution for the cold chains needed to store vital drugs and vaccines (Scotland, 2021). The *Commonwealth Living Lands Charter: A Commonwealth Call to Action on Living Lands (CALL)* (see Figure 2) was officially adopted at the Commonwealth Heads of Government Meeting in Kigali, Rwanda, in June 2022. It is an agreement by all 56 Commonwealth countries to safeguard global land resources; take coordinated action to address climate change, biodiversity loss and land degradation or desertification; and promote climate-resilient and sustainable land management. It is important that national action plans take account of such linkages if land systems are to adapt to climate risks (Commonwealth Secretariat, 2022; Scotland, 2021). By ensuring land systems adaption, agriculture can be protected, thus reducing food insecurity (see Chapter 12, "Agriculture and food safety and security").

Local government associations

Climate change is a huge issue facing local governments. Regional groups are often the first responders to climate disasters and events. The Caribbean Association of Local Government Authorities (CALGA) has members from most of the Caribbean countries. Under initiatives introduced by the Global Covenant of Mayors on Climate Change and/or the Commonwealth Local Government Forum, national members of CALGA are developing plans for climate change; however, these plans do not include health. The Trinidad Association of Local Government Authorities has nearly completed its plan for climate change and believes that the time is now right to incorporate health considerations (R4ACCHC, 2022a).

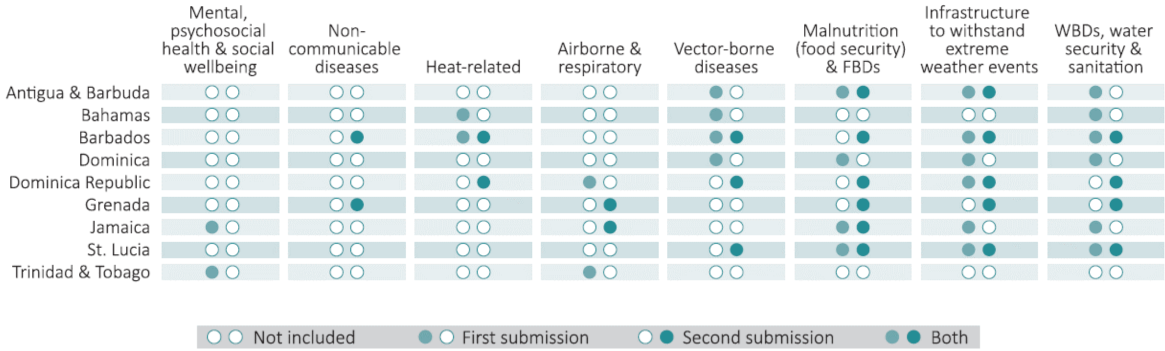
Research

There is very little research on Caribbean governments' work to address health and climate change. Globally, the *Lancet* Countdown on Health and Climate Change monitors government engagement in health and climate change (indicator 5.4). This indicator tracks statements made by national leaders at the United Nations General Debate (UNGD) and the United Nations General Assembly and mentions of health and climate change in nationally determined contributions (NDCs).[4] According to a 2022 report, the proportion of UN member

[4]The Paris Agreement requests that each signatory country outlines and communicate its post-2020 climate action plans. These are known as nationally determined contributions (NDCs). NDCs are key to the Paris Agreement to keep global warming to well below 2 °C. They set out each country's climate action plan to reduce emissions and adapt to climate impacts. Each country decides its own NDC and communicates it to the UNFCCC every 5 years. NDCs typically include energy, agriculture, forestry, transport, industry, and water. NDCs help to realise many benefits, e.g. economic, health, social justice, and biodiversity. NDCs contain targets, policies, and resources needed, e.g. financing, technology, capacity building. Collectively, these climate actions will determine whether or not the world achieves the long-term goals of the Paris Agreement (UNFCC, n.d.).

countries referring to the association between health and climate change had increased from 47% in 2020 to 60% in 2021. Among SIDS, 76% discussed the association between health and climate change in the 2021 UNGD (Romanello et al., 2022). Nine Caribbean SIDS made reference to health in their first or second NDC, with a focus on the health impacts of climate change and the urgent need for health adaptation (see Figure 3).

Figure 3: *Lancet* Countdown Indicator 5.4.2. Engagement in climate and health in NDCs, according to mention of health in a country's first and second NDC submissions



Source: Parker et al. (2022).

18.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Build awareness of climate change impacts on health among policymakers

Policymakers are generally aware of climate change issues, but few appreciate the linkages with health. Therefore, further advocacy and awareness building is needed (Allen et al., 2021; R4ACCHC, 2023b):

> For me, the most serious problem, I don't think the leaders appreciate the health impact. So, for me the bigger problem is the awareness of the health impact. I think they're aware of climate change, and I think they're aware of it from all the extreme events that we've had and the repercussions from that. But – there's not enough data either – but there's not a full appreciation of the linkages between climate and health.
>
> Interviewee from Caribbean Institute for Health Research, University of the West Indies, in Allen et al. (2021)

Awareness can be raised by nongovernmental organisations (NGOs) or professional bodies such as the Caribbean Alliance of National Psychological Associations (CANPA). Awareness-raising can also be taken a step further, to allow policymakers to understand how communities cope with the impacts of disasters. Since Hurricane Dorian affected the Bahamas (2019), CANPA has been discussing the possibility of assisting political leaders to build their knowledge concerning how members of their community can balance health goals with other needs during such crises (R4ACCHC, 2022b). In Guyana, a bottom-up approach is apparent, with healthcare workers and communities advocating for change (R4ACCHC, 2023b).

Data must be packaged in a way that enable them to be understood by policymakers, for instance in policy briefs, targeted specifically at policymakers, using language and infographics that speak to the "head, heart and pocket", as was done with HIV and noncommunicable diseases (R4ACCHC, 2023b). In the case of climate change, such policy briefs should include data demonstrating the impact of climate change and related disasters on the population's health, health systems and other sectors that affect health. Examples of information that would be helpful to include are economic costs to the government from damage to infrastructure including healthcare facilities and agricultural infrastructure, and labour productivity lost through death and illness (R4ACCHC, 2022c,d).

Structural/governmental and private sector actions

Given the complexity of climate change and health interactions and the limited resources available in Caribbean SIDS, government collaboration with other sectors is critical. There is also a need for collaboration across ministries in an "all of government" approach. General issues of collaboration are considered in Chapter 10, "Collaboration between agencies".

Establish public–private partnerships

The private sector can be a key player in climate change and health given its economic and social influence on determinants of health. Private–public partnerships can be formed between government and private providers of health insurance (Tewari, 2021), transportation, energy (Faria, 2021) and telecommunications services, as well other businesses, for example in the hotel and tourism industry (Madden-Greig, 2021). Private sector funding is important for the implementation of mitigation and adaptation strategies. For example, the Republic Bank has pledged USD 200 million in finance to governments and businesses for the development of climate-friendly products and services (R4ACCHC, 2022e).

Enhance government support for civil society climate and health projects

Civil society organisations (CSOs) play an important role as champions of the environment by being catalysts for development and betterment, and by fostering cooperation among key players in an effort to achieve equitable, sustainable and inclusive development goals. CSOs have the potential to negotiate and persuade all institutions and stakeholders to be more sensitive to citizens' and environmental needs and rights, thus making them valuable watchdogs and caretakers. CSOs are often first responders to emergencies and community needs. Government needs to support civil society and CSOs. It is recommended that governments:

- Build capacity among CSOs to implement programmes and support community needs (R4ACCHC, 2023b).
- Review and improve access by CSOs to funding, grants and subventions, removing red tape.
- Make more effort to ensure that community and outreach components of state policies are met.
- Create civil society and NGO-driven policies that take a bottom-up approach to address environmental and community issues and ensure that the responsibility for care of the environment is shared (Jaramogi, 2021).

The Caribbean Climate Justice Project seeks to educate and inform on the threats posed to lives and livelihoods in the Caribbean by climate change and to catalyse action on the necessary responses at the community, national and regional levels; it helps to give voice to the vulnerable populations including children and young adults. The Health Action Group of the Climate Justice Project seeks to draw attention to the health impacts of climate change, and through strategic partnerships with existing organisations, to influence policy changes to ensure that the health profiles of Caribbean citizens are not further damaged by climate change (Caribbean Climate Justice, nd; R4ACCHC, 2022d).

Prioritise policies and projects that provide climate change mitigation actions and health co-benefits

There are many types of initiatives that governments can support to achieve climate change mitigation, with health co-benefits. For example, they should support the development of blue–green infrastructure, increasing water features, plant and tree coverage to reduce heat, air pollution and GHG emissions (Mycoo, 2021; Sarjeant, 2021). Moving from fossil fuel-burning vehicles to hybrid and electric vehicles can mitigate GHG emissions and reduce air pollution (R4ACCHC, 2023c; see also Chapter 5, "Air quality"). Electric cars are now seen more frequently in the Caribbean, but their use could be increased further by offering incentives. Although duties on electric vehicles have been reduced relative to those on nonelectric vehicles, more needs to be done, for example by reducing purchasing costs and increasing the availability of charging ports. Caribbean governments need to provide further support for the use of solar energy and wind power and implement national initiatives that encourage households to be off-grid (R4ACCHC, 2022f). The promotion of active transport and alternative modes of transport such as cycling and walking can be encouraged by better urban planning, such as creating more pavements and cycle lanes with shade provided by trees and covered pathways (Rocke, 2022). New polices and legislation are needed, supported by planning and enforcement (Gordon-Strachan, 2021). Government action to reduce oceanic pollution and to protect coastal zones is also needed (see Chapter 14, "Marine resources and health", and Chapter 15, "Climate-friendly health-promoting infrastructure".

Protect Caribbean people from the health impacts of climate change through a strong and active legislative and enforcement agenda

Caribbean governments must protect the health of their citizens from the impacts of climate change through laws and regulations, supported by increased enforcement capabilities and action. Such laws and regulations must address the environmental and social determinants of health that moderate the health impact of climate drivers. Areas that would benefit from strengthened legislation or enforcement of existing policy include:

- Building codes to improve climate resilience, especially of health and drainage infrastructure;
- Provision of climate-resilient housing to low-income households;
- Prosecution of individuals and companies contributing to land and sea pollution;
- Universal provision of high-quality water and sanitation services (R4ACCHC, 2023d);
- Air quality standards and prosecution of those who infringe them (R4ACCHC, 2023c);
- Food quality standards and support of strategies to maintain them following severe weather events;
- Control of the nutritional quality of imported food products (R4ACCHC, 2023e);
- Environmental and social impact assessments, including community participation, of new infrastructural and industrial projects;
- Strengthening and enforcing equal opportunities legislation, leaving no one behind.

Integrate health into Caribbean legal frameworks addressing climate change and other environmental determinants of health

As shown earlier (see Section 18.1, "What is happening?"), health is generally addressed in only a minor way in international climate change agreements. International treaties on the environment tend to be separate from those on health. Caribbean countries have accepted both types of agreements. Their abilities to legislate on climate and health issues is further strengthened by their ratification of human rights instruments. For instance, all CARICOM governments have ratified the Universal Declaration of Human Rights, the International Covenant on Civil and Political Rights and the International Covenant on Economic, Social and Cultural Rights (Anderson, 2021).

However, there is a deficit in implementation of the international treaties at local level. For treaties to have legal force in most Caribbean countries, they must be transposed into national law. In Caribbean constitutions, there are references to the right to environmental conditions that are not harmful to health. Human rights principles enshrined in Caribbean law can be used to create policy, to protect health security and to encourage community participation (Brathwaite and Mendoza, 2021). To establish a legal framework for integrated climate change and health policies and strategies, the following are recommended (Brathwaite and Mendoza, 2021):

- Integration of health into climate change laws and policies with reference to human rights – this can occur through building of partnerships between CSOs and legal professionals;
- Recognising that climate change adaption and disaster risk reduction laws and policies are a critical element;
- Awareness that, within disaster management, relief efforts must be subject to global and local health standards and documented by the various ministries responsible for health, food and agriculture.

At present, there are few examples of dedicated climate change legislation. An exception is Dominica's Climate Resilience Act 2018. More common are frameworks of regulations, such as Antigua and Barbuda's Environment and Natural Resources Management Act 2019. These are important in regulating action on environmental determinants of health but should be supplemented by legislation that explicitly addresses impacts on health. A further useful approach is to refer to an international treaty within a piece of national legislation, noting that the national legislation accords with the stipulations of the treaty. This approach has been adopted in the Environmental Protection Act in Saint Kitts and Nevis (Anderson, 2021).

The Caribbean Public Health Forum, established in 2021, provides a further promising avenue for legislative development. It brings together Caribbean public health professionals and law professionals from the ministries of health and ministries of legal affairs in nine CARICOM Member States and five CARICOM Associate Member States. Its purpose is to consider the effective use of law to consider shared Caribbean public health concerns (Anderson, 2021).

Develop a data-sharing agreement between countries and across regional agencies

Caribbean governments need to collaborate with each other in establishing data-sharing agreements and protocols, so that each country can build on the knowledge and experiences of other countries (R4ACCHC, 2022d). Regional solidarity is very important, given the small size of SIDS and other challenges that limit their research and surveillance capacities (see Chapter 11, "Research and surveillance on climate change and health").

Advocate for changes to international climate change and health indicators to make them more relevant to Caribbean Small Island Developing States

International indicators for measuring climate change and health developments may not be beneficial or helpful to the SIDS in the Caribbean Sea, the Pacific, Atlantic and Indian Oceans and the Mediterranean and South China Seas. The Caribbean SIDS and other SIDS need to develop indicators appropriate to their contexts (R4ACCHC, 2023f). For example, it has been strongly suggested, by Caribbean regional climate and health agency representatives, that *Lancet* Countdown indicator 5.4 be expanded to include additional measures of government engagement, such as investments and budget allocations, policy and position papers and implementation of National Adaptation Plans. Governments can advocate for these changes (Allen et al., 2021; see also Chapter 10, "Collaboration between agencies").

Research gaps and how to address them

Identify best practices in developing and implementing national strategies on climate change and health

The Caribbean Action Plan on Health and Climate Change has as one of its national-level actions the preparation of health systems vulnerability and adaptation assessments and H-NAPs. Research is needed to determine how such measures can best be implemented, enabling governments to develop a culture around promoting evidence-based policies is key to ensuring that such research is conducted (R4ACCHC, 2023f). Some questions may include (Hassan, 2021):

- How do we ensure that evidence-based policies are implemented as intended?
- How do we evaluate the impact of policies on both climate and health?
- How do we hold institutions accountable for their performance in implementing the agenda?
- How do we develop a regional roadmap to raise awareness among the public in the Caribbean?

Conduct studies to ascertain how equity should be integrated into the national climate change and health agenda

The differential impact of climate change can worsen health disparities between different communities. Some questions may include:

- What is the status of policymakers' knowledge, attitudes and practice (KAP) in the area of climate and health equity? How do these influence their decisions on the allocation of resources? Policymakers should include not only responsible ministers, but also permanent secretaries and chief medical officers in the ministries responsible for health and the environment. Other relevant personnel in ministries responsible for the wider determinants of health, for example urban planning, infrastructure, transport and agriculture, should also be included in KAP studies (R4ACCHC, 2023b).
- How do governments fully engage frontline communities/groups in the process of developing, implementing, monitoring and sustaining policies to mitigate climate change and to adapt to its effects on health?

- How do governments work in an equitable and respectful way with indigenous populations, whose health and livelihoods are often more adversely affected by climate change than those of any other group?
- How do governments integrate climate and health equity into all its entities including agriculture?
- How do governments integrate climate and health equity into safe, resilient and equitable housing solutions?
- How important is updating legislative instruments in healthcare and climate change with mechanisms in governance to support linkages in healthcare and climate change adaptation, including equity concerns (Hassan, 2021)?

Determine the effectiveness of actions at the individual, community, structural/government and private sector

It is necessary to evaluate any actions to ensure effectiveness. These may be process, impact, cost–benefit and/or cost-effectiveness evaluations. Determining the barriers to and facilitators of implementation of a suggested action would also be helpful in determining the limitation and challenges and recommendations for the way forward. Research questions could include:

- What new literature has been developed to inform policymakers? How effective have these communication materials been?
- What have been the changes in policymakers' knowledge about health impacts of climate change?
- What support (e.g. financial, technical) have governments given to climate change and health-focused CSOs/NGOs?
- How many new policies relating to climate change mitigation actions and health co-benefits have the government implemented? What has been their effectiveness?
- Has health been integrated into climate change and disaster risk reduction laws and policies, at both national and regional levels?
- What is the process to develop data-sharing agreements between countries and across regional agencies?
- Has there been any change in indicators used to measure government engagement at the international level?

Surveillance gaps and how to address them

Monitor public statements of regional and national leaders for content pertaining to climate and health

It is important to listen to what leaders are saying and study how this might be used to address the challenges and to support resource mobilisation. Following severe weather events and at other key moments, it would be helpful to monitor the public statements of regional and national leaders (CARPHA, 2018; R4ACCHC, 2023b). These can include statements of policy and intent in regional meetings (e.g. CARICOM); media briefings and statements; political manifestos; statements at community meetings; and policy and position papers (Allen et al., 2021). Such statements can be used as measurements of implementation of international and regional commitments. Interministerial, interagency collaborative mechanisms and engagement with climate and health scientists and use of science in decision-making could also be monitored.

Monitor government adherence to the implementation of action plans and frameworks

By examining government climate change and health-related investments and budget allocations, policy and position papers and implementation of National Adaptation Plans, government adherence to implementation of regional and national action plans and frameworks can be ascertained. To ensure accountability, this monitoring can be conducted by regional academic institutions (R4ACCHC, 2023b). Government involvement in environmental resource management should be monitored (Allen et al., 2021; R4ACCHC, 2023b).

Research and surveillance capacity-strengthening needs

To address the research and surveillance needs to ensure government engagement, capacity must be built in implementation science and implementation research, impact evaluation and qualitative and mixed-methods research, as well as in advanced statistical methodologies. The following additional specialist expertise is required:

- Strategic planning including logframes;
- Public policy;
- Development of legislation.

There is also a need for enhanced information technology infrastructure and expertise, along with surveillance expertise, to build the databases needed for sharing of information. Statisticians and communications specialists with writing skills are needed to make technical reports accessible to decision-makers.

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