

Research for Action Agenda on Climate Change and Health in the Caribbean

PAHO Pan American Health Organization World Health Organization Americas Region

BlueSky Development Consulting

Yale SCHOOL OF PUBLIC HEALTH
Center on Climate Change and Health

EarthMedic EarthNurse

EMORY ROLLINS SCHOOL OF PUBLIC HEALTH

THE UNIVERSITY OF THE WEST INDIES MONA CAMPUS

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Washington, D.C., 2026

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Cover photograph: © PAHO. Vector Control officer conducting entomological surveillance to identify and quantify mosquito breeding sites; eliminating such sites reduces the transmission of mosquito-borne diseases like dengue, which are increasing due to climate change.

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Preface

Climate change poses an existential threat to public health in the Caribbean, particularly for small island developing states (SIDS). Increasingly frequent and intense climate hazards – including hurricanes, flooding, drought, extreme heat, and sea level rise – are already undermining health through direct injury and mortality, disruption of health services, food and water insecurity, population displacement, changes in vector-borne illnesses, and worsening outcomes for noncommunicable diseases.

These impacts are amplified by structural features of Caribbean SIDS, such as small and overstretched workforces, economic fragility, geographical isolation, and the concentration of populations and critical infrastructure in coastal zones. Addressing climate change and health (CC&H) is therefore a central public health priority for the region, requiring coordinated and evidence-informed action. The *Research for Action Agenda on Climate Change and Health in the Caribbean* report offers guidance on strategies for strengthening the response to climate change based on a regional consultation process, which identified 18 priority areas for action, and a review of Caribbean evidence on each of the priority areas.

This work advances the literature by providing the most comprehensive, regionally grounded synthesis of CC&H evidence to date and by translating that evidence into clear, cross-cutting recommendations for policy, practice, and research. It was undertaken to support timely, actionable, and Caribbean-led responses to CC&H as part of a growing recognition of climate change as the defining health challenge of this century. The development of this Research for Action Agenda reflects alignment with national, regional, and global public health commitments, including the Sustainable Development Goals and the Pan American Health Organization's mandate to strengthen health systems, reduce inequities, and promote resilience in the face of climate threats.

Communiqués from Caribbean Community (CARICOM) Heads of Government show that climate change is a top regional priority. However, despite strong political advocacy and leadership on CC&H from Caribbean governments, civil society, and academic institutions, progress in translating commitments into effective action has been hindered by siloed operations and critical gaps in data, research, funding, and surveillance tailored to the Caribbean context. This report responds to an urgent need to consolidate existing evidence, identify priority research and action areas, and provide practical guidance to accelerate implementation.

The *Research for Action Agenda on Climate Change and Health in the Caribbean* was developed through a rigorous, participatory, and multidisciplinary process. The Agenda was created through a collaborative effort involving representatives from civil society, academic institutions, and multilateral organizations across the Caribbean and North America. In 2021, this collaboration convened a virtual Conference on Climate Change and Health in Small Island Developing States, with a focus on the Caribbean.

The Conference received support from over 25 regional and international organizations and brought together over 150 speakers and over 600 participants representing 80 countries.

Development of the Agenda involved identifying priority research domains, reviewing and synthesizing relevant scientific evidence and conference contributions, and engaging in structured consultations with government officials, technical experts, and other stakeholders. The successful publication of the Agenda exemplifies the power of equitable collaboration between vested institutions with a shared urgency in the face of limited resources to conduct the work. This publication offers an abridged version of the much longer full Agenda, with the goal of making these important findings more accessible to policymakers, advocates, health professionals, civil society organizations, researchers, and the general public.

The findings demonstrate that climate change is already exerting ubiquitous, unrelenting, and unequal impacts on health in the Caribbean. Research gaps are particularly pronounced in areas of equity, implementation effectiveness, and health co-benefits of mitigation strategies. Recommendations for action are outlined to guide multisectoral and community collaboration to overcome CC&H challenges. By articulating a shared agenda for action, this report aims to support governments, nongovernmental organizations, health professionals, advocates, communities, researchers, and partners in accelerating evidence-informed solutions that protect health, advance climate justice, and promote resilient and sustainable development in the Caribbean.



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Acknowledgments

The *Research for Action Agenda on Climate Change and Health in the Caribbean* arose from a commitment by Caribbean citizens, health professionals, and researchers to address the profound threats to regional health posed by climate change. It was developed by a group comprising civil society, academic, and multilateral agency representatives from the Caribbean and North America. In 2021, the group organized the online Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean, which was supported by more than 25 regional and international organizations and attended by 162 presenters and 642 participants from 80 countries. This Agenda was formulated by prioritizing research areas, synthesizing evidence from conference presentations, scientific research, and surveillance, and holding consultations with government and other stakeholders and experts.

The agenda presented in this publication is a summarized and updated version of the document *Research for Action on Climate Change and Health in the Caribbean: A public, private, people's and planetary agenda*,[1] by the following members of the group: Caroline F. Allen and Renee M. West, Blue Sky Development Consulting; Georgiana Gordon-Strachan and Shelly McFarlane, Caribbean Institute for Health Research, The University of the West Indies; Saria Hassan, Rollins School of Public Health, Emory University; Karen Polson-Edwards and Audreyanna Thomas, Pan American Health Organization; C. James Hospedales, EarthMedic and EarthNurse Foundation for Planetary Health; Robert Dubrow, Yale Center on Climate Change and Health, Yale School of Public Health.

Dr. Hospedales, Professor Dubrow, and Dr. Hassan chaired the Committee that developed the Agenda. Financial support was provided by the U.S. National Oceanic and Atmospheric Administration and the Pan American Health Organization. The current version was written by Caroline F. Allen, Robert Dubrow, C. James Hospedales, and Saria Hassan. Sincere thanks are due to all participants in the conference and consultations and the agencies that supported the development of the Agenda.

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[1] Allen CF, West RM, Gordon-Strachan G, Hassan S, McFarlane S, Polson-Edwards K, et al. Research for Action on Climate Change and Health in the Caribbean: A Public, Private, People's and Planetary Agenda. [place unknown]: Research for Action on Climate Change and Health in the Caribbean Project; 2024. Available from: https://earthmedic.com/research-for-action-on-climate-change-and-health-in-the-caribbean/.

Abbreviations and acronyms

AC	air conditioning
CARICOM	Caribbean Community
CARPHA	Caribbean Public Health Agency
CC&H	climate change and health
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CIMH	Caribbean Institute for Meteorology and Hydrology
COVID-19	coronavirus disease 2019
CRAA	Caribbean Research for Action Agenda
CSO	civil society organization
EWS	early warning system
GHG	greenhouse gas
GIS	geographic information system
H-NAP	Health National Adaptation Plan
HSI	Hospital Safety Index
IWRM	integrated water resource management
KABP	knowledge, attitudes, beliefs, and practices
mhGAP	Mental Health Gap Action Programme
NCD	noncommunicable disease
NDC	Nationally Determined Contribution
NGO	nongovernmental organization
PAHO	Pan American Health Organization
PLWNCDs	people living with noncommunicable diseases
PM10	particulate matter, equal to or less than 10 μm in diameter
PM2.5	particulate matter, equal to or less than 2.5 μm in diameter
R4ACCHC	Research for Action on Climate Change and Health in the Caribbean
SDG	Sustainable Development Goal
SIDS	small island developing states
UN	United Nations
UWI	University of the West Indies
VBD	vector-borne disease
WASH	water, sanitation, and hygiene
WHO	World Health Organization

Executive summary

Caribbean small island developing states (SIDS) face climate change hazards, including flooding, drought, increased hurricane intensity, extreme heat, and sea level rise. The health of Caribbean people is threatened directly by these hazards, and indirectly by features of SIDS that affect health systems' capacities to respond, including the small human resource base, economic fragility, and concentration of populations and infrastructure near coastlines. This report offers guidance on strategies for strengthening the response to climate change and health (CC&H) challenges, based on:

1. A regional consultation process, which identified 18 priority areas for action in four domains (Box ES1); and
2. Review of Caribbean evidence on each of the priority areas *(1, 2)*.

This *Research for Action Agenda on Climate Change and Health in the Caribbean* report includes chapters on each priority area showing what is happening, what should be done, and what needs to be known in order to achieve climate-resilient health systems.

It is an abridged and updated version of the 2024 report, *Research for Action on Climate Change and Health in the Caribbean: A public, private, people's and planetary agenda (1)*.

This new version is being published to make the findings and recommendations of the unabridged version more accessible to policymakers, advocates, the general public, health professionals, civil society organizations, and researchers. In addition, CC&H is a rapidly evolving field, and this updated version incorporates developments in CC&H in the Caribbean since the writing of the unabridged report.

The *Research for Action Agenda on Climate Change and Health in the Caribbean* shows that Caribbean government, civil society, and academic leaders are at the forefront in advocating for action on CC&H globally. However, there are difficulties in translating commitments into action, partly due to gaps in data for action. Progress can be much faster if these gaps in Caribbean CC&H research and surveillance are addressed.

BOX ES1

Eighteen priority areas for action on CC&H in the Caribbean

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
5. Air quality
6. Heat-related illness
7. Mental health
8. Population displacement and migration
9. Distribution, equity, and justice

DOMAIN 2

Adaptation, planning, and resilience for health

10. Collaboration between agencies
11. Research and surveillance
12. Agriculture and food security and safety
13. Awareness and skills-building

DOMAIN 3

Mitigation action 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 action

17. Funding streams
18. Government engagement

How the Agenda was developed

The *Research for Action Agenda on Climate Change and Health in the Caribbean* arose from a commitment by Caribbean citizens, health professionals, and researchers to address the profound threats to regional health posed by climate change. It was developed by a group comprising civil society, academic, and multilateral agency representatives from the Caribbean and North America. In 2021, the group organized the online Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean, which was supported by more than 25 regional and international organizations and attended by 162 presenters and 642 participants from 80 countries. The Agenda was then formulated by prioritizing research areas, synthesizing evidence from scientific literature and conference presentations, and holding consultations with government and other stakeholders and experts. Further details of the methodology are provided in the introduction to this report and in a peer-reviewed journal article *(2)*.

Summary of findings from research and surveillance on CC&H in the Caribbean

Health impacts

Vector-borne disease (VBD) studies (see Chapter 2) examine how dengue is associated with climate variability; socioeconomic vulnerability to dengue; people's knowledge, attitudes, beliefs, and practices (KABP); future scenarios; and adaptation strategies. Recent work has focused on predicting outbreaks and developing early warning systems (EWSs).

CC&H studies of noncommunicable diseases (NCDs) (see Chapter 4) and mental health (see Chapter 7) in the Caribbean have mostly examined how these conditions have been affected by hurricanes, showing that, in the months following hurricanes, NCD mortality greatly exceeds immediate deaths due to the event and that adverse mental health consequences are persistent and debilitating. A growing number of studies of health impacts of extreme weather events (see Chapter 1) highlight the importance of building community and health systems resilience to reduce risk of negative health outcomes.

Exposures

Health outcomes of climate-related changes in heat; air quality; and water, sanitation, and hygiene (WASH) (see Chapters 6, 5, and 3, respectively) are emerging areas of research. Air quality studies have focused on Saharan dust and sargassum seaweed emissions. Recent modeling by the Lancet Countdown showed likely impacts of heat and other environmental determinants on health outcomes and vulnerable populations.

Vulnerabilities

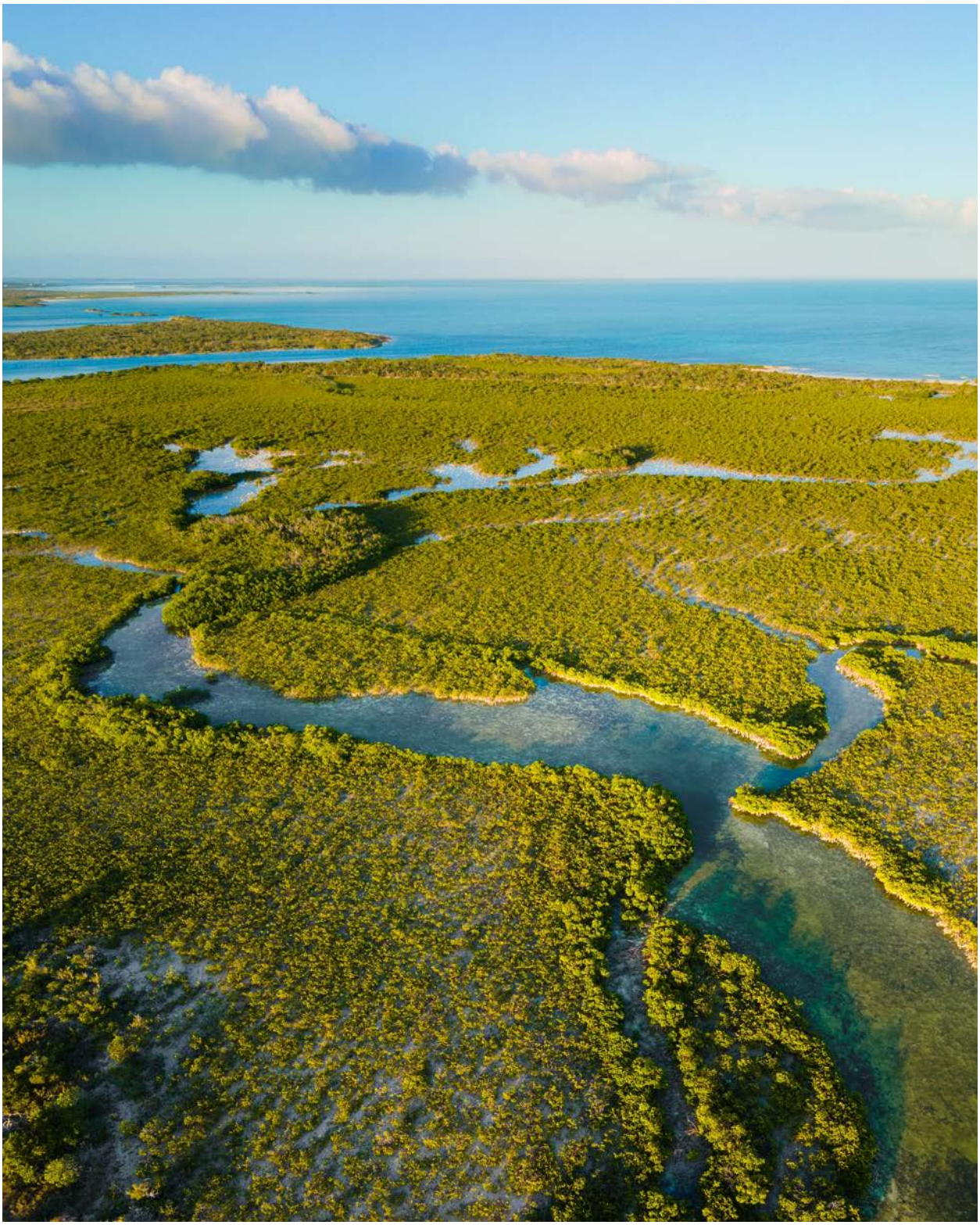
Caribbean studies on climate migration have examined impacts on livelihoods and mental health (see Chapter 8). Other empirical studies of populations vulnerable to climate change have focused on people with NCDs, with very few studies on socially and economically disadvantaged populations. Evidence to inform distribution, equity, and justice in CC&H is lacking (see Chapter 9).

This is a resource document for Caribbean climate change and health action by public and private entities and civil society, building on existing initiatives and enabling integrated, strengthened, and effective national systems.

Adaptation, planning, and resilience for health

Collaboration between agencies on CC&H (see Chapter 10) needs to be assessed by empirical, scientific research or monitoring in the Caribbean. There have been analyses of the integration of NCDs and mental health in disaster preparedness and response, but little original research demonstrating health outcomes. Joint policy responses and partnerships have been analyzed and methods for collaboration suggested.

Research and surveillance are critical to effective CC&H adaptation, mitigation, resource allocation, and policy, but there are many gaps in subject coverage and the availability of human, technical, and financial resources to conduct them. Challenges include lack of integration of health and meteorological data; paucity of data-sharing practices and multidisciplinary, collaborative, national and regional approaches; low rates of submission of research to peer-reviewed journals; and lack of monitoring, evaluation, and cost-effectiveness studies of initiatives and policies (see Chapter 11).



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Agricultural research has explored climate effects on food security and safety. Some reports suggest climate-smart agriculture strategies, but their potential health benefits have not been examined (see Chapter 12).

There is a growing body of research on awareness- and skills-building (see Chapter 13). This includes KABP studies of health professionals and studies of climate change training availability for health professionals. Welcome developments include studies evaluating capacity-building for health professionals and determining the effectiveness of media and communications.

Mitigation action and health co-benefits

Caribbean research has focused on climate change mitigation and other ecosystem services provided by the marine environment, the damaging marine effects of climate change, and marine policymaking (see Chapter 14). However, there is very little primary research demonstrating health impacts of oceanic changes, and none was identified examining the health benefits of marine interventions.

Health co-benefits of developing green, resilient infrastructure in the Caribbean have been presented, but empirical research showing impact on health outcomes is lacking (see Chapter 15). An exception is the work on smart health facilities (see Chapter 16).

Resources and engagement for action

There are studies of climate finance relevant to the Caribbean, highlighting huge funding gaps and innovative Caribbean initiatives to address them. However, studies showing health impact of funding are unavailable (see Chapter 17).

Regarding government engagement (see Chapter 18), there are a few studies on health content in Caribbean leaders' statements and policy documents on climate change, showing lack of health integration into planning processes. Other information on government engagement is from government, regional, and technical agency documents, and commentary pieces.

Recommendations for action and applied research

Cross-cutting themes and recommendations emerge from the analyses of the existing evidence across the 18 priority areas, to strengthen health system, societal, and political responses and thus build CC&H resilience in this highly vulnerable region.



Empower and involve people and communities in the CC&H response

It is critical to empower individuals and communities, and civil society organizations that represent them, with knowledge and skills on CC&H, and to involve them in decision-making. This is because:

- They are on the front lines, and their familiarity and experiences with their environments offer critical knowledge in areas such as water resource management, pollution reduction, and vector control, increasing the appropriateness and effectiveness of CC&H responses.
- Their constructive engagement in action to address CC&H, such as research and local food production, enhances adaptation and mitigation, and has co-benefits for their mental and physical health.

- Meaningful involvement of vulnerable populations in CC&H decision-making is essential for human rights protection.
- People with medical conditions, such as NCDs, can advise on strategies to protect and maintain their health in the face of climate change.

Adapting communications and engagement strategies to each community is key to their effective involvement.



Provide leadership for coordinated CC&H action

- Ensure that the health sector is integrated into climate change decision-making and that health policies address climate change, bringing together stakeholders across ministries and service delivery entities.
- Establish CC&H collaborative mechanisms between international, regional, national, and local government entities.
- Establish data-sharing mechanisms to build collective knowledge and joint strategies.



Collaborate across disciplines, sectors, and agencies to address CC&H

- Involve meteorological, environmental, and health experts; public, private, civil society, and academic representatives; and government officials responsible for health-determining sectors in initiatives to address CC&H challenges.
- Ensure collaboration within and between the health agencies and agencies responsible for health-determining sectors, including education; disaster preparedness and response; climate finance; food and water security; population displacement and migration; environmental regulation and enforcement including pollution and air quality; infrastructure, building regulations, public works, and utilities; transportation; management of the energy transition; marine and coastal resources; and research (to build evidence-based strategies). Strategies include joint meetings, training, funding joint work, and mandating collaboration.
- Build CC&H knowledge and skills in these agencies and among their workforces.



Advocate for and work toward justice in CC&H

- Continue international advocacy to increase resources for Caribbean adaptation, mitigation, damage, and loss, from the highly industrialized countries that have far greater responsibility for greenhouse gas (GHG) emissions than Caribbean SIDS.
- Continue to pursue reforms in international climate finance to enable resources to be provided on a scale that can make a substantial difference to the CC&H resilience of the region.
- In the Caribbean, address natural resource exploitation and inadequate social determinants of health (e.g., education and housing) that put the health of vulnerable populations disproportionately at risk (e.g., people on low incomes, Indigenous people, young people, older adults, displaced people, people with disabilities, and women).
- Protect all citizens, regardless of social standing, through laws, regulations in areas such as climate-resilient building codes, pollution controls, water and sanitation services, air and food quality standards, protection of land and ocean biodiversity, environmental impact assessments, and equal opportunities for all.



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- Establish and support community participation mechanisms for social and gender equity in CC&H-related policymaking.
- Strengthen research and surveillance on socioeconomic and demographic risk factors, with a focus on vulnerable groups, to enable policies and interventions that promote justice.

Empower the workforce to address CC&H

- Build health professionals' capacities to recognize, prevent, and treat physical and mental health conditions impacted by climate change hazards.
- Integrate CC&H into the curricula of health professional training institutions.
- Enhance policymakers' and government officers' knowledge and skills in evidence-based CC&H adaptation and mitigation measures.
- Strengthen information for action through communications, meteorology, and statistics training.
- Include responsibilities for addressing CC&H in job descriptions.
- Provide workers with equipment, supplies, climate-resilient facilities, and psychosocial support to address CC&H.

Increase CC&H education, awareness, and evidence-sharing

- Increase education on CC&H for the public and policymakers.
- Raise awareness and engage people from different segments of society using strategic communication methods and media partnerships.

- Enhance understanding by using real-world health scenarios and human-interest stories.
- Improve science communication with specific audiences through community participation, direct engagement, traditional media, and social media using culturally appropriate methods.
- Develop early warning systems for the public that include likely health consequences of climate change events such as flooding, along with advice on protective measures.
- Increase publication rates of Caribbean research to elevate the region's profile in global CC&H policymaking.



Enhance resources for CC&H action

- Support justice in the allocation of climate finance, as indicated above.
- Develop and support Caribbean and South–South financial collaborations, as well as civil society and public–private sector partnerships.
- Sustain existing innovations, such as parametric disaster insurance for countries and vulnerable populations.
- Create databases of relevant funding opportunities.
- Provide local, dedicated funds.
- Enhance skills in writing and submitting funding applications.
- Conduct cost-benefit and cost-effectiveness analyses of CC&H action.
- Invest in climate-resilient, environmentally sustainable infrastructure and health facilities.
- Develop fiscal measures to support sustainable investment and deter harmful resource use.
- Cost CC&H measures and include them systematically in national budgets and Nationally Determined Contributions (NDCs).



Make infrastructure and healthcare facilities more climate resilient

- Establish climate-resilient infrastructure to keep people safe during extreme weather events and to protect them from climate change hazards such as rising temperatures and sea levels.
- Build/retrofit and maintain Smart health facilities across the Caribbean (see Chapter 16).
- Strengthen delivery of physical and mental health services in emergency situations, especially to vulnerable communities, including adoption of standard operating procedures for health facilities, transport, and disaster shelters.
- Strengthen disaster response procedures to minimize the time needed to restore critical utilities, WASH infrastructure, and food security.
- Procure effective and cost-efficient medicines, medical products, and technologies to respond to climate-sensitive health conditions and to be available during and after disasters.
- Provide health care sustainably, using renewable energy, minimizing pollution and waste, and using water and other resources efficiently.



Invest in green initiatives with health co-benefits

Physical and mental health can be boosted while reducing pollution, ambient temperatures, and GHG emissions by the following measures.

- Transition from fossil fuels to clean, renewable sources of energy.
- Increase green spaces and water features in urban areas.

- Provide infrastructure for active transport (walking and cycling).
- Employ climate-smart agriculture.
- Reduce, reuse, and recycle waste.
- Harvest rainwater.
- Reduce oceanic and land pollution.
- Protect coastal zones.
- Promote plant-rich diets.



Research adverse health impacts of climate change in the Caribbean context

- Address research gaps on how climate change affects health in the Caribbean (see Domain 1 "Climate change health impacts, exposures, and vulnerability" of this report).
- Develop indicators to quantify health impacts of climate change, inform appropriate and effective action, and monitor changes over time.



Conduct research to find out what works in addressing CC&H challenges

- Strengthen research on adaptation, mitigation, resources, and engagement for action, as detailed in Domains 2, 3, and 4 of this report.
- Research the effectiveness, costs, and benefits of CC&H interventions.
- Document, monitor, and evaluate national and regional CC&H action and policy.
- Study implementation to identify barriers and facilitating factors.
- Investigate how to adapt CC&H practices proven effective globally to the Caribbean context.
- Publish and share Caribbean examples of good and/or promising practices.



Strengthen research and surveillance capacity

- Invest in local CC&H research and surveillance skills-building, personnel, institutions, equipment, technology, projects, and programs to develop appropriate and effective Caribbean solutions to CC&H challenges.
- Integrate climate and health information systems.
- Strengthen health surveillance systems, with a greater focus on CC&H, including greater coverage of climate-sensitive health conditions, morbidity outcomes, and vulnerable groups; more frequent reporting; and more robust quality assurance and quality control procedures.
- Optimize limited research resources by increasing community research skills and involvement.
- Create mechanisms for pan-Caribbean and international collaboration, training, data-sharing, and dissemination of information on research opportunities.
- Produce science communication products and tools (see Chapter 13) for policymakers.
- Provide training in writing grant applications and articles for peer-reviewed publications.
- Increase capacities in epidemiology, meteorology, public health, environmental science, statistics, communications, behavioral science, laboratory science, information technology, geography, implementation science, monitoring, evaluation, and cost-benefit and cost-effectiveness studies.
- Develop multidisciplinary research collaboration and teams, especially between health, environmental, and meteorological experts.



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Conclusion

The *Research for Action Agenda on Climate Change and Health in the Caribbean* is a first-of-its-kind summation of what is known about the impact of climate change on health in the Caribbean, and what needs to be done, focusing on 18 priority areas identified through extensive stakeholder consultation and review. Each priority area was the subject of a separate narrative review, resulting in the most comprehensive compilation of CC&H evidence on the Caribbean to date. The compilation was subjected to analysis based on an ecological model, allowing for understanding of how health impacts, exposures, and vulnerability are affected by action (or lack thereof) to adapt to or mitigate climate change, and how action itself is facilitated or hindered by the financial and policy environment. The analysis highlights individual, community, government, and private sector actions that are needed to advance progress on CC&H in the Caribbean. It also highlights research and surveillance gaps and shows ways they can be addressed to strengthen evidence-based action and make systemic changes to improve climate resilience, health, and societal well-being in the highly vulnerable Caribbean region.

This report is intended to serve as a resource document for CC&H action by public and private entities and civil society, building on

existing initiatives and enabling integrated and strengthened national CC&H systems to drive effective action. Implementation of this Agenda will require multidisciplinary and cross-institutional collaboration that involves fundraising, advocacy, education, research capacity-building, community engagement, and a range of dissemination efforts. The vision is for the *Research for Action Agenda on Climate Change and Health in the Caribbean* to be a collaborative living document placed in the hands of leaders, practitioners, and advocates to further develop action and research to reduce the negative impacts of climate change on health in the Caribbean region and seize the opportunity to promote health and well-being.

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Introduction: Rationale and methodology

People in the Caribbean are experiencing consequences of climate change in their daily lives, including infrastructural, property, and environmental damage wrought by stronger hurricanes and sea level rise *(1, 2)*; higher temperatures and humidity that make it more difficult to exercise and sleep *(3, 4)*; and floods and droughts that strain access to sanitation and threaten food security *(3)*. These changes take place in the context of existing health vulnerabilities, such as high rates of noncommunicable diseases (NCDs) at relatively young ages *(5–7)*; environmental conditions favoring the reproduction of disease vectors such as mosquitoes *(6)*; socioeconomic inequalities *(8)*; and health system resource constraints commonly affecting small island developing states (SIDS) *(9)*. The interaction of climate change with existing health and social conditions is threatening physical and mental health, with major implications for human development.

In 2018, the Third Global Conference on Health and Climate Change: Special Focus on SIDS, a World Health Organization (WHO) initiative, helped draw global attention to the vulnerabilities of SIDS *(10)* and indicated the need to strengthen evidence to understand the impacts of climate change on health, prepare health systems, and build the health argument for investment in climate change adaptation and mitigation *(10–12)*. A group comprising representatives from civil society, academia, and multilateral agencies from the Caribbean and North America then formed an alliance to address knowledge and practice gaps related to climate change and health (CC&H) in the Caribbean. They set up the Research for Action on CC&H in the Caribbean (R4ACCHC) initiative, with the following goals:

1. Develop evidence-based recommendations for actionable research and capacity-strengthening to inform multilevel mitigation and adaptation strategies to reduce the adverse effects of climate change on health in the Caribbean SIDS.
2. Engage a broad coalition of civil society, government, and academic stakeholders in developing recommendations to ensure relevance and practicability.
3. Disseminate the resulting Research for Action Agenda widely to raise awareness, elicit funding, and mobilize key partners to implement the agenda.

The current report from the R4ACCHC initiative results from activities to develop evidence-based recommendations on CC&H in the Caribbean (Goal 1), which included a review of scientific evidence and stakeholder engagement (Goal 2). It is a major output of the initiative in support of Goal 3. Through identification of what is already known about CC&H in the Caribbean, this report presents evidence-based recommendations for strengthening action and research. It is an abridged and updated version of a much longer 2024 report from the R4ACCHC team, *Research for Action on Climate Change and Health in the Caribbean: A Public, private, people's and planetary agenda (13)*. By examining key issues, recent trends, and ongoing initiatives, this new, updated report seeks to highlight the urgent need for coordinated action, resilience building, and policy innovation to protect the health and well-being of Caribbean communities from the ravages of climate change.

How the agenda was developed

The process by which the R4ACCHC group developed the 2023 *Research for Action Agenda on Climate Change and Health in the Caribbean* (also known as the Caribbean Research for Action Agenda, or CRAA) is described in detail in a peer-reviewed journal article *(14)*. It had two major components:

1. A regional consultation process, which identified 18 priority areas for action in four domains (see Box 1); and
2. Review of Caribbean evidence on each of the priority areas.

The first stage of the consultation and evidence-gathering process was a groundbreaking four-day, online Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (the Conference), which was held in 2021 and supported by more than 25 regional and international organizations and attended by 162 presenters and 642 participants from 80 countries. Presenters were experts on health, environmental, and policy topics related to CC&H in the Caribbean SIDS. Sessions were recorded and results were used to inform the content of the CRAA.

An organizational framework for synthesizing CC&H evidence was developed by reviewing the themes and subtopics of the Conference, various CC&H conceptual frameworks *(15–17)*, and existing syntheses of CC&H evidence for the Caribbean *(11, 12, 18, 19)*. A modified version of the Lancet Countdown on Health and Climate Change conceptual framework *(15)* was selected, enabling analysis of health impacts, exposures, and vulnerability and how they are affected by the major domains of climate change action (adaptation and mitigation) and by the policy environment (financial resources and government engagement) (Figure 1).

Given the wide range of health outcomes and determinants that may be affected by climate change, it was necessary to identify priority areas for the CRAA. The team first reviewed results of a previous project in which interviews were conducted with key stakeholders in the Caribbean and other SIDS to identify the most relevant areas for monitoring progress in addressing CC&H *(20, 21)*. Presentations from the 2021 Conference and previously published syntheses of Caribbean research and action on CC&H *(12, 18, 19)* were also reviewed. A draft list of priority areas was then discussed in 16 stakeholder dialogue meetings with

FIGURE 1

Organizational framework for analysis of CC&H evidence



Source: Developed by the authors based on the Lancet Countdown on Health and Climate Change conceptual framework. Watts N, Amann M, Arnell N, Ayeb-Karlsson S, Beagley J, Belesova K, et al. The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises. Lancet. 2021;397(10269):129–170. Available from: https://doi.org/10.1016/S0140-6736(20)32290-X.

70 representatives from 14 Caribbean academic, civil society, governmental, private sector, professional, technical, and training organizations. Adjustment of the list based on the consultative review process resulted in the selection of 18 priority areas grouped under four domains, shown in Box 1.

Scientific literature and data sources were reviewed to identify information relevant to Caribbean SIDS for each of the domains and priority areas. An exploratory approach was adopted as the scope of potential climate change impacts on health is wide and this is a relatively new area of research. The narrative review method was used *(22)*, enabling an open-ended, holistic review of literature on each priority

BOX 1

Eighteen priority areas for action on CC&H in the Caribbean

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
5. Air quality
6. Heat-related illness
7. Mental health
8. Population displacement and migration
9. Distribution, equity, and justice

DOMAIN 2

Adaptation, planning, and resilience for health

10. Collaboration between agencies
11. Research and surveillance
12. Agriculture and food security and safety
13. Awareness and skills-building

DOMAIN 3

Mitigation action 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 action

17. Funding streams
18. Government engagement

area. This was appropriate given the need to identify emerging areas of research on the topics, new interpretations, and gaps. The main limitations of narrative reviews are their lack of standardization and that they do not answer specific, highly focused research questions (such as, "What is the impact of rising temperatures on incidence of dengue in Grenada?"). Rather, the method synthesizes evidence from studies with a variety of research questions on a defined topic *(23)*.

Evidence synthesis started by identifying studies on each of the priority areas cited in existing reviews of CC&H in the Caribbean *(11, 12, 18, 19)*. Targeted searches were then conducted on the PubMed database for Caribbean-specific information on CC&H in each of the priority areas *(18)*. Search terms included "Caribbean," "climate change," and the titles or derivatives of the titles of each of the priority areas. For example, for the priority area, "vulnerability to vector-borne diseases," the term "vector-borne disease" was used. Further searches were conducted using "Caribbean" with priority area titles or their derivatives and environmental determinants of health associated with climate change, such as "flood" and "extreme heat." There was also a review conducted of the content of the 2021 Conference presentations, as well as of information from reputable technical agencies (e.g., Caribbean regional and United Nations agencies) via their websites or by contacting technical officers. Results from the global literature were used to infer likely effects of climate change on health in the Caribbean on topics where there were gaps in Caribbean literature.

For each priority area, available evidence was analyzed to identify the scope, findings, and limitations of existing research and surveillance in the Caribbean. This analysis is presented in the "What is happening?" section of each chapter of the unabridged report. From the evidence, recommendations for action, including for research and surveillance, were derived and are presented in the "What should be done?" section of each chapter. However, in the current abridged version of the report, recommendations for research and surveillance are separated from recommendations for other actions and are presented in the "What do we need to know?" section of each chapter.

Drafts of priority area chapters for the unabridged report were reviewed by Caribbean-based experts in relevant fields of CC&H. After incorporation of their comments, an online workshop was held in May 2023, at which 78 experts, policymakers, and civil society advocates provided feedback on the findings in breakout rooms on individual chapters. The feedback was incorporated into the 2024 unabridged CRAA *(13)*.

Following the development of the unabridged version, cross-cutting themes arising from the findings were identified and published in a peer-reviewed journal article. These themes were used to refine the recommendations for presentation in the current abridged report. For simplicity, in the current report some recommendations from the unabridged version were merged based on conceptual similarity. The overall recommendations presented in the executive summary of the current report were derived by listing the recommendations for each priority area and identifying how they can be grouped

across priority areas as recommendations for overall CC&H action and research.

The current report draws on international literature on CC&H to provide context and understanding of the issues but focuses on evidence from the Caribbean. The references in each chapter are therefore predominantly sources of evidence about the Caribbean. Further references to international literature are provided in the respective chapters of the unabridged CRAA *(13)*. The current, shorter version provides additional, new Caribbean references.

This new, updated, abridged version of the CRAA is being published to make the findings and recommendations of the unabridged version more accessible to policymakers, advocates, the general public, health professionals, civil society organizations (CSOs), and researchers. In addition, CC&H is a rapidly evolving field, and this updated version incorporates developments in CC&H in the Caribbean since the writing of the unabridged CRAA.

The authors envision the CRAA to be a living document, the implementation of which will require multidisciplinary and cross-institutional collaboration that involves fundraising, advocacy, education, research capacity-building, community engagement, and a range of dissemination efforts. The authors urge the Caribbean SIDS community to use the evidence and recommendations presented here to build on and reinforce existing CC&H activities and to develop new initiatives to reduce the adverse impacts of climate change on the health of current and future generations.



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DOMAIN 1

Climate change health impacts, exposures, and vulnerability

1. Health impacts of extreme weather events

What is happening?

Occurrences of unusually severe weather conditions – extreme weather events – are increasingly impacting Caribbean SIDS. They include hurricanes, heavy rainfall, floods, heat waves, droughts, and wildfires. Climate change is affecting their frequency, intensity, and duration, disrupting seasonal patterns, often leading to cascading consequences, such as landslides resulting from heavy downpours following drought, that damage infrastructure, livelihoods, and health. They create complex, interconnected health challenges that extend far beyond immediate physical injuries, affecting entire health systems, economies, and social structures in the region.

Severe weather events in the Caribbean

As consequences of climate change, weather conditions are becoming drier overall, while rainfall episodes are getting heavier *(1)*.
The severity of tropical storms is already at unprecedented levels *(2)*, with faster intensification (meaning less time to prepare), stronger winds (amplifying destruction), more rainfall (bringing greater rain and flood damage), and lasting longer (bringing more destruction). For example, 2017 saw the strongest Atlantic storm on record, Hurricane Irma *(3)* (Figure 2), and the devastation of Dominica and Puerto Rico by Hurricane Maria *(4–6)*. Hurricanes are increasingly destructive due to storm surges from sea level rise and loss of natural barriers such as coral reefs and mangroves.

Geographical and topographical features can put people at risk *(6)*. Mountainous Dominica experienced widespread destruction from Hurricane Maria's torrential downpours cascading down mountainsides *(4)*. Flood-prone plains exist in countries like Trinidad and Tobago. Low-lying areas in countries such as The Bahamas and Guyana are vulnerable to storm surges *(7)* (Box 2).

Impacts on health and health systems

Extreme weather events affect health directly and indirectly.

- Forces related to the event, for example from torrents and falling buildings, cause drowning and trauma.
- These forces damage healthcare facilities, equipment, and medical supplies.
- Access to health care is reduced by damage to roads, transport, electricity, water supply, and communications *(8)*.
- Access to healthy food and clean water is reduced by damage to agriculture, sanitation systems, and food supply chains.

FIGURE 2

Category 5 Hurricane Melissa about 50 miles south of Jamaica in 2025



Source: U.S. National Aeronautics and Space Administration Earth Observatory

- Workplaces and sources of livelihood are damaged, causing unemployment and poverty – important social determinants of health.
- Population displacement raises risks of infections, vector-borne diseases (VBDs), mental illness, and gender-based violence.

Caribbean evidence

Estimation of health impact

Researchers have assessed hurricanes' health impacts using before-and-after data, post-event surveys, clinicians' observations, and medical records *(5–7, 9–20)*. For example, a study compared numbers of deaths in Puerto Rico in the three months following Hurricane Maria with the same period the previous year. Numbers were estimated to be 70 times higher than official estimates, which only took account of immediate trauma and drowning. The authors helped explain excess mortality by

BOX 2

Health and other challenges of hurricanes in The Bahamas

"Being an archipelago is challenging, as any of the 30 inhabited islands can be affected. There can be great displacement and injuries, infections, lack of access to medication, anxiety, and depression after hurricanes or other disasters. There is little warning – 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: Dialogue with representatives of the University of the West Indies, School of Clinical Medicine and Research, The Bahamas, for the Agenda for Action on Climate Change and Health in the Caribbean.

also conducting a household survey identifying deaths attributable to decreased access to health care *(5)*. There is relatively little research on health impacts of extreme weather events other than hurricanes *(21–23)*.

Preparedness and response

Studies have examined health and agricultural systems' preparedness, resilience, and response, showing need for disability services, mental health care, vector control, and agricultural capacity-building, and instances of displacement and evacuation arising from systemic weaknesses *(7, 19, 24–34)*. A study with overweight adults found that those with lower hurricane preparedness[1] had more hurricane-related detrimental health impacts and higher odds of developing NCDs compared to others *(35–37)*. Research shows that ecosystem features such as coral reefs, mangroves, and karst soils help prevent negative health outcomes of extreme weather events *(22, 38–40)*.

Extreme weather events create complex health challenges extending far beyond immediate physical injuries, affecting communicable and noncommunicable disease rates as well as entire health systems, economies, and social structures.

What should be done?

Individual and community actions and how to support them



Empower communities with knowledge and skills

Civil society organizations (CSOs) can help build extreme event preparedness and response capacities across society. The following issues should be discussed by experts with CSOs to develop effective community learning and action strategies, including exercises and simulations:

- How to prevent and respond to common health risks from each type of extreme event.
- Local emergency procedures and facilities.
- Emergency mental health and physical first aid.
- Accessible sources of healthy food, medical supplies, equipment, and information in emergencies, especially for people living with disabilities, mental health challenges (see Chapter 7), and NCDs *(31, 33)* (see Chapter 4).
- Building and maintaining climate-resilient homes and community facilities.

CSOs can also assist in designing effective early warning and support systems using various communication methods.

[1] The measure of preparedness had two major components: gaps in information (e.g., about hurricanes, food security) and gaps in resources (e.g., economic resources, alternative energy sources during power cuts).

Government and private sector actions



Integrate health in disaster preparedness and response

Health policymakers, experts, and clinicians should be involved as decision-makers, advisors, and providers in the design and running of disaster preparedness and response mechanisms. Areas for integration include:

- Management and access to care of vulnerable populations, including women, children, older adults, people living with NCDs (PLWNCDs), and people with disabilities *(30)*.
- Strengthening essential medicine and healthy food supply chains, especially for vulnerable populations *(31, 33)*.
- Provision of and training in psychological support.
- Safety, access to care, treatment, and sexual and reproductive health of displaced people *(32)*.



Build workforce capacity

Healthcare training should include risk communication with patients and post-event care (see Chapter 13) *(41)*. Transport, emergency shelter arrangements, psychosocial support, and team-resilience training should be made available to healthcare workers to help them continue their work *(7)*. Agricultural workers should be trained in hurricane preparedness and recovery practices *(26)*.



Develop climate-resilient infrastructure and health facilities

Health facilities and shelters must be built and equipped to be resilient to extreme weather events. Caribbean governments are collaborating with the Pan American Health Organization (PAHO) to build and retrofit health facilities to climate-resilient standards through the Smart Health Facilities initiative (see Chapter 16). Governments should ensure the resilience of public buildings, transport, and utilities, and provide a supportive legislative, regulatory, and fiscal environment for climate-resilient construction (see Chapter 15). They should incorporate nature-based solutions such as the planting and conservation of mangroves to protect coastal zones.

What do we need to know?

Research gaps and how to address them



Research health outcomes of extreme weather events

Research should cover both the direct and indirect health impacts (mortality and morbidity) of the full range of extreme weather events affecting the Caribbean. Current research focuses on hurricanes. Surveillance strengthening is needed to achieve this: see below.



Research preparedness and response

This should cover:

- Preparedness of the general and vulnerable populations in terms of knowledge; preparation of emergency kits and plans; access to medication; food security; savings; and insurance coverage *(35, 36)*.
- Preparedness of the health system in terms of inclusion in decision-making and early warning systems (EWSs); medical and food supply chains; workforce skills coverage; resilience of infrastructure and electronic systems;



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accessibility for people with disabilities; community outreach and case-finding; mental health care; sustainable finance; and insurance *(13, 28, 31–33)*.

- Response analysis, including identification of incidents, challenges, and successes in health care, such as performance of smart health facilities.
- Implementation science approaches to building health and agricultural systems resilient to extreme weather events.

Surveillance gaps and how to address them

Monitor excess deaths, excess morbidity, and population displacement

Time series data should be used to calculate excess deaths that may be attributable to extreme events. Parallel surveys asking people to report household deaths and disruption to medical care can assist in explaining excess deaths. Syndromic surveillance data should be consistently analyzed to identify extreme event-related infections, VBD outbreaks, and other adverse health outcomes. To properly assess the range of impacts of climate change on health, the breadth and completeness of coverage of disease surveillance systems require strengthening.

To improve responses following extreme events, governments should investigate internal displacement patterns and monitor travel patterns and health conditions among the displaced *(24, 32)*, moving beyond counting numbers of people in emergency shelters.

Strengthen early warning systems

EWSs are intended to give communities advance notice of impending hazards; enable the timely activation of preparedness, prevention, and mitigation activities; and reduce harm. Their effectiveness and timely deployment for the full range of extreme event types is critical. Information on health risks and healthcare availability should be included.

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2. Vulnerability to vector-borne diseases

What is happening?

Vectors are living organisms that transmit disease-causing microorganisms between humans or from animals to humans. Climate change is generating environmental conditions favoring vector proliferation and disease transmission. Addressing VBDs involves both environmental and disease management.

Aedes aegypti mosquitoes transmit most VBDs in the Caribbean, including dengue, chikungunya, Zika virus disease, and yellow fever *(1)*. Dengue symptoms include fever, headache, nausea, vomiting, rash, and muscle pain, with hemorrhage risks. Chikungunya causes joint pain and arthritis-related disability. Zika virus infection causes joint pain and is linked to severe birth defects and nervous system damage. Yellow fever virus infection causes fever, severe headache, body aches, vomiting, and weakness, potentially leading to jaundice and organ failure. There is an effective vaccine for yellow fever; recently developed vaccines for dengue require targeted use to avoid potentially serious side effects *(2)*.

Malaria and lymphatic filariasis are endemic in a few Caribbean countries *(1)*, transmitted by *Anopheles* and *Culex* mosquitoes, respectively. Malaria causes fever cycles, organ failure, and impaired consciousness. Lymphatic filariasis causes swelling of limbs and other body parts.

Climate change favors mosquito reproduction through flooding, heavy rainfall, and sea level rise, as still water is needed for larvae development. Extreme weather damages sanitation systems, while droughts increase water storage in containers, creating breeding sites *(3, 4)*. Higher temperatures accelerate larvae development and increase mosquito feeding frequency. *Aedes aegypti* mosquitoes thrive in hot, densely populated Caribbean urban areas where they easily find people to feed from and places to lay their eggs *(4, 5)*. Low-income areas with poor sanitation, and the women, children, older adults, and people with disabilities who spend most time in them, are especially vulnerable to VBDs *(4, 6)*.

Other vectors transmit diseases in some Caribbean countries *(1)*:

- Sandflies spread leishmaniasis, causing skin sores, fever, and organ enlargement. Climate change affects spatial distribution of the vector *(7)*.
- Freshwater snails spread schistosomiasis, causing gastrointestinal symptoms and liver damage. Rising water temperatures and altered precipitation patterns contribute to spread *(8)*.

Caribbean dengue prevalence has increased since the 1980s *(9)*, with record-breaking infection levels in 2024 *(10)*. Major chikungunya and Zika virus disease outbreaks occurred between 2013 and 2016, with 2499 excess deaths in Jamaica in 2014 *(11)*. Zika virus disease brought economic losses through decreased tourism arrivals, worker absenteeism and reduced productivity *(1)*.

Caribbean evidence

Caribbean research on VBDs is substantial compared to other climate change health outcomes *(12, 13)*, dating back to the Trinidad Regional Virus Laboratory, the Caribbean Epidemiology Centre in Trinidad and Tobago, and the U.S. Centers for Disease Control and Prevention Dengue Lab in Puerto Rico. A comprehensive program examined dengue, including climatological risk factors; socioeconomic vulnerabilities; knowledge, attitudes, beliefs, and practices (KABP); predictive modeling; and adaptive strategies *(9)*. Subsequent research has concentrated on VBD risk factors and information services.

VBD risk factors

Studies demonstrate positive relationships between rising temperatures and dengue incidence *(14–20)*. Findings on precipitation and dengue incidence are inconsistent, possibly because both heavy precipitation and water shortages can increase risk *(4, 15, 17–22)*. Geographical risks and expansion in dengue's and chikungunya's geographical range have been identified *(4, 21, 23–25)*. Puerto Rico research found dengue increases associated with rising temperatures, sea level rise, and rainfall *(18)*.



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Caribbean vector-borne disease research has combined meteorological and epidemiological data, spearheading the development of early warning systems and other climate services for health.

VBD information services

Caribbean VBD research has spearheaded the development of information products and communication known as climate services for health. By combining meteorological and epidemiological data, climate predictors of VBD outbreaks have been identified, enabling EWS development *(17, 19, 26–34)*.

What should be done?

Individual and community actions and how to support them



Involve communities in environmental management

Communities should be actively involved in reducing standing water where mosquitoes can breed, including uncovered water drums and containers, other receptacles, plastic litter, discarded tires, solid waste, guttering, cisterns, pipes, building features, and potholes. Proper waste and water management also limits other vectors such as flies, reducing the spread of their associated diseases. Organizing collective, community clean-ups is often more effective than individual messaging *(35)*. All community members should be involved, since *Aedes aegypti* mosquitoes can fly up to 200 meters from their breeding site and transmit disease to anyone within that radius.

Mosquito barrier methods such as insect screens, bed nets, and wearing long-sleeved garments help prevent transmission. Vector control professionals can collaborate with communities to advise them and install technologies to kill mosquitoes and larvae.

Government and private sector actions



Implement One Health and integrated vector management strategies

The One Health approach recognizes that the health of humans, animals, and ecosystems is interconnected and brings together teams of health and environmental specialists, including veterinarians, public health scientists, clinicians, environmental managers, and entomologists. Integrated vector management involves governmental and community action across sectors, making use, based on evidence, of high and low technologies and environmental management, with reduced reliance on toxic insecticides. Lessons learned from implementation include the need for equitable collaboration (see Chapters 9 and 10); skilled human resources in key areas such as vector control and laboratory testing (see Chapter 13); resilient water, sanitation, and hygiene and waste management infrastructure and services (see Chapters 3 and 15); public health regulations on water storage *(27)*; and focus on vulnerable and impoverished communities (see Chapter 9) *(3, 5, 35)*. The latter can be assisted by donation of supplies and equipment, and guidance on storing water safely by modifying containers (Figure 3).



Support health security measures

Health security measures should be supported and implemented, such as yellow fever vaccination for visitors from countries where the disease is endemic, spraying aircraft to prevent mosquito transport,

FIGURE 3

Health promotion banner from the Caribbean Public Health Agency (CARPHA) aimed at preventing the spread of mosquito-borne diseases



Source: CARPHA

and strengthening VBD surveillance. The 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. A Caribbean network of VBD experts (CariVecNet) has been established. Tourism establishments can assist by removing breeding sites and installing barrier methods.

Include VBDs in disaster preparedness and response

Extreme weather events damage sanitation and other infrastructure and disrupt vector control activities. VBD risks must be considered in designing climate-resilient infrastructure and human resource management strategies *(3, 13)* (see Chapters 1, 3, 15, and 16). Surveillance and EWSs are critical to VBD preparedness and response (see below).

What do we need to know?

Research gaps and how to address them

Conduct social, behavioral, and communications research on VBDs

Greater understanding of human roles in VBD risks is needed in order to address them. This involves:

1. **Identification of macro-level determinants.** How political-economic and ecological factors affect VBD risk in the Caribbean must be understood. These include trade, travel, and migration patterns; ecosystem effects on pathogen behavior and human susceptibility; water and land use; human mobility; economic development and urbanization pathways; and the resilience of public health infrastructure *(28)*.
2. **Identification of vulnerable populations.** Research is needed on the distribution of VBD cases by population and geographical area. Associated vulnerability factors should

be identified, such as poor water access, inadequate waste removal, open containers, flooding risk, risk of isolation following extreme events, low income, and history of marginalization. The special needs of women, children, older adults, and people with disabilities and NCDs should be considered through research with them.

3. **Design and evaluation of behavioral and communication interventions.** It is critical to understand barriers to and facilitators of preventive behavior. To inform development of effective communication and behavioral interventions, KABP studies are needed with the general population, policymakers, and health professionals about vectors, breeding practices, disease transmission, and prevention *(36)*. Vulnerable populations should be enabled to explain barriers to prevention and propose solutions. Behavioral theory should be applied to develop interventions *(37)*, which should be tested for effectiveness. Strategies may include environmental activities *(35)*, digital health interventions, and financial incentives. Communications research is needed on optimal ways to communicate VBD information, especially from EWSs, to stakeholders *(31)*.

Surveillance gaps and how to address them



Strengthen VBD information systems

To optimize prevention and control strategies, regional VBD surveillance should be strengthened in the following areas:

1. **Disease and vector mapping.** The distribution of vectors, disease cases, and viral strains must be mapped and monitored *(5, 38)*.
2. **Interoperability of information systems.** Disease, vector, and weather information must be joined up. Digitization and collaboration between agencies are needed *(27, 28, 31)*.
3. **Surveys.** Surveys of VBD seroprevalence, breeding sites, and relevant environmental conditions (e.g., water storage, solid waste management) are needed *(39)*. Communities can be involved in data collection *(40)*.
4. **Outbreak analyses.** Excess mortality and morbidity analyses are needed to identify health impacts of outbreaks *(11, 41)*.
5. **EWSs.** Develop and deploy improved EWSs, using results of research to predict VBD outbreaks. Such research requires high-quality longitudinal data on both climate and nonclimate (e.g., water and land use, human mobility, vector control measures) drivers of VBDs.

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3. Water, sanitation, and hygiene

What is happening?

Water, sanitation, and hygiene (WASH) are essential for health but face mounting challenges from increased temperatures, precipitation extremes, drought, other extreme weather events, and sea level rise associated with climate change. Consequent threats to water availability and quality are interconnected: limited and intermittent water supplies increase risks of contamination and chemical changes in the water distribution system.

WASH and health in the context of climate change

The body requires water to balance internal temperature and keep cells alive. Survival time without water is estimated at under five days, depending on factors such as age, sex, weight, height, exercise patterns, and external temperature. With climate change reducing rainfall, increasing heat, and increasing the unpredictability of seasonal weather patterns, water and food insecurity (see Chapter 12) are likely to increase in the Caribbean, exacerbated by demand from the tourism industry. Climate change-exacerbated drought, hurricanes, saline intrusion and other pollution resulting from sea level rise, and flooding can cause major disruption of WASH systems and reduce the availability and quality of fresh water and safe food, contributing to malnutrition *(1)*.

Risks of pathogen and harmful chemical exposure through poor water quality, sanitation, and hygiene are aggravated by climate change.

- Waterborne diseases with gastrointestinal and other symptoms, such as schistosomiasis, cryptosporidiosis, giardiasis, cholera, and noncholera vibriosis can be spread by floodwaters and can result from damage to water treatment and distribution facilities by severe weather events *(2)*. During drought, pathogens become concentrated in fresh water, causing waterborne infections.
- Contact with animal urine spreads leptospirosis, causing symptoms ranging from fever to organ failure. Flooding contributes to transmission to humans *(3)*.
- Climate change favors reproduction of disease vectors such as mosquitoes through flooding, heavy rainfall, and sea level rise, as still water is needed for larvae development. Droughts increase water storage in containers, also creating breeding sites (see Chapter 2) *(4, 5)*.
- Warming oceans and lakes, combined with elevated phosphorus and nitrogen from agricultural runoff (promoted by extreme precipitation), promote growth of algal blooms. Exposure to phycotoxins produced by algae can cause liver, gastrointestinal, kidney, neurological, skin, and respiratory conditions (see Chapter 14).



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Institutional and behavioral risks

Water security varies between Caribbean countries depending on geographical features, with demand relative to supply being generally high in SIDS *(1, 6, 7)*. Climate change vulnerabilities are compounded by institutional and behavioral factors.

- **Potable water loss** due to leaks, theft, metering inaccuracies, and other factors *(1)*. A study of national water companies in 11 Caribbean countries found that between 20% and 73% of water they produced in 2021 was lost before it reached the end-user or customer *(8)*. Weak monitoring of water distribution systems contributes to the challenges *(7, 9, 10)*.
- **Contamination.** The risk of human, animal, industrial, and agricultural waste entering the water supply is increased by inappropriate liquid and solid waste disposal, especially into the ocean; inadequate water treatment, distribution, storage, and drainage infrastructure; and oceanic and other source pollution. Septic tanks, commonly used in the Caribbean given limitations in public sewage systems, may leak fecal waste during flooding. Dumping solid waste into rivers, streams, ravines, and drains in the Caribbean clogs waterways, exacerbating flooding and contaminant exposure *(1, 7, 11)*.
- **Deforestation and watershed change.** Improper land use and infrastructure development can damage and reduce water sources *(1, 7)*. Loss of coverage and shade from trees and plants, which may be aggravated by severe weather events, leads to greater exposure of water sources to contamination. For example, following the defoliation of 80–90% of trees in Dominica by Hurricane Maria, new algal blooms arose in defoliated areas *(12)*.
- **Disaster preparedness.** Lack of climate-resilient water infrastructure, emergency water supplies, public toilets, and other hygiene facilities contribute to water shortages and disease spread following disasters.

- **Inequality.** Vector-borne and infectious diseases spread rapidly within and from low income and marginalized communities with inadequate water supply and WASH infrastructure. Households experiencing water outages pay for trucks to fill their water tanks, leading to financial hardship.

Caribbean evidence

Caribbean studies have looked at the impact of rainfall patterns and extreme weather events on gastrointestinal illnesses *(2, 3, 13)*. Risk of gastrointestinal illnesses was reduced in areas with ecosystem services offering flood protection, such as karst soils, and increased in flood-prone areas *(14)*. Syndromic surveillance data analysis showed that the numbers of gastrointestinal cases increased more rapidly in 2017 in countries that were struck by hurricanes at Category 4 or 5 strength than in countries that were not *(15)*.

Negative impacts of climate change on water supplies can be mitigated by reducing potable water loss, pollution, deforestation, and social inequalities, by sustainable water and land management practices, and by strengthening disaster preparedness.

Chapter 2 presents studies showing how climate change affects VBD spread via the proliferation of standing water breeding sites.

Chapter 12 presents studies examining effects of drought and floods on food security and safety.

Three reviews of evidence from SIDS identified water resource management challenges, including climate-related and human-induced challenges and their likely health impacts *(1, 7, 16)*. Another study used geographic information system (GIS) technology and modeling to examine how nature-based solutions can achieve sustainable water–energy–food nexus conditions for health *(17)*.

What should be done?

Individual and community actions and how to support them



Involve communities in integrated water resource management

Integrated water resource management (IWRM) involves coordinated development and management of water, land, and related resources, to maximize social welfare equitably without compromising vital ecosystem sustainability *(18)*. Communities and nongovernmental organizations (NGOs) should be involved in advocating for, designing, and working on appropriate local solutions for water availability and quality. Given government responsibilities for water as an essential resource, public agencies should supervise community projects and mobilize financial and

technical support. Communication strategies and tools can assist communities and individuals in conservation, safe storage, and recycling of water.

Government and private sector actions



Protect rights to WASH for all

The human right to safe drinking water is recognized as binding international law by the United Nations (UN) General Assembly and Human Rights Council *(19)*. The human right to sanitation has been recognized as a distinct right. These rights were asserted in UN Sustainable Development Goal (SDG) 6: Ensure availability and sustainable management of water and sanitation for all. Governments should review environmental and public health legislation, building codes, and their enforcement, taking account of concerns of vulnerable communities and additional risks posed by climate change, to ensure equitable access to WASH.



Develop climate-resilient, sustainable WASH infrastructure and services

Governments must address water loss and contamination. Development partners and the private sector can contribute to strengthening and ensuring WASH infrastructure, much of which currently is not fit for purpose in the Caribbean:

- Monitor, maintain, and reinforce treatment, distribution, storage, drainage, sewage, metering, and information systems infrastructure and supplies to climate-resilient standards for all residents.
- Impose penalties for water theft, dumping solid waste in water courses, industrial pollution, and destruction of protective ecosystems such as forests.
- Educate and support the public in IWRM.
- Ensure provision of WASH infrastructure to vulnerable populations, including low-income, urban, squatter, and Indigenous communities, and women, children, and people with disabilities.

Sustainable technologies should be harnessed for optimal water use, including traditional water management methods and nature-based solutions such as diverting high water flows into natural storage areas. Rainwater harvesting should be accompanied by support for water treatment and safe storage. Water recycling and ways to ensure its safety and acceptability should be explored and adopted. Urban agriculture, including vertical and rooftop gardens, and aquaculture can reduce the need for land and irrigation. Desalination options should be carefully considered, since some involve high energy consumption and degrade the marine environment *(1, 7)*.



Integrate WASH in disaster preparedness and response

WASH disaster preparedness and response strategies include *(21)*:

- Development of water, sanitation supplies, solid waste, and debris management plans for each area;
- Development of hazard-specific plans, e.g., for droughts;
- EWSs to assure water storage and access;
- Rapid response teams to fix damaged infrastructure;
- Decentralization of stored water, sanitation supplies, and refuse collection.



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What do we need to know?

Research gaps and how to address them

Conduct research on WASH in the Caribbean

Original Caribbean research is needed on:

- How climate change is affecting the biological and chemical composition of water sources;
- How climatic factors and nonclimatic drivers (such as water and land use) interact to affect water security and safety, including the spread of waterborne infections;
- The impact of water security and quality on mental health, population displacement, and economic decline;
- Effectiveness, environmental impact, safety, acceptability, and costs of water resource management options such as desalination, irrigation practices, rainwater harvesting, and water recycling;
- Factors influencing community and industrial water and waste practices;
- Implementation science studies of community-based IWRM and WASH integration in disaster preparedness and response *(1, 7)*.

Surveillance gaps and how to address them

Monitor WASH infrastructure and water pollutants

To maintain water availability and quality, WASH infrastructure and water pollution should be continuously monitored. In addition, these data should be integrated with waterborne and foodborne disease monitoring, which is conducted by countries and the Caribbean Public Health Agency (CARPHA), to inform EWSs. Areas for strengthening include:

- Metering and monitoring WASH systems;
- Monitoring organic and inorganic water pollutants;
- Monitoring disease impacts of climate hazard and pollution events;
- Monitoring water management behavior.

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4. Noncommunicable diseases and risk factors

What is happening?

Noncommunicable diseases (NCDs) or chronic diseases are a group of conditions that are generally not passed from person to person[2] and are mainly of a long duration and progress slowly *(1)*. They are the leading causes of disability and death in the Caribbean *(2)*. About three-quarters of all deaths in the region are caused by NCDs, and 40% of these NCD deaths occur prematurely, in people under 70 years old *(3)*.

Climate change exacerbates NCD risks through extreme weather events, rising temperatures, air pollution, and environmental degradation.

Extreme weather events

- Extreme weather events directly affect health, and through destruction of infrastructure, affect the access of PLWNCDs to resources that are vital to maintain their health (see Chapter 1).
- Disaster preparedness can reduce NCD health risk.

Caribbean evidence

- Hurricane Maria (2017) disrupted availability of utilities (water, telecommunications, and electricity) and health care (e.g., roads and health facilities were damaged or closed and access to medicine or respiration equipment was severely limited). This helped explain why the number of deaths in Puerto Rico in the three months following the hurricane was 62% higher than during the same period in the previous year *(4)*. Lack of electricity affected refrigeration of medicines and food, exacerbating chronic conditions such as diabetes *(5)*. Half of excess deaths in Puerto Rico occurred from NCDs (heart disease, diabetes, and Alzheimer disease) *(6)*. The greatest public health impact from the hurricane was on older adults and PLWNCDs *(7)*.
- A study of overweight adults in Puerto Rico found that those with lower hurricane preparedness[3] reported more hurricane-related detrimental health impacts and had higher odds of developing new NCDs compared to others *(8–10)*.

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2 Some cancers have infectious disease causes and risks, but most NCDs are not transmissible.

3 The measure of preparedness had two major components: gaps in information (e.g., about hurricanes, food security) and gaps in resources (e.g., economic resources, alternative energy sources during power cuts).

The needs of people living with noncommunicable diseases and disabilities must be integrated into disaster preparedness and management and climate change and health professional training.

Heat

- Viscosity (thickness) of blood increases when temperatures are higher, which can lead to high blood pressure and heart rate – risk factors for cardiovascular disease events such as heart attacks and strokes.
- Extreme heat can restrict the bronchi (the tubes that connect the windpipe to the lungs), causing breathing difficulties among people with respiratory conditions such as asthma.
- Dehydration from heat affects essential bodily functions, including regulating internal temperature and keeping cells alive, adding to challenges for PLWNCDs, especially those with kidney disease.
- Heat can reduce outdoor physical activity, contributing to increased NCD incidence because physical activity helps prevent NCDs.
- People with NCDs and mental health conditions often take medications that increase susceptibility to the effects of heat (see Chapter 6).

Air pollution

- Wildfires, floods, hurricanes, and Saharan dust events add harmful particles to the air, causing and worsening respiratory conditions like asthma (see Chapter 5).

Caribbean evidence

- Visits to emergency medical facilities by people with asthma have been found to be correlated with Saharan dust events *(11, 12)*.

Environmental degradation

- Climate change can damage the agriculture and fisheries sectors, restricting access to healthy foods that prevent NCDs and are vital to the health of PLWNCDs. It also increases reliance on imported and processed foods, which tend to be high in fats, sugars, and artificial chemicals, increasing NCD risk and worsening the health of PLWNCDs *(13, 14)*.

Caribbean surveillance

- National surveillance systems monitor NCD mortality (deaths) from specific diseases. These data are collated and analyzed by CARPHA.
- NCD registries are being developed in several Caribbean countries, providing numbers of cases.
- A few initiatives to integrate NCD and climate data exist, such as the quarterly Caribbean Health Climatic Bulletin, which includes advice for people with specific conditions *(15)*.
- There are no established systems for integrating NCD and meteorological data.



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What should be done?

Individual and community actions and how to support them

Empower PLWNCDs with knowledge and skills

Information products such as leaflets, radio broadcasts, and social media posts should be developed through collaboration between PLWNCDs and experts in climate, health, and disaster management to help PLWNCDs manage their conditions in the face of slow onset or sudden impact climate change-related events *(13)*. EWSs should be enhanced to include notification of impending events tailored to the vulnerabilities of PLWNCDs, as is done in the Caribbean Health Climatic Bulletin *(15)*, and should be evaluated for reach and impact. Information should be provided on where to access medical care, food, and shelters in the event of disasters *(13)*.

Government and private sector actions

Train healthcare professionals on the links between climate change and NCDs

Health professionals must receive training on NCD impacts of climate extremes and environmental factors affected by climate change, such as air pollution, as part of their regular curriculum, to better advise and treat patients. Training in disaster preparedness and response, including shelter management, tailored to PLWNCDs must be included.

Develop health promotion for NCDs

The main risk factors for NCDs should be addressed to create an enabling environment for prevention. This includes implementing strategies to increase physical activity and to reduce alcohol consumption, tobacco smoking, and poor nutritional habits, including diets high in salt, sugar, and fat, and low in fresh fruits

and vegetables. Some actions are win-win for climate mitigation and NCD prevention, e.g., more plant-rich diets and alternative transport like biking and walking. Action at regional and international levels should be stepped up to address commercial determinants of health such as processed food marketing practices.

Health promotion for NCD prevention and control should be gender- and age-responsive, given differing risk behaviors and capacities *(16)*. It also should take climate change into account, such as promoting scheduling of physical activity when it is relatively cool and creating walking/cycling paths shaded by trees *(17)*. Developing greener urban spaces can reduce greenhouse gas emissions and reduce urban heat while encouraging physical activity, providing health co-benefits of mitigation and adaption *(18)*.

Include NCDs in national disaster preparedness and recovery policies

Elements to include in disaster preparedness and recovery policies and protocols include infrastructure resilience; NCD self-management education (see above); registries of medically vulnerable people; local points for medication and food distribution; disease surveillance; addressing mental health needs; assuring supply of healthy, primarily unprocessed or minimally



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processed food; and refraining from seeking, accepting, or making donations of ultra-processed food and beverages *(13, 14, 19)*. Planning should involve PLWNCDs and representatives of ministries and agencies responsible for health-determining sectors, such as planning, the environment, local government, works and transport, utilities, communications, and finance. Financial and logistical support should be provided for NCD kits, comprising medical supplies to be distributed during emergencies *(20)*.

What do we need to know?

Research gaps and how to address them



Conduct research on the health effects of climate stressors on PLWNCDs in the Caribbean

There is need for research to establish the impact of rising temperatures, climate-related air pollution, and extreme weather events (and their complex interactions with other environmental factors) on PLWNCDs. Such research, which has been scarce globally, needs to be conducted throughout the Caribbean *(18)*.

In Puerto Rico following Hurricanes Irma and Maria, a study found that PLWNCDs with diet changes due to lack of refrigeration and cooking for more than three months had worse health outcomes than other PLWNCDs *(8)*. Women with gynecological cancers experienced challenges from wind, water, heat, air pollution, noise pollution, and mosquitoes *(21)*.



Find out what works in addressing NCD impacts of climate change

Almost all studies of NCDs and climate change responses in the Caribbean are descriptive *(13)*. Interventions to alleviate NCD impacts of climate change need to be further documented and monitored with health outcome-based indicators for PLWNCDs and behavioral indicators for target populations. Evaluation methodologies should be applied, including trials, to determine the effectiveness of interventions and strategies, and to develop policies and protocols accordingly. Implementation science studies should explore how interventions can be applied in Caribbean contexts.

Surveillance gaps and how to address them



Develop integrated climate and NCD monitoring systems

Dialogue should intensify between government and regional agencies responsible for health surveillance and those monitoring weather and environmental factors, to develop integrated surveillance and monitoring systems. On the health side, there should be continued efforts to strengthen mortality surveillance in relation to climate events, build NCD registries, and establish systems at the health facility level to monitor NCD-related events such as strokes.

Research using data from climate and health monitoring systems is needed to identify climate-related risk factors for NCDs and to assist in the development of EWSs and other prevention and treatment interventions.

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5. Air quality

What is happening?

In 2015, the World Health Assembly recognized air pollution as a major risk factor for NCDs such as asthma, cancer, chronic obstructive pulmonary disease, ischemic heart disease, and stroke. The most vulnerable populations include those with preexisting cardiovascular or respiratory diseases (e.g., coronavirus disease 2019 [COVID-19]), older adults, infants, children, and outdoor workers *(1)*.

Climate change's impact on air quality

Climate change affects human exposure to air pollutants by changing weather patterns, altering human-made emissions through adaptive responses, affecting natural pollution sources, changing airborne allergen distribution, and causing wildfires.

Air conditioning (AC) use exemplifies adaptive responses. While protective against heat-related illness due to rising temperatures, AC use generates greenhouse gas (GHG) emissions and toxic air pollution from fossil fuel combustion used to power the AC. Use of AC without attention to ventilation can lead to poor indoor air quality.

Measures to mitigate climate change by reducing GHG emissions have health co-benefits because they also reduce air pollution, especially particulate matter and ground-level ozone *(2)*.

Types of toxic air pollution

Fine **particulate matter,** less than or equal to 2.5 μm in diameter (PM2.5), can be inhaled deeply and enter the bloodstream, contributing to pulmonary and cardiovascular diseases. Long-term exposure increases risks of infant mortality, low birthweight, diabetes, dementia, lung cancer, and death. Larger particles, less than or equal to 10 μm (PM10), can irritate the nose and eyes and increase rates of respiratory disease.

In the Caribbean, key sources of particulate matter include wildfires (which are increasing due to climate change), waste burning, fossil fuel combustion (the main cause of climate change), and Saharan dust. Hurricanes also increase dust and waste that needs to be incinerated *(3)*.

Harmful chemicals and gases result from human activities and natural processes. Sargassum seaweed proliferation around Caribbean coastlines, caused by climate-altered ocean nutrient balance, releases toxic hydrogen sulfide and ammonia gas as it decays *(4)*. Ground-level ozone is formed when some gases from cars, power plants, industries, and landfills, such as methane, react with heat and sunlight. It causes respiratory problems, airway damage, and premature death, with levels projected to increase with rising temperatures *(2)*.

Airborne organic matter, including pollen from higher temperatures and atmospheric carbon dioxide, fungi and mold in the aftermath of hurricanes and floods, and fungal spores due to drought, is forecast to reach higher concentrations in a climate-changed future, potentially increasing asthma, allergies, and infection risks *(3, 5)*.

Saharan dust, a complex form of particulate matter, is composed of organic and mineral matter, chemicals, viruses, and bacteria. The intensity of Saharan dust storms may increase with climate change. While contributing beneficial nutrients to some marine and terrestrial species, several constituents have negative health impacts. Caribbean PM10 concentrations from Saharan dust regularly exceed WHO guidelines *(6, 7)*.

Caribbean evidence

Caribbean primary research on air pollution and health has focused on Saharan dust impacts, examining hospital admissions and asthma incidence from dust events, with varied results *(6, 8–12)*. Studies of exposure to noxious gases from sargassum seaweed have shown increased risks of hypertension among pregnant women, and neurological, digestive, and respiratory disorders *(4, 13–16)*. A study in Latin American and Caribbean cities showed that incidence of COVID-19 was positively correlated with ambient air levels of nitrogen dioxide (produced from combustion processes, such as in vehicles and power plants), PM10, and PM2.5 *(17)*. Experts have extrapolated from global studies about likely health effects in the Caribbean *(2, 7, 18, 19)*, but empirical research is lacking on most forms of climate change-related air pollution.

Climate change affects human exposure to air pollutants by changing weather patterns, altering human-made emissions through adaptive responses, affecting natural pollution sources, changing airborne allergen distribution, and causing wildfires.

What should be done?

Individual and community actions and how to support them



Empower communities to reduce air pollution

Individuals and communities can reduce air pollution by using renewable energy such as solar, wind, and hydropower. They can also pool transport, increase active transport (walking and cycling), use electric vehicles, compost food waste to reduce landfill methane, and plant trees. Alternative fossil fuels such as liquid petroleum gas and compressed natural gas emit fewer pollutants than conventional petroleum but leak methane (which contributes to ground-level ozone and is a potent greenhouse gas) and consume more energy to produce, providing false solutions.



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NGOs, community-based organizations, and private companies can raise public awareness and market products enabling greener consumption. Governments should increase and promote recycling facilities and provide tax incentives for renewable energy and electric vehicle use.

Reduce personal exposure when air pollution levels are high

Personal protection when pollution levels are high, especially important for those with preexisting conditions like asthma, includes staying indoors with closed windows; using air conditioners on recirculation mode; using portable air purifiers; wearing N95, PN95, KN95, or P100 masks; avoiding strenuous outdoor activity; and relocating temporarily. Most filters reduce particulate matter but not gaseous pollution.

Air quality monitoring and alerts are needed for EWSs. For example, Trinidad and Tobago's Air Quality Monitoring and Information System tracks air pollution via sentinel stations. The public can view current pollution levels and associated health risks online *(20)*. National broadcast weather reports also include air pollution alerts and advice.

Government and private sector actions

Strengthen regulations and policy

Governments should establish WHO-aligned air quality standards *(1)*; institute mandatory targets, subsidies, and incentives for transitioning from fossil fuels to renewable energy; convert government facilities to renewable energy; maintain AC units to improve indoor air quality; expand public transport; enforce land, maritime, air transport, and industrial emission standards; develop green spaces and active transport facilities (see Chapter 15); implement control measures for particulate matter, other toxic pollutants, and methane; and support training of the health workforce. Caribbean-relevant control measures include banning open-air burning of agricultural and solid waste, improving animal manure management, eliminating high-emitting diesel vehicles, reducing leakage from gas transmission pipelines, and recovering and using emissions from biodegradable waste and oil and natural gas production *(21)*. National and local government procurement, infrastructure, and transport should support air pollution reduction.

What do we need to know?

Research gaps and how to address them



Identify health impacts of air pollution

Studies should focus on identifying and quantifying respiratory, cardiovascular, and other health effects of air pollution types aggravated by climate change in the Caribbean, including ground-level ozone, toxic gases from sargassum seaweed, particulate matter, fungi and mold, and Saharan dust.

Research is needed to identify communities highly exposed to pollution, including which residents, workers, and vulnerable groups (children, older adults, those with chronic conditions); and to discover patterns and trends in admissions to healthcare facilities in relation to air pollution levels. The WHO AirQ+ tool can enable estimation of the burden of disease attributable to air pollution, using local air pollution, health, and population data *(22)*.

Factors contributing to pollution, such as incineration, traffic congestion, and waste management, should be studied to develop behavioral interventions and policy remedies.



Evaluate air quality action

Air quality monitoring, procedures, and regulatory activities should be documented, monitored, and evaluated. Impact assessments including air quality and health data should accompany urban planning, industrial, transport, and waste management projects.

Surveillance gaps and how to address them



Establish integrated air quality and health surveillance and early warning systems

Temporally and spatially detailed air pollution data are needed, requiring investment in monitoring equipment and forecasting. Health surveillance must be strengthened to enable integration of health outcomes with air pollution data (see Chapter 11). Successful initiatives include the Caribbean Dust and Air Quality Forecasting Centre based in Barbados *(7)* and Trinidad and Tobago's Air Quality Monitoring and Information System *(20)*.

Satellites and ground station data on Saharan dust are being used to estimate impacts on respiratory diseases in Puerto Rico. This has led to the design of a public health Saharan dust EWS, including online visualization tools and communication with healthcare providers and the public *(6)*.

Initiatives such as these assist in better understanding how climate change affects the amount and timing of Saharan dust clouds in the Caribbean.

Involving the public in data collection can foster engagement. In a campaign in African cities, runners are provided with portable air quality monitors to map pollution levels and raise awareness *(23)*.

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6. Heat-related illness

What is happening?

Caribbean temperatures have been increasing at an accelerating rate since the nineteenth century *(1–4)*; 2024 was the warmest year on record for the Caribbean since measurements began *(5)*. Furthermore, extremes of the heat index (a measure of heat stress that combines temperature and humidity) are increasing even faster than temperature extremes *(6–8)*. Unprecedented high temperatures, humidity, and heat waves are damaging health directly and via their effects on determinants of health such as food production *(9, 10)*. Extreme heat may occur with other extreme weather events that have additional negative health impacts (see Chapter 1) *(11)*.

Extreme heat can overwhelm the body's cooling methods such as increased blood flow to the skin and sweating, leading to electrolyte imbalances, reduced blood circulation to vital organs, and potentially multi-organ dysfunction. Heat-related illnesses include heat rash, heat cramps, heat exhaustion, heat syncope (fainting or dizziness), and heat stroke, a potentially fatal medical emergency (Figure 4) *(12)*. Extreme heat can trigger acute health events such as kidney failure and heart attack and exacerbate preexisting NCDs like asthma and congestive heart failure.

Ambient temperatures affect cognition and mood. Excessive heat exposure can reduce children's learning ability and increase cognitive difficulties among vulnerable groups such as older adults. Heat exposure is associated with irritability, anxiety, violent acts, and increased emergency admissions for mental disorders (see Chapter 7).

Specific groups vulnerable to heat, due to high levels of unavoidable exposure, lack of access to effective cooling methods, or biological susceptibility, include children, older adults, pregnant and menopausal women, people with preexisting NCDs, people experiencing homelessness, outdoor workers, farmers, athletes, tourists not accustomed to warm weather, displaced persons, and people living in poverty in urban areas. The "urban heat island effect" causes temperatures to be higher in urban than rural areas, as dense concentrations of impermeable surfaces absorb and retain heat.

Health system design is needed to keep facilities, medicines, and people cool. Schools and elder care homes should also be kept cool. Some medicines and treatments reduce physiological heat tolerance. Increasing heat also can facilitate the spread of harmful organisms such as bacteria, sargassum seaweed (see Chapters 5 and 7), and insect disease vectors (see Chapter 2).

Caribbean evidence

A study explored heat stress trends in the Caribbean during 1980–2019 using the

FIGURE 4
Heat-related illness

Heat syncope – dizziness and fainting, due to dehydration, vasodilation, cardiovascular disease and certain medications

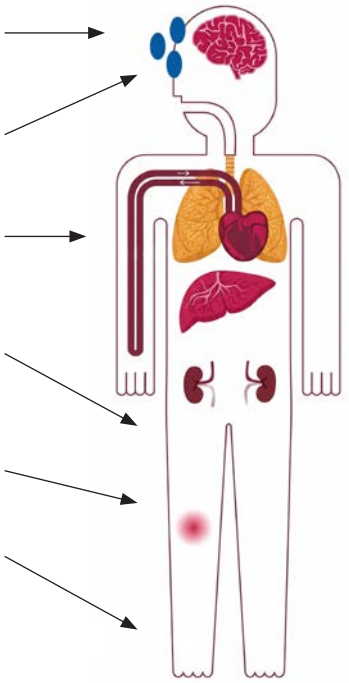
Excessive sweating can deplete fluid and salts

When blood temperature rises, the body stimulates sweat glands, dilates blood vessels and increases the heart rate

Heat cramps – caused by dehydration and loss of electrolytes, often following exercise

Increased blood flow to the skin cools the body by radiating heat, leading to heat rash (small, red itchy papules)

Heat oedema – mainly in the ankles, due to vasodilation and retention of fluid



Health effects of heat

The main causes of illness and death during a heatwave are **respiratory and cardiovascular diseases.** Additionally, there are specific heat-related illnesses including:

Heat exhaustion
- Nausea or irritability
- Dizziness
- Muscle cramps or weakness
- Feeling faint
- Headache
- Fatigue
- Heavy sweating
- High body temperature

Heatstroke
- Hot, dry skin or profuse sweating
- Confusion
- Loss of consciousness
- Seizures
- Very high body temperature

Source: Landeg O, Extreme Events and Health Protection Team. COVID-19 and summer temperatures. London: UK Health Security Agency; 2021 [cited 15 October 2025]. Available from: https://ukhsa.blog.gov.uk/2020/06/24/covid-19-and-summer-temperatures.

Universal Thermal Climate Index. This measures human thermal discomfort from combined environmental variables: temperature, relative humidity, wind speed, and solar radiation. A regional increase in the index of more than 0.2 °C per decade was found, with the Lesser Antilles having an increase of 0.45 °C per decade *(13, 14)*. Pascal et al. *(15)* demonstrated an association between higher temperatures and increased risk of mortality between 2000 and 2015 in French Guiana, Guadeloupe, and Martinique. A pilot project in Grenada examined the utility of using meteorological indices with a combination of health indicators (hospital admissions, emergency room visits, and all-cause mortality) to establish a heat threshold for use in heat EWSs in the Caribbean *(16)*.

Epidemiological modeling on health impacts of extreme heat in SIDS showed that both the number of deaths attributable to heat and the number of days of health-threatening heat exposure experienced by persons aged 65 and over doubled between 2000 and 2022. The number of hours during which there would be extreme heat stress risk from light- or moderate-intensity physical exercise more than doubled between 1991 and 2023 *(17)*. The number of potential labor hours lost from health-threatening heat exposure rose by 75% between 1991 and 2023, with losses greatest in outdoor occupations: agriculture and construction (see Figure 5 for Caribbean data) *(17)*.

Several studies have examined the perceived health impacts of rising temperatures. A global survey with health professionals, including Jamaica, indicated that heat-related illnesses were affecting local populations and were expected to become more frequent or severe *(18)*. Healthcare professionals in Grenada and Trinidad and Tobago, including veterinarians, perceived that hotter temperatures were causing more heat-related illness and hospital admissions and more deaths among working and domestic animals *(19)*. Focus groups with patients with cancer and healthcare providers following Hurricanes Irma and Maria in Puerto Rico and the United States Virgin Islands noted that temperatures were above normal for five consecutive days after the events and ranked heat as the number one environmental stressor *(11, 20)*. A health professional observed:

> Remember that patients who are undergoing chemotherapy suffer a lot from heat and hot flashes; they sweat more, and they are sick. Some of them vomit and not even having 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 about the most *(20)*.

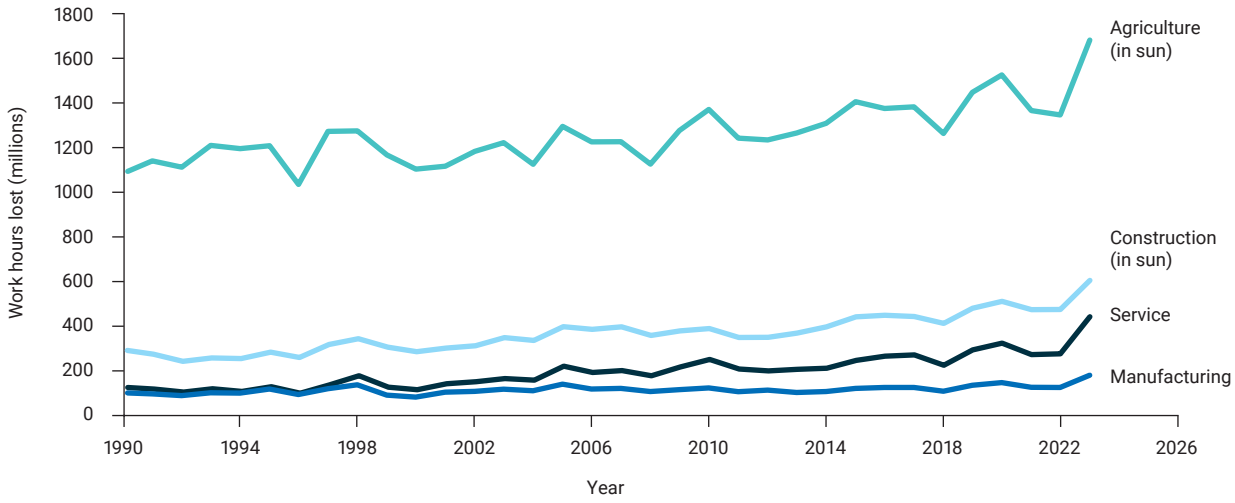
What should be done?

Individual and community actions and how to support them

Develop knowledge of the risks of heat-related illness

Awareness of the risk of heat-related illness should be increased via the media and

FIGURE 5
Potential work hours lost due to heat by employment sector, 1990–2023, in Caribbean SIDS



Source: Gordon-Strachan GM, Parker SY, Harewood HC, Méndez-Lázaro PA, Saketa ST, Parchment KF, et al. The 2024 small island developing states report of the Lancet Countdown on health and climate change. Lancet Glob Health. 2025;13(1):e146–e166. Available from: https://doi.org/10.1016/S2214-109X(24)00421-2.

educational institutions. EWSs should be developed *(16, 21)*, with simple messages on how to stay cool. The public should be educated about the meaning of heat index, which should be routinely reported by weather reports and apps. Targeted communication is needed with vulnerable groups *(21)*.

Key recommendations for staying healthy in high temperatures include:

- **Cool the living space:** Keep the temperature below 32 °C during the day and below 24 °C at night. This can involve using natural ventilation, closing curtains facing sunlight, using fans, and keeping rooms closed when using AC.
- **Keep out of the heat:** Stay in the coolest part of the building and avoid strenuous exercise. Avoid going outside or stay in the shade. Ensure children do likewise. Do not leave animals or children in parked vehicles.
- **Keep the body cool:** Take cool showers, wear light, loose-fitting clothes, and use light bed sheets. In extreme heat situations, if unable to take advantage of AC, wet your head and clothing and get in front of a fan *(7)*.
- **Stay hydrated:** Drink fluids regularly, avoiding caffeine, sugary drinks, and alcohol.
- **Access and give help:** Get help if you do not feel well. Check in regularly with vulnerable people, such as older adults and people with disabilities.
- **Store medications properly:** Store medications below 25 °C or in the refrigerator.
- **Beat the heat:** Paint the roof white or with heat-reflective paints.

To adapt to record-breaking temperature rises and reduce heat-related illness in the Caribbean, healthcare facilities, care homes, schools, public works, housing, and daily schedules should be designed to optimize cooling.

Government and private sector actions

Develop extreme heat emergency preparedness and response plans

National response plans for extreme heat events should be developed, including:

- EWSs to alert the public *(16, 21)*;
- Climate-resilient emergency shelters for vulnerable people, equipped with high powered fans or AC and with arrangements for transport to the shelters;
- Assignment of government agency responsibilities for maintenance of health and key services; e.g., water and electricity;
- Training and equipment for healthcare providers and first responders to deliver medical care in heat emergencies.

Response plans should be developed at the local (e.g., municipal) level and for outdoor sports and cultural events such as Carnival.

Sustainably control temperatures in health and social care facilities

Maintaining cool temperatures in health facilities is critical for patients' health, infectious disease prevention, proper medication storage, and effective functioning of some equipment. Energy-efficient AC and refrigeration systems should be installed with climate-resilient features. Other cooling methods can also be used, such as fans, ventilation, shading (e.g., verandas, louvers, trees), high-albedo and green roofs, and building materials with high thermal mass *(22)* (see Chapter 16). Temperature control is also critical in facilities for vulnerable populations, such as schools and care facilities for older adults.



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Implement policies to protect people from extreme heat

Fiscal measures and grants can enable equitable access to sustainable cooling solutions in all homes. Occupational health and safety regulations are needed, for example on:

- Provision of water, rest, and shade for outdoor workers, according to ambient temperature and physical work demands;
- Appropriate clothing and personal protective equipment;
- Adjustment of work schedules to avoid working during the hottest part of the day;
- Acclimatization of new workers;
- Temperature thresholds above which workers are dismissed from work.

What do we need to know?

Research gaps and how to address them

Explore the relationship between ambient temperature, morbidity, and mortality

Biometeorological indices such as the Universal Thermal Climate Index *(13)* and the heat index should be used to measure thermal discomfort. Suggested research topics using such measures include:

- Health effects of short- and long-term heat exposure, with an emphasis on vulnerable groups;
- Differences between men and women in the health effects of heat exposure;
- The role of acclimatization to heat and humidity in the Caribbean;

- How increased ambient temperatures affect the spread of infectious and vector-borne diseases, and the incidence of NCDs and related health events (e.g., heart attacks).

Health effects can be measured by health facility admissions, all-cause mortality, and disease-specific mortality and morbidity data. This combined approach is being used in a project in Grenada to establish a heat threshold for health *(23)*. Data should be disaggregated to explore impacts on vulnerable groups.



Research how ambient air temperatures affect the healthcare system

Identifying how high temperatures affect health systems can improve emergency preparedness and climate change adaptation planning. Suggested research questions for Caribbean settings include:

- Are temperature increases and heat waves associated with increased health facility attendance?
- How do they affect the storage of medicines and the performance of medical equipment?
- How do they affect critical infrastructure for health such as electrical equipment, water pipes, building materials, and roads?
- Are there enough healthcare professionals and first responders trained in response to heat-related illnesses?

Surveillance gaps and how to address them



Involve communities in surveillance and research

Individuals, communities, and NGOs can be involved in monitoring impacts of rising temperatures and heat waves, collecting data using digital devices. Local ecosystem changes, such as harmful algal blooms, can be recorded.[4] Sensors measuring air temperatures, humidity, and location can be provided to generate maps showing high temperature areas, such as those experiencing the highest intensity of the urban heat island effect *(24)*. The data can be combined with local health data, such as health facility admissions, to measure correlations.

KABP surveys and action research projects can assess and track communities' knowledge, the effectiveness of interventions, and how communities engage in action to address heat-related illnesses.



Establish surveillance integrating temperature and health information

Systems must be developed to integrate data from meteorological monitoring (ambient air temperature and humidity) and health monitoring (heat-related illnesses and mortality, which should be routinely reported). This is necessary for health planning and the development of effective EWSs. EWS information should be tailored for health professionals and groups vulnerable to heat-related illnesses.

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4 For example, the Local Environmental Observer (LEO) Network of the Alaska Native Tribal Health Consortium enables members to share observations and news articles on unusual environmental events online. See: https://www.leonetwork.org/en/docs/about/about.

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7. Mental health

What is happening?

Climate change affects mental health in varied, complex, and interconnected ways. Climatic events such as hurricanes, heat waves, and droughts, can affect mental health either directly, such as via extreme temperatures, or indirectly, via damage or destruction of housing, infrastructure, agriculture, and livelihoods, which often can lead to temporary or permanent displacement (see the other chapters in Domain 1 "Climate change health impacts, exposures, and vulnerability" of this report). These events can result in or trigger a wide variety of mental health conditions, including anxiety, grief, depression, acute traumatic stress, post-traumatic stress disorder, psychoses, suicidal ideation, self-harm, suicide, alcohol and substance abuse, aggression, violence, antisocial behavior, sleep disorders, and sexual dysfunction *(1–3)*.

Psychological distress can be caused by specific climatic events such as hurricanes but also can result from knowledge of the dire consequences of climate change and/or experiencing its slow-moving impacts, such as sea level rise and loss of ecosystems and landscapes. New concepts, including climate change anxiety, solastalgia, and ecological grief have been developed to describe different aspects of this psychological distress. Young people and Indigenous peoples are especially susceptible to these types of distress *(2, 4, 5)*.

Chronic stress can worsen health outcomes for PLWNCDs. The mental health impacts of climate change vary across populations, depending on their geographical conditions and access to resources *(2)*.

Climate change also affects mental health via its biological impacts. Extreme heat can negatively affect mood, sleep patterns, and cognition. It also can adversely affect reaction time and ability to pay attention to tasks, resulting in increased workplace and other accidents *(6)*. Warming waters contribute to the proliferation of harmful algal blooms, which produce neurotoxins that cause symptoms such as headache, confusion, and muscle tremors, as well as longer-term neurological damage. Air pollution (see Chapter 5) has been linked to neuroinflammation, dementia, and Parkinson disease. Children and older adults are especially vulnerable to biological effects of climate extremes.

Caribbean evidence

Caribbean populations that rely heavily on local ecosystems – such as certain Indigenous groups, small farmers, and fisherfolk – are particularly vulnerable to the mental health impacts of climate change *(7)*. Researchers have highlighted environmental injustice and its effects on mental health in the region *(8)*.

A 2021 qualitative evidence synthesis of peer-reviewed literature regarding mental health and climate change in SIDS identified no Caribbean-based observational studies *(9)*. The current review found some such studies, mostly focused on extreme weather events, some examining mental health impacts of event-related displacement and migration *(10–12)* (see Chapter 8).

Studies following Hurricanes Irma and Maria in Dominica, Puerto Rico, and the United States Virgin Islands, and following Hurricane Dorian in The Bahamas, found immediate to long-term mental health impacts of extreme weather events. Limited access to communication and basic necessities such as water immediately triggered widespread panic *(13)*. With time, people began processing their experiences, and some developed a post-traumatic growth mindset.

> They spoke about what it was like during impact, being exposed to the elements, having a loved one ripped away by the storm surge, and struggling to transport an injured family member to the clinic. Almost always, they mentioned being separated and not knowing the whereabouts of family members. Fear and loss were shared by all, and sheltering survivors bonded together to support each other. Some spoke optimistically about rebuilding the community *(14)*.

Children exhibited trauma, finding schoolwork challenging and being fearful of weather changes *(15, 16)*. Among older adults, the stress caused by disruption and displacement had severe mental and physical health impacts (see Chapter 8). People showed signs of post-traumatic stress disorder and an inability to function normally.

To reduce trauma, anxiety, grief, and cognitive disruption associated with climate change, communities such as Indigenous people, young people, and front-line health workers should participate in design of adaptation, mitigation, and disaster preparedness.

> After the hurricane I cannot even move as fast as I could. Sometimes tears come from my eyes. I used to be so vibrant during my work, my outside garden, my backyard garden, but now I cannot *(11)*. (Woman interviewed in Dominica following Hurricane Maria.)

Changes in gender roles were traumatic.

> The men, they kind of get scared because they feel that they are the protector and they are not sure how are they going to continue protecting their family, continue doing what they have to do for their family *(13)*. (Another woman interviewed in Dominica following Hurricane Maria.)

People with preexisting mental health conditions were at risk due to disruption of healthcare access and therapeutic routines *(14)*. In Puerto Rico, the number of suicides was 26% higher six months after Hurricane Maria than in the year prior to the event *(17)*.

The importance of mental health system preparedness to provide psychosocial support for the population and for healthcare staff was emphasized as part of disaster preparedness and response strategies *(18–22)*. The University of the West Indies is implementing the course, Disaster-Related Psychological Trauma and Mental Health Training for Emergency Professionals in the Caribbean *(23)*.

Beyond the trauma of hurricanes, sargassum seaweed strandings along Caribbean coastlines, which are associated with oceanic warming, release hydrogen sulfide as they decompose. Caribbean studies have shown a significant association between exposure to sargassum gaseous emissions and neurological conditions such as central sleep apnea *(24, 25)*.

What should be done?

Individual and community actions and how to support them



Develop knowledge of climate change and mental health links and care options

Public awareness of the mental health impacts of climate change should be strengthened *(26)*, along with knowledge of local resources for self-care and help-seeking, such as directories of available providers. Education and communication campaigns to destigmatize mental ill-health and show ways it may be affected by climate change are critical to increase help-seeking behavior *(8)*. EWSs are important in enabling people to prepare psychologically for impending risks. Communication in the aftermath of an event is also critical to nurturing coping skills. Social media, chat groups, television, radio, mobile loudspeakers, flyers, and community meetings can be used to provide information on how to access resources.



Engage communities in climate change mitigation and adaptation

When faced with evidence of climate change, people can become overwhelmed by grief at the loss of places they feel connected to *(4)*, and by anxiety about the future *(5)*. Taking action by reducing greenhouse gas emissions, engaging in adaptation interventions, and becoming involved in climate advocacy can enable a sense of agency and protect mental health, especially among vulnerable populations such as Indigenous people, young people, and people with mental health conditions *(7)*.

Government and private sector actions



Strengthen mental health services and their integration in emergency management

Caribbean mental health services are already overstretched. Globally, the Mental Health Gap Action Programme (mhGAP) includes guidance and support to increase access to effective mental health care, especially in developing countries. It includes strategies such as integrating mental health into primary care, strengthening referral pathways, and mental health training for all health providers *(27)*. Such measures are essential in developing



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mental health systems that can face the challenges of climate change.

Implementation of the mhGAP Humanitarian Intervention Guide *(28)* is important to address outcomes of extreme weather events, providing skills such as psychological first aid. Disaster preparedness and recovery plans should include mental health provisions. Caribbean research highlights the importance of pre- and post-event communication channels, mental health care and medication access points, need-based triage, and staff training *(20–23)*. Cooperative agreements between Caribbean countries to facilitate access to services in the event of disaster should include mental health services.

Include neurological and cognitive health in CC&H strategies

Strategies should be developed to prevent harmful impacts on the neurological and cognitive health of climate change exposure pathways, such as extreme heat, poor air quality, and sargassum seaweed. Examples of such strategies include rapid removal of sargassum seaweed from beaches, provision of cooling centers during heat waves, and installation of AC or other cooling measures in facilities for children and older adults (see Chapter 6).

Care providers should be trained in how climate change affects neurological and cognitive health and effective prevention and treatment methods. The needs of people with learning and cognitive challenges should be considered in CC&H strategy development.

What do we need to know?

Research gaps and how to address them



Strengthen research on extreme weather events and mental health

There are gaps in Caribbean research on extreme weather events and mental health. Recommendations include:

- Longitudinal research to assess effects of events on short- and long-term incidence of mental health conditions, disaggregated by diagnosis, age, gender, and preexisting health condition.
- Analysis of the types and quality of treatment received, disaggregated by demographic factors, diagnosis, and whether the person was displaced.
- Assessment of the impact of extreme events on the health workforce and their mental health help-seeking behavior following events.
- Evaluation of mental health system preparedness and response, including implementation of mhGAP recommendations and impact on incidence of mental health conditions.



Research psychological responses to climate change

As mentioned, knowledge about climate change and experiencing its slow-moving effects can cause psychological distress, including intense grief and hopelessness, notably in young and Indigenous people. Research is needed to better understand the emerging concepts of climate change anxiety, solastalgia, and ecological grief *(4, 5, 7)* in the Caribbean context. This research can inform communication campaigns and the development of appropriate support and community empowerment strategies to build resilience.



Evaluate strategies to protect cognitive health

Intervention studies are needed to understand whether and how adaptation measures, such as the use of AC or other cooling measures in schools and elder care facilities, can protect cognition and neurological health.

Surveillance gaps and how to address them



Establish surveillance integrating mental health and weather information

Health and Climate Change Country Profiles for the Caribbean show that only a minority of countries have mental health monitoring systems in place *(29)*. Administrative data from mental health services can help monitor reporting patterns and care and support services provided, offering guidance for service management and policy. Local registries of people with mental health conditions, once they adhere to confidentiality standards, can assist in directing resources to vulnerable people. Mental health data from these sources and periodic surveys must be combined with meteorological data to identify associations between climate events and short- and long-term mental health, and to develop mental health EWSs.

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8. Population displacement and migration

What is happening?

Human displacement and migration are social consequences of climate change that affect health and may be driven by health needs. Poverty, inequality, and political instability interact with climate change in influencing population movement and health. Both extreme weather events, such as hurricanes, and gradual climate change consequences, such as more frequent droughts, can result in population movement. Strengthening the climate resilience of infrastructure (see Chapter 15) and services can sometimes enable people to avoid displacement.

Displacement refers to forced and involuntary movement, while migration is the movement of people away from their place of usual residence, either across an international border or within a state. Migration serves as both a voluntary adaptation strategy and an involuntary response when other climate adaptation measures fail. Climate-related displacement and migration can be temporary or permanent, can be internal within the same country or external to a different country in the Caribbean or beyond, and can be caused by loss of livelihood, housing, medical care, food security, and/or a sense of security.

Migration is not a universally available adaptation option. Vulnerable populations such as people on low incomes or with disabilities may be stranded in circumstances of climate-related danger. Vulnerabilities are further addressed in Chapter 9.

During the migration process and after they reach their destination, climate migrants 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 exacerbation of NCDs, spread of infectious diseases, sexual and gender-based violence, injuries, poor pregnancy outcomes, and mental disorders. Migrants to other countries may face xenophobia promoted by politicians for their own political ends.

Caribbean evidence

The high vulnerability of Caribbean populations to climate change increases the risks of displacement and migration, which often occur repeatedly *(1)*. The Americas account for 22% of the world's internally displaced people, with environmental and natural disasters being the principal cause of displacement for 90% of those in the Americas *(2)*. The nine countries/territories with the highest recorded population displacement risk due to disasters, relative to

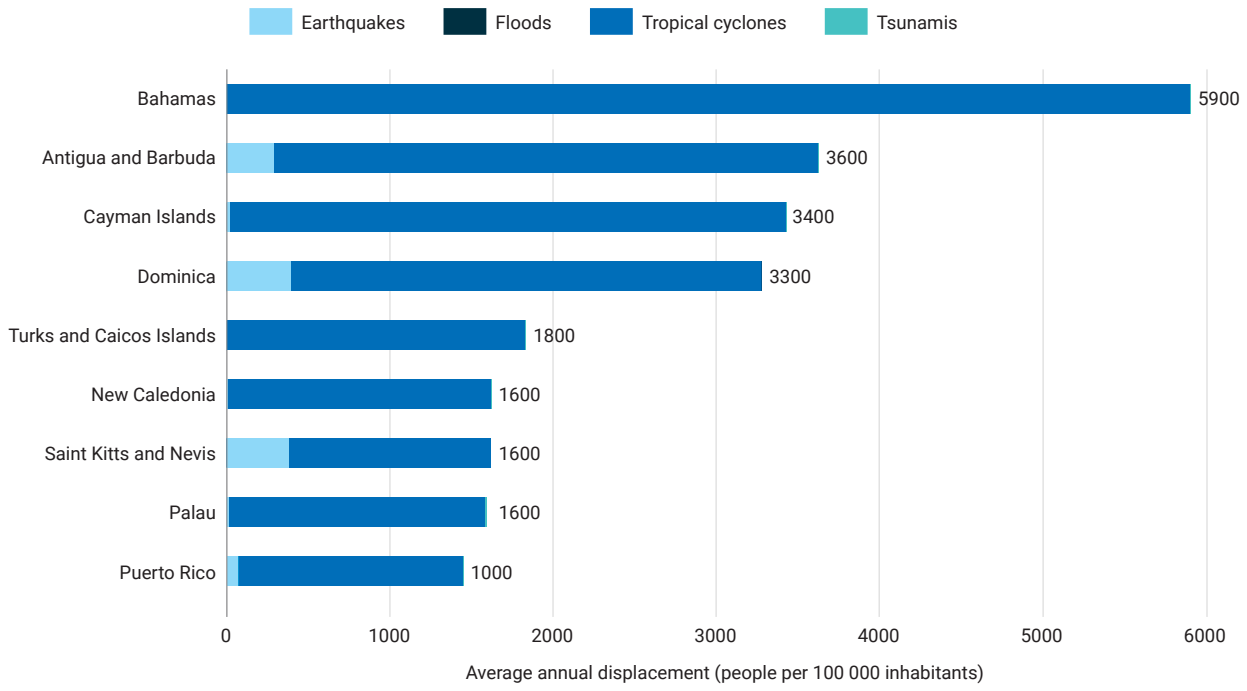
population size, are SIDS, of which seven are in the Caribbean; tropical cyclones are the main type of disasters affecting them (Figure 6) *(3)*.

Studies examine displacement experiences from extreme weather events *(4–9)*. Mental health emerges as the most important health and well-being issue, with others including unemployment, financial loss, food insecurity, dehydration, waterborne diseases, rights abuses, and injuries *(5, 8, 9)*. Losses of health, culture, and agency due to disconnecting from one's home and social support are among the most devastating impacts. Yet "noneconomic loss and damage" is scarcely acknowledged in policies and government actions, resulting in limited attention to the importance of return and reconstruction to health and well-being *(7)*. For example, Barbudans who evacuated following Hurricane Irma experienced profound psychological trauma from being detached from their customary land *(5)*. For vulnerable people such as older adults, the effects of displacement can be fatal, as shown in Dominica:

> My father died, not soon after. His health deteriorated quite a bit since the storm. He was living at his house. Someone took him, put him

FIGURE 6

Expected average annual disaster displacement relative to population size (number of people displaced per 100 000 inhabitants)



Source: Adapted from Internal Displacement Monitoring Centre. Global disaster displacement risk: a baseline for future work. Geneva: IDMC; 2017. Available from: https://www.internal-displacement.org/publications/global-disaster-displacement-risk-a-baseline-for-future-work/.

> in a house in [a new housing project]. He was not able to move around at all. So, he was restricted, and his health deteriorated *(6)*. (Woman interviewed in Dominica following Hurricane Maria.)

Policies are lacking to relocate people safely from hazard-exposed areas, to empower health personnel to provide appropriate care without burnout, and to collect data on health conditions that may be associated with displacement *(5)*.

Family networks and the Caribbean diaspora are critical sources of support and adaptation for displaced people, helping with access to local services *(6, 9)*. There are disparities within the Caribbean in government support to migrants. For example, migrants from Dominica to Guadeloupe following Hurricane Maria received immediate assistance, but then experienced difficulties in obtaining migrant authorized status, which led to material insecurity *(9)*. The Organization of American States and the Caribbean Community (CARICOM) facilitate intercountry mobility in general, but in the wake of hurricanes the capacities of recipient country agencies were overstretched, resulting in insufficient care for displaced people and high employee stress *(5)*. On the other hand, aid and logistical assistance from other Caribbean countries was helpful in meeting basic needs following Hurricane Maria *(9)*.



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Displacement can be caused by post-disaster lack of local access to health care. Such lack of access can result from damage to health facilities *(10)* (see Chapter 16), limited access to equipment and medications used to manage medical emergencies *(11)*, or unavailability of needed medical treatments, especially for complex preexisting conditions such as cancer *(12)*. However, displaced populations may also face barriers accessing health care in their new location due to limited shelter accommodation that provides security and access to health care for vulnerable populations such as women, children, older adults, and people with disabilities *(12)*; cultural and internalized stigma combining with discriminatory immigration rules to limit access to needed mental health care *(13, 14)*; or lack of resettlement health services *(9)*.

What should be done?

Individual and community actions and how to support them

Include communities in developing adaptation to stay in place and managed migration strategies

Geographically defined communities most at risk of displacement through climate drivers such as sea level rise, flooding, drought, landslides, bush fires, and hurricanes should participate meaningfully in developing strategies to adapt their surroundings to become more climate resilient and to plan their migration to safer places if necessary. Assisting communities' wishes to stay in place by supporting climate-resilient adaptation may be more protective of mental health than migration. All scenarios should include access to mental and other health care.

Migration options may involve temporary displacement, or permanent relocation involving "managed retreat" from high-risk areas such as coastlines threatened by sea level rise *(15)*. Diaspora communities and associations can collaborate in developing migration plans and can send remittances to support people affected by disasters.

Government and private sector actions



Ensure coordinated government and community responses to displacement and migration

Emergency preparedness and response plans should consider the needs of displaced people by ensuring access to health care (see Chapters 1, 4, and 7) *(16)*, shelter, food, clothing, and security, with special provisions for displaced vulnerable populations. The CARICOM ministerial Council for Foreign and Community Relations should agree to general measures to address climate migration. Contingency plan operationalization, including logistics and transport for displaced people and health professionals, should be accelerated in the run up to and during hurricane season. Strategies should be developed that respect the human rights of affected communities, including the option to stay in place if desired and feasible, and informed consent procedures for "managed retreat." Collaborative and effective outreach mechanisms should be established with affected communities and NGOs, including diaspora organizations. Dominica has developed a strategy for relocating people away from hazard-exposed areas, which can be adapted to other countries *(5)*.

Review and strengthening of regional and bilateral agreements on the movement of people between countries is needed and should include access to health and other services by climate migrants. Multilateral and aid agencies can provide technical and financial support. Advocacy, negotiation, and public sensitization are needed to increase responsiveness to climate migrants' needs in recipient countries, along with adaptation measures to prevent the need for migration. Affording climate migrants the same legal status as refugees should be considered *(16)*.

Caribbean climate-displacement studies highlight the need to protect mental health, reduce disease and economic losses, safeguard human rights, plan relocation, and maintain diaspora links.

What do we need to know?

Research gaps and how to address them



Identify the push factors for Caribbean migration

Theoretical frameworks and tools have been developed to facilitate research to identify combinations of climate change, socioeconomic,

and institutional factors that determine displacement and migration risk *(17, 18)*. These can be applied and adapted in the Caribbean, along with participatory methodologies to deepen understanding of local dynamics.



Research associations between climate migration and health

The body of Caribbean research on the health effects of climate-related displacement and migration can be strengthened to include identification of risk factors and types of mental health conditions and noncommunicable, infectious, and vector-borne diseases among migrants compared with the general population in places of origin and destination.



Study the costs and benefits of adaptation and managed migration options

Research on the relative costs and benefits of staying in place options involving adaptation for climate resilience versus managed migration should be conducted to guide policymakers. This research should examine costs and benefits of climate-resilient health care, housing, security, capital and running costs of emergency facilities, loss/gains in employment, and physical and mental health burden, e.g., lost workdays and interpersonal violence.



Conduct systems research on health care for displaced people and migrants

Research should examine:

- Comparison of the healthcare experiences of migrants (both internal and external), including their health-seeking behavior and access to and quality of care, with the general population in places of origin and destination;
- The resilience of supply chains for medical supplies and food for migrants;
- Audit for appropriately trained staff;
- Policies governing health care for non-nationals;
- Procedures for medical evacuation and repatriation of migrants;
- Availability of language services and cultural adaptation for migrants;
- Communities' emergency health preparedness and response for migration.

Surveillance gaps and how to address them



Conduct disaster displacement risk assessments

For governments to plan, disaster risk assessments are needed, including hazard type, identification of risky settings and areas, demographics of at-risk communities, available resources including health care, and adaptation and mobility options.



Integrate climate, displacement, and migration information

Information systems on displacement and migration should be strengthened. Surveys using digital devices, with confidentiality safeguards, can monitor peoples' movements, the climate events that displaced them or which threaten to do so, their accommodations, motivations, health concerns, and experiences at destinations. Methodological and ethical limitations, such as difficulty in monitoring undocumented migrants, must be considered. Climate data provided by meteorological agencies can be combined with displacement and migration data.

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9. Distribution, equity, and justice

What is happening?

Exposure and health outcomes related to climate change do not affect all people equally. Their distribution tends to accord with existing patterns of social and economic inequality and preexisting health conditions such as NCDs. Those already facing disadvantage are more likely to be exposed to environmental changes and to experience their adverse effects.

To survive and thrive, people need access to resources such as water, food, energy, natural environments, means of livelihood, adequate income, health care, housing, and education, all of which are affected by climate change. Historical and ongoing injustices, particularly in resource extraction and labor exploitation, create and intensify the vulnerabilities of certain populations and places to climate change. GHG emissions, pollution, and biodiversity losses, especially affect exploited and marginalized populations such as Indigenous people and many people of African descent in the Americas.

The social determinants of health approach asserts that circumstances where people are born, work, live, learn, play, pray, and age – shaped by power and resource distribution – are central in determining health outcomes. "Upstream" factors such as income, education, and poverty, and hierarchical social norms such as gender and ethnicity, can greatly affect the ability of individuals to prevent illness and attain health and well-being. Economic policies, social norms, and political systems favor some populations over others, perpetuating social gradients where health is positively associated with resource control and higher social status. As a result, vulnerability to climate change – including the degree of exposure to risks, sensitivity to risks, and adaptive capacity to cope – is distributed unequally within and between populations.

Given these variations, achieving equity often requires dedicated collaborative initiatives and tailored provisions for vulnerable populations. This principle applies both globally, in the pursuit of climate justice between countries, and nationally, in addressing inequities between groups.

Caribbean evidence

Caribbean SIDS suffer some of the most serious consequences of climate change *(1–4)*. Caribbean politicians and academics have argued that inherent geographical vulnerabilities have been exacerbated by colonial and neocolonial exploitation. These combined vulnerabilities have been asserted in calls for increased resources for Caribbean adaptation and

mitigation from the highly industrialized countries that have far greater GHG emissions *(4)*. The Barbados Prime Minister's statement below *(5)* provides an example:

> This world still looks too much like it did when it was part of an 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 *(5)*.
> (Mia Mottley, Prime Minister of Barbados, at the Opening of the COP27 World Leaders Summit, 2022.)

Caribbean politicians are also increasingly drawing attention to global health inequalities arising from climate change in their international statements *(6)* (see Chapter 18).

The populations especially vulnerable to specific health exposures and outcomes of climate change have been identified in other chapters in Domain 1 "Climate change health impacts, exposures, and vulnerability" of the current report. However, there are not many empirical studies of these vulnerabilities in the Caribbean. These studies include the following:

- A study of dengue mortality in Latin America and the Caribbean showed that higher population density (typical of poor urban slums) was associated with increased risk while higher scores on the Human Development Index (which combines educational attainment, income, and life expectancy) were protective *(7)*.
- A study in three low-income communities in Jamaica found that risk factors for dengue transmission clustered in one of the communities – a rural "squatter community" where levels of the following were lowest: knowledge of dengue symptoms; protective measures such as insect screens; pipe-borne water supply; proximity to health facilities; income; and ability to cope financially without donations and borrowing. Most people in this community had a chronic illness and were in households headed by women *(8)*.
- A study of overweight adults in Puerto Rico found that those with fewer economic resources, less knowledge about hurricane risks and food security, and without alternative sources of energy during power cuts were more likely to develop diabetes following Hurricane Maria *(9)*.
- A study with people who were internally or externally displaced after Tropical Storm Erika or Hurricane Maria in Dominica found that their vulnerability to mental health conditions was associated with social determinants of health, including loss of livelihoods, poverty, food insecurity, poor access to housing, health care, and psychosocial services, and (for external migrants) insecure legal status *(10)*.

The number of Caribbean countries that have completed Health Vulnerability and Adaptation Assessments is growing, but a need to strengthen their integration into climate change policy has been identified *(11)*.

A scoping review of research on climate change, community action, and health in the English-speaking Caribbean showed that

only 2 of the 14 articles identified examined direct health impacts. The other articles focused on social determinants of health such as livelihoods (especially in agriculture, fishing, and tourism) and food security *(12)*.

Participants in the 2021 Caribbean Conference on CC&H in Small Island Developing States provided expert opinions and testimonies on the impacts of climate change on health of vulnerable populations *(2, 13–17)*, and on policy, legal, and civil society strategies to protect vulnerable populations, build their resilience, reduce inequalities, and redress injustice *(1, 3, 15, 18–24)*. An area highlighted was the shortage of Caribbean academic publications on CC&H, which was argued to result from global academic resource inequalities and lack of research capacity-building *(19)*.

Climate change's health harms in the Caribbean fall unevenly along lines of poverty and marginalization, so justice demands redress, equity-focused policy, and meaningful inclusion of vulnerable groups.

What should be done?

Individual and community actions and how to support them



Meaningfully involve vulnerable populations in CC&H decision-making and human rights protection

Advocacy is needed to contest and seek legal, financial, and policy redress for natural resource exploitation and inadequate social determinants of health that put the health of vulnerable populations disproportionately at risk. These populations should lead advocacy and be meaningfully involved in CC&H initiatives, meaning not only that they are consulted but that they have decision-making and executive roles. Autonomous community projects and collaboratively governed initiatives between civil society and government, academic, and other entities should be supported *(24)*. Resources and education should be provided to compensate for power imbalances and to enable vulnerable communities to implement their own ideas for developing and enhancing their health. Communication should be tailored to the community concerned, taking account of language and cultural and educational differences *(25)*. It is especially important to involve young people because they bear the accumulated consequences of climate change despite not having contributed to its origins *(2, 13, 24)*.

Box 3 provides an example of a community-led initiative *(15)*.

BOX 3

Addressing determinants of health of Wayana people in Suriname

In Suriname, the Wayana Indigenous people live mostly in forested areas. Illegal logging and gold mining, and climate change are depleting the natural resources people rely on for subsistence, livelihoods, and health. These activities contribute to deforestation, mercury contamination of water sources, and extreme weather events such as droughts, floods, and forest fires. Hunting and fishing, which are important to the culture, are increasingly unproductive. Lack of legal recognition of land rights and educational opportunities have contributed to growing insecurity. Rates of suicide have escalated as ecological grief has increased. The community has established a foundation that conducts educational, cultural, and community activities (see photo) to overcome these challenges, including a fish farming project and mental health support. Rates of suicide in the community are now falling.

Source: Itoewaki J. Climate change and the impact on the mental health of the Wayana indigenous youth. Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean; 5–8 October 2021; Available from: https://www.youtube.com/watch?v=f1XuSXafPng.



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Government and private sector actions

Develop and implement CC&H strategies using a human rights perspective

Addressing the social determinants of health in CC&H policy and strategy includes tackling "upstream" causes of health vulnerabilities, such as poverty, lack of education, and discrimination based on disability, gender, and ethnicity. It also means tailoring responses to socioeconomic differences. For instance, gender-responsive strategies may involve providing services at different times and in different places for men and women given their differing workplace and care responsibilities.

Given the historical responsibility of the Global North countries and multinational corporations for climate change, justice will require the developed world to finance global mitigation and adaptation efforts, including provision of resources to the Global South, including the Caribbean. However, the developed world will not do this without advocacy from the Global South. Campaigns for climate justice

by the region's politicians on the global stage should include the right to health, incorporating messages about health impacts of inequalities *(6)* (see Chapter 18). International human rights and climate change agreements can be invoked to support action. For example, the Paris Agreement's preamble asserts both the right to health and Indigenous peoples' rights. This can be invoked to motivate action to protect access to natural resources and promote the health of Indigenous people *(26)*.

In July 2025, the International Court of Justice issued an advisory opinion which affirmed that states have binding legal obligations to prevent considerable environmental harm, cooperate in good faith to tackle climate change, and ensure that their Nationally Determined Contributions under the Paris Agreement reflect the "highest possible ambition." The Court made clear that governments are accountable not only for their own emissions but also for those of corporations operating within their borders. This ruling can be used internationally by Caribbean leaders and nationally by civil society in campaigns for GHG emission reductions and to address commercial practices that damage vulnerable populations' health. To maximize impact, governments and civil society actors can include the ruling in policy, litigation, and advocacy *(27)*.

Efforts to promote the health of vulnerable populations should include enforcement of environmental laws and action on findings of participatory environmental and social impact assessments of industrial and infrastructure projects. Enforcement of equal opportunities legislation is also critical to addressing social determinants of health.

Governments and technical agencies should actively support vulnerable populations in codeveloping appropriate and sustainable CC&H resilience strategies. Communities should be enabled to identify their natural, built, financial, human, social, political, and information resources that need strengthening *(23)*. Agencies should streamline and improve CSO access to funding *(20)*. United Nations agencies can help strengthen the integration of NGOs into CC&H responses at regional and national levels *(1)*. EWSs should be adapted to facilitate understanding of them among vulnerable populations, including people with disabilities, low literacy levels, and different language needs.



Develop health sector partnerships and strategies focusing on equity and inclusion

There are many civil society environmental initiatives in the Caribbean, but they rarely address health impacts *(12, 24)*. Public health departments and healthcare agencies work on environmental determinants of health and involve communities to varying degrees but often do not address social determinants such as poverty. Interagency and intersectoral partnerships should be built to develop holistic and more effective CC&H strategies that target vulnerable populations and address social determinants of health (see Chapter 10).

Within the health sector, there is a need to allocate resources to populations with greater health needs related to climate change. For example, mobile clinics may be needed for geographically remote communities, wheelchair ramps and health education materials in Braille or audio format for people with disabilities, and interpreters for non-native language speakers.



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Additionally, strategies are needed to encourage and support historically marginalized and underrepresented populations to enter the health professions. People from vulnerable populations should be encouraged to apply and workplaces adapted accordingly.

What do we need to know?

Research gaps and how to address them

Identify social, demographic, and geographical factors associated with climate-related health outcomes

Social, economic, and geographical factors that can modify or mediate the relationship between CC&H should be included in Caribbean research. Indicators should measure dimensions of potential vulnerability, including, for example, area of residence, age, gender, ethnicity, socioeconomic status, sector of employment, level of education, food security, water security, housing quality, disability, and preexisting health conditions. Local environmental conditions should be considered, such as location in a flood plain or coastal area, industrial pollution, and ease of access to health care and sanitation services. The social determinants of health approach can help guide the choice of issues to study and variables to include. Multivariate quantitative analyses should aim to identify risk for climate-sensitive health conditions according to these indicators, as well as their modifying or mediating effects in relation to specific climate exposures (e.g., hurricanes, heat waves) and specific health outcomes.

GIS 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 harm to vulnerable populations.



Conduct participatory behavioral research on how social and environmental determinants of health affect climate-related health outcomes

Behavioral research is needed to inform policy development and strategies to build resilience. It is necessary to know how and why social and environmental circumstances influence health outcomes of climate change in Caribbean contexts. Retrospective studies can examine differences across populations and communities in health outcomes and access to health and other key services following extreme weather events. Research with local people, using primarily qualitative methods, can enable them to speak out on the challenges they face, clarifying key dynamics and sources of vulnerability and resilience. Participatory and peer-led action research can help develop sustainable adaptation and policy strategies.



Research climate change impacts on health according to biological differences and preexisting medical conditions

Research is needed on predisposition to ill-health from climate change according to biological differences and preexisting medical conditions, in the Caribbean context. For instance, what are the health effects of exposure to extreme heat on pregnant people and fetuses? How do physiological differences in body temperature regulation according to age affect the ability of different age groups, especially the very young and the very old, to handle heat stress? How does a hurricane affect the health of people living with diabetes? This research should be combined with behavioral research to examine how social determinants interact with medical factors, and to examine the effectiveness of adaptive measures adopted by populations at risk.

Surveillance gaps and how to address them



Include demographic and social stratification variables in health surveillance systems

Mortality and morbidity data, and routine administrative data on receipt of health services, should be disaggregated by sex and age group, to enable gender and life course analyses of how climate change affects health. Ideally, socioeconomic indicators such as occupation, education level, and employment status should also be included in surveillance systems. Place of residence should be linked to information about neighborhood socioeconomic characteristics to enable geographical analyses of vulnerability.



Monitor socioeconomic and environmental health impacts and inequities

Government and private sector strategies and economic development practices should be monitored and evaluated, applying a human rights lens. Metrics should be developed to enable examination of the socioeconomic and environmental costs and benefits of projects addressing CC&H for different populations and geographical areas *(22)*. Climate change mitigation and adaptation projects themselves should be assessed for costs and benefits.

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DOMAIN 2

Adaptation, planning, and resilience for health

10. Collaboration between agencies

What is happening?

Caribbean SIDS have severe resource limitations, making it very important that they pool and share resources in a coordinated way *(1)*. Regional collaboration boosts the climate resilience and adaptation of individual countries and territories. International partners can also play key roles. Government, civil society, academia, and private sector agencies can address CC&H through active partnerships that build on each other's strengths, drawing on the history of regional collaboration through institutions such as CARICOM.

Addressing CC&H requires multiple types of intervention and expertise. Given that many of the determinants of CC&H are beyond the control of the health sector, interministerial and cross-sectoral collaboration are critical. In this report, the "What should be done?" and "What do we need to know?" sections of each chapter have highlighted the importance of partnerships and multisectoral approaches to action and research, with Chapters 3, 12, 14, 15, and 16 focusing on specific sectors. This chapter provides some examples of collaboration and the status of evidence on collaboration in the Caribbean, before presenting recommendations.

Intergovernmental policymaking: Caribbean Action Plans on CC&H

The 2019–2023 *Caribbean Action Plan on Health and Climate Change (2)* was the region's first collaborative framework addressing CC&H. The Plan was developed in consultation with national governments at the Third Global Conference on Health and Climate Change in Grenada in 2018. The importance of engagement, coordination, and collaboration with other sectors and development partners for resources to address CC&H was emphasized *(2)*.

Following reviews of progress, in June 2025, Caribbean countries and regional institutions met in Barbados to discuss a draft Caribbean Action Plan for Climate Change and Health for 2026–2031, which reiterated and increased the emphasis on collaboration. There was renewed commitment to mechanisms such as interministerial committees; interprogrammatic and multistakeholder task forces; inclusion of health chapters of National Adaptation Plans; and integration of health into disaster preparedness, response, and recovery. New collaborative recommendations included conducting joint climate change and health projects addressing the needs of vulnerable populations; establishing interagency agreements enabling exchange of climate and health data; and establishing climate-informed disease surveillance systems.



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Partnership between Caribbean regional agencies: The Strengthening Climate Resilient Health Systems Project

In 2020, the European Union (EU), in collaboration with CARICOM, funded a grant to six Caribbean regional institutions for the Strengthening Climate Resilient Health Systems Project. Its focus areas include enhancing surveillance, supporting public health systems, generating/communicating data, developing EWSs, training personnel, and creating climate-resilient food, water, and sanitation plans. Multisectoral and interdisciplinary teams are key to its implementation *(3, 4)*.

Co-development of EWSs

Agencies have collaborated to develop EWSs that provide alerts on climate-related health risks. The Caribbean Institute of Meteorology and Hydrology (CIMH) and Cuba's Instituto de Meteorología have both focused on predicting and preventing adverse health outcomes through collaboration with the health sector, public utilities, local and international researchers, and disaster management agencies *(5–8)*.

The Early Warning Information Systems Across Climate Timescales (EWISACTs) program involves codesign and co-delivery of sector-specific EWSs and information products *(9, 10)*. This includes the Caribbean Health Climatic Bulletin, developed and disseminated by CARPHA, CIMH, and PAHO *(11)*.

National partnership building: Dominica's Climate Resilience and Recovery Plan

Dominica's Climate Resilience and Recovery Plan 2020–2030 provides policy direction for nationwide collaboration, as it specifies the key organizations responsible for delivery of each of its focus areas (e.g., strong communities, a robust economy, well-planned and durable infrastructure). The Plan includes the Enhanced Social Safety Net Initiative, for which the Ministry of Health, Wellness and Social Services is one of the key delivery entities. This utilizes collaborative approaches to protect vulnerable communities through partnerships between government agencies and village councils *(12)*.

Regional hub: Lancet Countdown Regional Centre for SIDS

In 2022, the Lancet Countdown Regional Centre for SIDS, based at the University of the West Indies (UWI) Mona campus, in Jamaica, was launched via the Lancet Countdown global initiative to track progress on CC&H. This is one of the regional centers set up to provide high-resolution data and foster professional collaboration on CC&H *(13)*. The Centre focuses on integrated surveillance and EWSs, CC&H research, and facilitating funding for health sector climate resilience. Its establishment followed a consultative process to identify priority areas, with Caribbean and Pacific academic institutions, regional health agencies, government agencies, and CSOs *(14, 15)*.

Caribbean evidence

Information on collaboration between agencies in the Caribbean consists mostly of descriptions of existing initiatives *(3–5, 9–11, 14–16)* and expert recommendations for collaboration *(1, 17–24)*. There is very little empirical examination of the process or impact of collaboration itself.

Caribbean countries need to establish practical ways to work together and across sectors, disciplines, and agencies on climate change and health, and to regularly assess whether this collaboration is effective.

Two papers from the same initiative examined collaborative development of EWSs for prevention and control of VBDs *(7–8)*. The team was a consortium consisting of academic institutions from within and outside the region, CARPHA, CIMH, and ministries of health from Barbados and Dominica. The team conducted consultative interviews, surveys, and national workshops with stakeholders, including questions on how to strengthen interagency collaboration. Findings highlighted the need to:

- Strengthen partnerships between health and meteorological agencies, the private sector, academia, and civil society;
- Build Caribbean capacity in statistics, GIS, and modeling;
- Engage senior leadership;
- Mandate the health sector to address threats posed by climate change, and the climate sector to address health impacts;
- Establish multilateral collaboration agreements, national CC&H committees, and shared spaces of dialogue;
- Develop information-sharing platforms and products for diverse audiences;
- Nurture communities of practice;
- Attract funding for collaborative ventures *(7, 8)*.

What should be done?

Individual and community actions and how to support them



Involve civil society as integral partners in CC&H initiatives

Communities most exposed to climate change risks must be integrally involved in "bottom-up" decision-making. This can ensure equity and justice while creating champions for climate

action (see Chapter 9). Community involvement can also facilitate the effective implementation of national strategies at a local level *(22)*. For effective collaboration, logistics of engagement and communication methods must be designed according to community culture and needs.

Collaborating with CSOs can extend the reach and impact of CC&H initiatives. Industry associations, such the Caribbean Hotel and Tourism Association, can engage their members, related businesses, and the public in sustainable practices and policy change *(24)*. Faith-based organizations can provide moral leadership and suasion on CC&H and provide support to people affected by climate change through their networks *(19)*. Media and communication industries also play a key role in keeping the public informed.

Government and private sector actions



Join up siloes and coordinate action

Leadership is needed to bring together people and entities and coordinate action in pursuit of shared goals. The starting point is conviction that the climate crisis is a health crisis, followed by political commitment to mobilize to address this crisis. Intermediate goals and resources need to be identified based on local evidence and co-development processes.

The ministry responsible for health must be integrally involved in climate change policy and planning processes for national CC&H action to be effective *(25, 26)*, and health chapters should be included in National Adaptation Plans (see Chapter 18). Mechanisms should be developed for collaboration between the health ministry and agencies responsible for health-determining sectors; e.g., meteorological services and ministries responsible for agriculture, disaster management, education, energy, environment, finance, food, infrastructure, planning, public works, sanitation, security, transport, and water.

Potential mechanisms for collaboration and coordination include:

- Development of multisectoral coordinating mechanisms, such as interministerial committees and national and regional Climate Change and Health Commissions *(20)*;
- Interprogrammatic and multistakeholder task forces;
- Memorandums of understanding between agencies;
- Trained and appropriately mandated focal points for CC&H;
- Development of online and other information and communication platforms;
- Data-sharing agreements and protocols;
- Joint training and workshops across health, climate services, and other relevant sectors.



Integrate health and climate planning and action

Mechanisms and procedures for collaborative action should be implemented not only by central government leaders but by health and environmental agencies from the executive to the service delivery level, and by local governments and municipalities. Collaboration between health and disaster management agencies is especially critical (see Chapter 1).

Each health or environmental agency should consider its responsibilities and how climate change affects abilities to exercise them. Agencies may, for instance, ally with

educational institutions, CSOs, and faith-based organizations who can provide support to build community resilience and emergency response (see Chapter 9). To sustain services in the face of climate change, health providers need to maintain and update agreements with public and private providers of goods and services such as electricity, water, insurance, and maintenance of facilities, technology, and supply chains (see Chapters 15 and 16). Because burning fossil fuels emits GHGs and harmful air pollutants (see Chapter 5), and every sector uses energy, the ministry of health should liaise with other ministries, especially agriculture, energy, infrastructure, planning, and transportation, to protect health by advancing the transition from fossil fuels to clean energy. To advance CC&H research and surveillance and production of integrated climate and health information systems, collaboration between health and meteorological agencies is essential (see Chapter 11).

What do we need to know?

Research gaps and how to address them



Use implementation science to identify models of collaboration

Implementation science consists of two main processes:

1. Identify uptake barriers and facilitators for evidence-based innovations across multiple contexts.
2. Develop and apply implementation strategies that overcome these barriers and enhance the facilitators to increase uptake of the innovations.

The approach recognizes that contextual factors, not just intervention effectiveness, play a role in whether and how quickly an innovation will become widely used *(27, 28)*.

Processes of CC&H collaboration in Caribbean contexts should be researched using implementation science methods. Criteria for effective collaboration should be defined at the onset, such as inclusion of people in situations of vulnerability. Research can involve observation of collaborative mechanisms in action, and data collection with stakeholders to identify barriers and facilitators to working together productively on specific CC&H issues. Recommended models for collaboration arising from the research should themselves be evaluated for effectiveness through further operational research.

Surveillance gaps and how to address them



Monitor collaboration between agencies

A recommendation from participants in consultations that led to the establishment of the Lancet Countdown SIDS hub was that collaboration itself should be monitored *(14, 15)*. 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 memorandums of understanding or shared data repositories) and track progress in their implementation. Indicators may also identify meetings and track progress in implementation of their decisions. These surveillance data can be included in implementation science research.

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11. Research and surveillance

What is happening?

Robust research and surveillance are necessary to understand and develop policies and plans to mitigate the effects of climate change on health in the Caribbean. Despite the presence in the region of multiple agencies that collect relevant data and of over 200 universities and colleges *(1)*, this potential remains largely unrealized.

This chapter summarizes the status of CC&H research and surveillance in the Caribbean and makes recommendations to enable the production of sufficient high-quality evidence for action. A selected sample of key Caribbean research references is provided for illustration.

Research and surveillance on health outcomes, exposures, and vulnerabilities

Health outcomes

Health outcomes are unevenly covered in primary CC&H research[5] in the Caribbean *(2)*. **VBDs** (see Chapter 2) are widely studied. The research program, Climate Change Impact on Dengue, examined how dengue is associated with climate variability; socioeconomic vulnerability; KABP; future scenarios; and adaptation strategies *(3)*. Recent work has focused on predicting VBD outbreaks and developing EWSs (e.g., *[4]*).

The few CC&H studies of **NCDs** (see Chapter 4) and **mental health** (see Chapter 7) in the Caribbean have examined how these conditions have been affected by hurricanes (e.g., *[5, 6]*), with little attention to other environmental determinants. A growing number of studies of **health impacts of extreme weather events** highlight the importance of building community and health systems resilience to reduce risk of negative health outcomes *(7, 8)*.

Exposures

Heat, **air quality**, and **WASH** (see Chapters 6, 5, and 3, respectively) are emerging areas of research, with few empirical studies to date (e.g., *[9–12]*). Air quality studies have focused on Saharan dust and sargassum seaweed emissions. Recent modeling by the Lancet Countdown on Health and Climate Change showed the impacts of heat and other environmental determinants on various health outcomes and vulnerable populations *(13)*.

Vulnerabilities

A small number of original Caribbean studies were identified on **climate migration**, looking at impacts on livelihoods and mental health of displacement *(14)*, and evacuation due to hurricanes (e.g., *[15]*) (see Chapter 8).

[5] In primary research, original data are collected. This contrasts with secondary research, which analyzes previously collected data.

Surveillance systems should combine health and meteorological data, to enable climate change and health analysis and the development of research. Peer-reviewed evaluations of adaptation, mitigation, finance, and governance initiatives are needed.

Empirical studies of populations vulnerable to climate change have focused on people with NCDs (e.g., *[7]*), with very few studies on socially and economically disadvantaged populations (e.g., *[16]*). Evidence to inform **distribution, equity, and justice in CC&H** is lacking (see Chapter 9).

Surveillance on health outcomes, exposures, and vulnerabilities

Data on some VBDs and NCD mortality are gathered in national surveillance systems and reported to CARPHA. Mental health and heat-related illness surveillance is very limited. Health and meteorological data are rarely combined in surveillance systems, limiting comprehensive analysis and the development of a coherent body of research.

Research on adaptation, mitigation, resources, and engagement

There are very few peer-reviewed evaluations of adaptation, mitigation, finance, and governance initiatives.

Adaptation

Collaboration between agencies on CC&H (see Chapter 10) has not undergone empirical, scientific research or monitoring in the Caribbean. There have been analyses of the integration of NCDs and mental health in disaster preparedness and response, but little original research demonstrating health outcomes *(8)*. Joint policy responses and partnerships have been analyzed (e.g., *[17]*) and methods for collaboration suggested (e.g., *[18]*).

Agricultural research has explored climate effects on food security and safety (e.g., *[19]*), but links to public health remain underdeveloped. Some reports suggest climate-smart agriculture strategies, yet their health benefits have not been thoroughly examined (see Chapter 12) (e.g., *[20]*).

There is a growing body of research on **awareness- and skills-building** (see Chapter 13). This includes KABP studies of health professionals (e.g., *[21]*) and studies of climate change training availability for health professionals (e.g., *[22]*). Welcome developments include studies evaluating capacity-building for health professionals (e.g., *[23]*) and determining the effectiveness of media and communications (e.g., *[24]*).

Very few countries have conducted **health vulnerability and adaptation assessments**. One of the challenges in conducting these is the lack of evidence on hazards, impacts, vulnerability, and risk *(25)*.

Mitigation

Oceans play a major role in climate change mitigation by absorbing carbon dioxide emissions and heat. Caribbean research has focused on these and other ecosystem services provided by the **marine environment**, as well as on damaging marine effects of climate change (see Chapter 14). An example of the latter is proliferation of harmful algal blooms (e.g., sargassum seaweed) in the Caribbean *(12)*. However, there is very little primary research demonstrating the health impacts of oceanic changes, and none was identified examining the health benefits of marine interventions.

The health co-benefits of developing green, resilient **infrastructure** and urban environments in the Caribbean have been presented (e.g., *[26]*), but there is a lack of empirical research showing impact on health outcomes (see Chapter 15). An exception is the work on **smart health facilities** (see Chapter 16), for which monitoring and evaluation indicators have been developed and applied by PAHO *(27)*.

Resources and engagement

Funding streams for climate and health action are documented, and there are studies of climate finance relevant to the Caribbean *(28)*. However, studies on the impact of funding streams on health are unavailable (see Chapter 17).

Research on **government engagement** is also limited (see Chapter 18). There are a few studies on health content in Caribbean leaders' statements and policy documents on climate



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change, showing a lack of health integration into planning processes *(13, 29, 30)*. Other information on government engagement is from government, regional, and technical agency documents, and commentary pieces.

What should be done?

Individual and community actions and how to support them



Empower communities and professionals

Colleges and universities can provide critical training in relevant fields and in grant proposal and academic publication writing. Academic-community partnerships hold immense potential in addressing CC&H through research, especially when engaging vulnerable populations in bottom-up action projects that promote health equity and climate justice *(31)*. Training and mobile data collection tools can facilitate vulnerability assessments and environmental monitoring. Meaningful involvement fosters CC&H ambassadors who can translate evidence into action.

Primary care physicians can play a pivotal role by gathering data and linking local communities with implementing agencies *(32)*. Strengthening research skills among health professionals through partnerships with educational and technical agencies is crucial. Health sector managers should enable participation of staff in research, ensuring access to research facilities, and enhancing grant proposal and publication-writing skills.



Improve science communication

Research must be effectively shared with those who should act upon it *(33)*. Reports and academic papers are necessary but insufficient – information products should be designed for specific audiences and disseminated using traditional media, social media, and direct engagement. Human-interest stories and real-world health scenarios can enhance public understanding of CC&H issues *(24)*.

Global scientific collaboration is vital in boosting CC&H actions. However, most Caribbean research remains unpublished in peer-reviewed journals, making it difficult to access. Increasing publication rates will elevate the Caribbean's profile in global CC&H discussions.

Government and private sector actions



Collaborate and share

Given the small size and resource constraints of individual Caribbean states and territories, collaboration between governmental, technical, development, academic, and private sector agencies is essential. Key initiatives to support research include:

- Development of Caribbean sources of research funding;
- Research and surveillance training;
- Joint procurement of research equipment;
- Evidence-sharing agreements, protocols, databases, and information hubs;
- Collaborative mechanisms for ethics review, including human and biodiversity impacts;
- Building multidisciplinary research teams;
- Standardized indicators, research methods, and data security protocols.

Build pathways from evidence to action

Strategic control and sustainability will be enhanced by increasing national and regional investment in research and surveillance. Cost-benefit and other economic analyses will help convince policymakers to invest in research as they will appreciate its utility in decision-making.

Effective communication between scientists and policymakers is a critical step on the pathway to effective action. Training and tools can promote science literacy among policymakers and policy literacy of scientists *(34)*. Dialogue should take place for mutual understanding.

Action support tools – including channels for information exchange, guidance materials, advisory services, policy trackers, newsletters, carbon calculators, and implementation science research – can orient stakeholders, including those in the private sector (e.g., tourism), in rolling out evidence-based recommendations and international best practice *(35)*.

What do we need to know?

Research gaps and how to address them



Fill research gaps and boost publication

Gaps in Caribbean evidence are especially severe for the priority areas of heat-related illness, mental health, WASH, air quality, population displacement and migration, and distribution, equity, and justice. There is a grave lack of evaluative research and monitoring of action in all areas of adaptation, mitigation, governance, and finance of the CC&H response, hindering accountability and effectiveness.

Without primary research, the Caribbean relies heavily on evidence from larger developed nations, which may not be relevant to regional needs. To advance CC&H responses, Caribbean nations must cultivate original research and systematically document local initiatives.



Monitor action and find out what works

Adaptation, mitigation, resource, and engagement initiatives should be systematically monitored, showing their health consequences. Quantitative and qualitative progress indicators should be developed for each priority area *(36)*. Evaluation methodologies should be applied, including trials, to determine intervention effectiveness and guide policy. Implementation studies should explore how interventions can be applied in Caribbean contexts. Economic studies are needed to assess the costs of action and inaction, and how adaptation and mitigation can save resources.



Invest in research and surveillance capacity

Investing in local research resources will empower Caribbean professionals to address CC&H challenges effectively. National governments should create an enabling research environment through dedicated research policies and funding.

Current international research grant models tend to exclude Caribbean nations due to income classifications. Funding criteria must be adjusted to recognize the vulnerabilities of SIDS.



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National and regional agencies should establish integrated information systems with shared data access. Health and meteorological agencies require specialized personnel, including statisticians, epidemiologists, vector control experts, microbiologists, information technologists, and GIS specialists. Communication specialists, implementation scientists, and economists are also needed to bridge research and action and for policy research.

Climate-resilient research facilities, including secure electronic and hard copy data storage systems, will ensure long-term viability.

Surveillance gaps and how to address them

Develop integrated climate and health monitoring systems

Dialogue should intensify between health surveillance and meteorological agencies to create integrated monitoring systems designed according to the needs of Caribbean SIDS. Health agencies should enhance mortality surveillance, patient registries, and real-time electronic data recording.

Climate-smart surveillance should be developed combining epidemiological, meteorological, agricultural, and environmental data to improve EWSs and interventions. Health information systems should also incorporate socioeconomic data to identify vulnerable populations and ensure targeted interventions.

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12. Agriculture and food security and safety

What is happening?

Climate change threatens agriculture, and therefore food security and safety, and livelihoods. Hurricanes, floods, drought, wildfires, and excessive temperatures damage or destroy crops and livestock. Saltwater intrusion and coastal erosion due to sea level rise, as well as coastal flooding, cause loss of agricultural land. Extreme heat promotes the spread of crop and livestock pests.

The safety of existing food supplies may be compromised by climate change. Floods, droughts, and sea level rise may lead to contamination of water sources, so that ability to clean and prepare food safely is impaired (see Chapter 3). Floods can spread sewage and directly contaminate crops. Spoilage of food increases with rising temperatures and with inability to refrigerate food, as often happens with power outages following hurricanes.

Agriculture also contributes to climate change, mostly through emissions of methane from livestock during digestion, and nitrous oxide from nitrogen fertilizers. Molecule-for-molecule, these gases have many times the global warming impact of carbon dioxide, but last for much less time in the atmosphere.

Caribbean evidence

There are limited empirical studies directly linking climate change, agriculture, food security, and food safety in the Caribbean, but existing research allows for extrapolation of health consequences from climate impacts on these sectors. Studies on dietary patterns also contribute to understanding these relationships.

Caribbean agriculture faces challenges, such as limited arable land, scarce water resources (see Chapter 3), and low productivity in predominantly small-scale farming *(1, 2)*. Research highlights farmers' concerns about droughts and unpredictable weather associated with climate change *(3)*, and shows that hurricanes lead to practices to reduce financial loss, both before the hurricane arrives (e.g., taking seedling trays indoors, cutting trenches to channel water away from crops, early harvesting and storage for selling post-hurricane) and after the hurricane has passed (e.g., harvesting still marketable produce for immediate sale, scaling down production) *(4)*. Many farmers expressed dissatisfaction with post-disaster government relief efforts such as requiring them to travel to register for assistance and providing coupons for seeds for only one type of crop from one company *(4)*. Studies

in Cuba examined farming techniques that can be used in tropical climates to increase resilience to droughts and hurricanes, concluding that biodiversity, especially in productive biota and auxiliary vegetation, plays a major role in the resilience of farms *(5)*.

The prevalence of moderate or severe food insecurity is much higher in the Caribbean than globally (71.3% versus 30.4%) *(6)*, driven by heavy reliance on imports, especially in the hospitality and tourism sector *(7)*. Climate events further threaten access to local produce, increasing dependence on imported, often highly processed foods *(8–10)*, which is associated with rising rates of overweight, obesity, and NCDs *(11–13)*. Most Caribbean people do not meet the recommended daily intake of fruits and vegetables *(14)*. A sharp increase in the number of babies born with neural tube defects following Hurricane Gilbert in Jamaica was attributed to low folate intake by the babies' mothers during the periconceptional period because the hurricane reduced access to fruit and vegetables *(15)*.

The needs of farmers should be incorporated into disaster preparedness and response, consulting and helping them with techniques to protect and recover their crops, livestock, and facilities from damage.

Caribbean countries may also be vulnerable to health impacts of climate change because of land use practices. A study found significant positive associations between lethality of floods and hurricanes and percentage of total land dedicated to agriculture and percentage urban population. The authors attribute these associations to damage to protective natural ecosystems and unplanned infrastructural development that may reduce resilience to climate change *(16)*.

Food insecurity affects some populations disproportionately, including Indigenous groups, women, children, older adults, and people with low income *(1, 17)*. Indigenous communities, especially in remote areas, face particular risks when climate events affect staple crops and infrastructure *(18)*. Climate change also affects Caribbean fisheries: this issue is addressed in Chapter 14.

Food hygiene can be disrupted by extreme weather events, increasing vulnerability to foodborne pathogens such as *Salmonella*, which accounts for the largest numbers of foodborne disease cases in the region *(13)*. Caribbean countries where Hurricanes Irma and Maria made landfall at Category 4 and 5 strength experienced more rapid increases in reported gastroenteritis cases than countries that were not struck by the hurricanes *(19)*.

No empirical studies were identified on the Caribbean agriculture sector's contribution to GHG emissions, but it is presumed to be small



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due to the region's size and limited cattle farming. However, significant beef and dairy imports mean that consumption patterns may indirectly contribute to methane emissions.

What should be done?

Individual and community actions and how to support them

Involve communities in initiatives to increase production and consumption of local food

Communities and households have the potential to help change the way food is produced and consumed, contributing to more sustainable Caribbean food security systems. Backyard and community gardens can provide fruits and vegetables that contribute to a nutritious, low-cost diet. Educational resources, training, and start-up supplies can be provided for people to engage in organic farming, rainwater harvesting, and other sustainable farming methods for their own gardens and as part of agricultural initiatives by civil society *(20)*, local businesses *(21)*, and government entities *(22)*. Home and school-based growing initiatives can include education on climate resilience that can also encourage the consumption of local food *(23)*.

Co-creation and participatory methodologies are important to the success and sustainability of initiatives to involve communities in production and consumption of local food. These must be supported by sustainable resource flows and measures to boost the resilience of local food production and marketing *(24)*. These methodologies can be complemented by communications campaigns to engage the public in understanding the health benefits of various foods. Targeted education is needed for vulnerable populations such as pregnant women.

Government and private sector actions

Support climate-smart agriculture

Climate-smart agriculture involves adaptation to and mitigation of climate change in agricultural practices, thus enhancing food security, increasing productivity, building resilience, and

reducing GHG emissions. This includes using resilient crop varieties and animal breeds, climate-proof irrigation and drainage systems, sustainable land management practices, and integrating food safety considerations into production and storage methods *(25)*. Technical and financial support may be provided in partnership with the Caribbean Agricultural Research and Development Institute *(2)* and international agencies *(7, 26, 27)*.

Promote local agriculture and health co-benefits

Promoting consumption of locally grown fresh fruits, vegetables, beans, and grains can lead to healthier diets, reduce dependence on meat and dairy imports, and contribute to global GHG emission reductions. Institutions, including healthcare facilities, schools, and businesses, should be encouraged/incentivized to source and/or grow local food for their patients, students, customers, and staff *(7)*. For example, the South-West Regional Health Authority in Trinidad and Tobago has developed a culinary medicine food park at a hospital, where food is grown to assure a consistent supply of safe and nutritious food for its patients (Figure 7). Public–private partnerships can help tourism and other commercial enterprises to orient their spending toward local suppliers, which will help strengthen the local food sector. In supporting sustainable agriculture, it is important to prioritize

FIGURE 7
Culinary medicine food park at San Fernando General Hospital, Trinidad and Tobago



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the cultivation of local/indigenous crops that are well adapted to local climatic conditions.

Policy, trade, and fiscal measures are also needed to address commercial determinants of health. CARICOM Heads of Government developed the Regional Food and Nutrition Security Policy and Action Plan, and committed to a suite of economic strategies to support regional agriculture and reduce the region's food import bill by 25% in five years *(12)*. The Government of Guyana developed its own project in support of this plan, involving investment in agricultural infrastructure, diversification of crops and food sources, food storage systems designed for long-term preservation, and training for local farmers on sustainable agriculture techniques *(28)*. CARPHA developed a Six-Point Policy Package to promote healthier food environments and address childhood obesity, including policy recommendations to address food labeling; nutrition standards and guidelines for schools and other institutions; food marketing; nutritional quality of food supply; trade and fiscal policies, including taxation of sugar-sweetened beverages; and food chain incentives *(29, 30)*.



Include agriculture and food security and safety in disaster preparedness and response

The needs of farmers should be incorporated into disaster preparedness and response, consulting and helping them with techniques to protect and recover their crops, livestock, and facilities from damage. Assistance should be provided with clearing debris; rebuilding, repairing, and replacing damaged items; and upgrading to more climate-resilient varieties. These measures are crucial not only to benefit farmers but also to prevent post-disaster food insecurity in the general population.

An important recent climate finance initiative is the introduction of parametric risk insurance for vulnerable populations, including farmers, under the Livelihood Protection Policy of the Caribbean Catastrophe Risk Insurance Facility (CCRIF) *(31)* (see Chapter 17).

To further ensure access to nutritious food, preparedness measures should be taken, such as providing fresh food storage facilities with backup generators and clearing drainage infrastructure to prevent flooding. Disaster response measures to drain floodwaters, restore sanitation and sewage facilities, and ensure public health inspection of eating establishments, are critical to preventing foodborne illnesses. Governments should seek to ensure continued access to fresh produce and minimally processed foods with low sugar and salt content, in preference to ultra-processed foods which are often donated following disasters.

What do we need to know?

Research gaps and how to address them



Conduct operational research to guide food systems and policy

Process and outcome evaluations are needed to guide the design of food systems and associated policy initiatives in the Caribbean context. Participatory research should be conducted with farmers to identify appropriate climate-smart agriculture implementation methods, technologies, and crop and livestock types *(5)*. Barriers and facilitators should be identified relating to recruitment of young people into agriculture, and to initiatives such

as the integration of food systems into disaster preparedness and response; "buy and grow local" campaigns; and implementation of policies such as the Regional Food and Nutrition Security Policy and Action Plan. Impacts on vulnerable populations, including small farmers, should be integrated into operational research.

Surveillance gaps and how to address them

Develop climate services for agriculture

Information services, including EWSs for extreme weather events, can assist food producers' productivity and resilience. Participatory Integrated Climate Services for Agriculture help farmers make informed decisions under variable climatic conditions *(5)*. The approach involves combining participatory decision-making tools with information about local weather conditions and crop, livestock, and livelihood options *(14)*. The CIMH/World Meteorological Organization's Regional Climate Center produces a monthly bulletin showing climate impacts and predictions based on its weather forecasting and drought monitoring products *(32)*.

Integrate meteorological and food-related data

Meteorological data should be combined with data on reported cases of foodborne illness and on quantities and types of food locally available by geographical origin. This will permit epidemiological studies identifying climate change impacts on food safety and security.



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13. Awareness and skills-building

What is happening?

Public and professional understanding of CC&H, based on sound evidence (see Chapter 11), are critical for effective action. To meet the challenges of CC&H, there must be widespread awareness and skills development across society, including citizens, policymakers, healthcare professionals, and specialists in various fields *(1)*. Commitment to addressing CC&H must be strengthened by using effective communication methods tailored to different audiences.

Caribbean evidence and initiatives

Public awareness and knowledge of CC&H

An online survey of 2599 respondents from 10 English-speaking Caribbean countries found that over half (60%) believed that climate change was linked entirely or mostly to human activities. Three-quarters (76%) believed climate change has a moderate or large impact on health, mainly through extreme events, VBDs, heat, and air quality. The study revealed knowledge gaps regarding climate-health links and at-risk populations: less than a third identified contaminated water or food scarcity as resulting from climate change, or thought that the health of people with disabilities, immigrants, pregnant women, Indigenous people, and healthcare workers would be affected. Doctors and nurses were seen as the most trusted sources of information. Convenience sampling may have led to an overrepresentation of those already interested in CC&H, so knowledge gaps could be greater *(2, 3)*.

Earlier KABP surveys in Saint Kitts and Nevis and Trinidad and Tobago found that most people understood climate change as increased temperature and rainfall and ranked health as the most important climate change issue *(4)*. A further survey in Saint Kitts and Nevis revealed that 11% had not heard of climate change, 43% felt unprepared to manage its impacts, and 35% were unaware of any government actions to enhance adaptive capacity *(5)*.

KABP surveys on links between dengue and climate change in three Caribbean countries found that most respondents attributed rises in dengue cases to increases in breeding sites in the wet season. Fewer attributed rises to climate change or increasing temperatures *(6)*.

Overall, surveys reveal moderate climate change awareness but knowledge gaps about specific health risks, vulnerable populations, and government actions. Respondents tend to focus on visible impacts (extreme weather, VBDs) rather than underlying climate mechanisms. Findings suggest the need for CC&H education and the potential role of health professionals in information delivery.

Media, communications, and influencers

Very little Caribbean-based research was found on the effectiveness of CC&H-related communication to the public. News media content analysis revealed health is among the most popular topics across Caribbean countries, suggesting health outcomes provide an effective entry point for climate change communication *(7)*. Media content linking CC&H remains scarce at the regional level, but the NGO EarthMedic/EarthNurse has published weekly climate and health columns in the Trinidad and Tobago Guardian newspaper since September 2024, including articles by health professionals and columns showcasing community actions.

Professional capacity and training

Caribbean health professionals are critical to the CC&H response through public health measures (e.g., vector control), patient care, and public education *(1)*. Interactions with patients can raise their awareness that climate change is affecting health and that health sector capacity-building is needed *(8–10)*. In one study, Caribbean health professionals overwhelmingly thought that climate change was real and agreed that health professionals should bring its health effects to the attention of policymakers and the public. However, most had not received any formal training on CC&H *(11)*. Barriers to their willingness to engage in communication included perception that their personal involvement will not make a difference, and lack of time, knowledge, and peer support *(11)*; these barriers were similar to those found in an international survey *(12, 13)*.

Climate change and health training must be provided systematically to health professionals to enable appropriate care, treatment, public health measures, and public education.

Health professional capacity-building in CC&H is growing. The Caribbean CC&H Responder Course *(14)* is a project led by the EarthMedic and EarthNurse Foundation for Planetary Health, the UWI, and the Global Consortium on Climate and Health Education based at Columbia University. The course, which provides continuing medical education credits, includes didactic and interactive "skills and practice" sessions using case studies. The curriculum is based on CC&H educational standards for analytic skills and knowledge; communication and collaboration; and policy, public health, and clinical practice competencies *(15, 16)*. Pre- and post-course surveys showed significant improvements in awareness of climate change impacts, communication skills, preparedness, and climate change mitigation responsibility *(16)*. Participant feedback also showed increased confidence to engage with communities and in application of climate and health knowledge to their scope of work *(1)*.

There are other important CC&H education initiatives:

- UWI and PAHO conduct online training in disaster-related psychological trauma and mental health for emergency professionals *(17)*;

- UWI manages the One Health program and the CC&H Leadership Fellowship program, designed to build CC&H leadership skills among selected professionals *(18, 19)*;
- UWI is increasing its focus on climate change across its teaching programs and has developed a multidisciplinary policy-oriented postgraduate Climate Studies degree. This includes one session on CC&H;
- A 2025 university student textbook on Public Health in the Caribbean includes a chapter on CC&H *(20)*;
- PAHO's Climate Change and Environmental Determinants Unit has conducted CC&H workshops in the Caribbean via its country programs, and offers a CC&H course for the Caribbean general public via the PAHO Virtual Campus on Public Health *(21)*;
- The Bahamas National Climate Change Committee has led training of health professionals and community members as part of the country's evolving Climate Resilient Health System *(22, 23)*.

However, initiatives to integrate CC&H into mainstream professional training are at a nascent stage *(22, 24)*. A study at the UWI Mona, Jamaica, medical school found that only 4.4% of courses to qualify as a physician addressed climate change *(25)*. With around 239 universities and colleges across Caribbean countries *(26)*, there is potential for considerable expansion of skills-building.



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What should be done?

Individual and community actions and how to support them



Engage individuals and communities by using strategic communication methods

Using strategic communication methods can assist in raising awareness and engaging people in CC&H action. After defining communication goals, it is important to:

1. **Lead with health.** Health is a common human concern that is more immediately felt than climate change, so communicating about health can help motivate people to act on climate change and health.
2. **Understand your audience.** Research can assist understanding (see below), so that one can tailor messages and means of communication to the interests, values, and behavior patterns of each target audience *(27)*.
3. **Choose the right channels and messengers.** Conduct audience analysis to inform the choice of media (e.g., face-to-face meetings, traditional media, and/or social media), type of communication (e.g., written, audio, and/or visual), and the type of messenger (e.g., peer influencer and/or expert). Messengers should be chosen who are trusted, liked, and respected, such as health professionals *(2)*. Professional and industry associations can assist *(28)*.
4. **Appeal to hearts, minds, and pockets.** Engage people's emotions and moral beliefs *(27)*. Faith-based organizations, sports people and other celebrities, young people, and influencers from affected communities, can help connect people with information that can assist them in protecting and advancing their health and economic well-being *(29–33)*.
5. **Tell stories.** Use human-interest stories and personal experiences. For example, young people already engaged in CC&H action can explain what motivated them and how they overcame challenges to achieve meaningful change *(31, 34, 35)*.
6. **Provide relevant, useful information.** Say the things that are of most value to your audience. Learning about health-harming pathways of climate change (e.g., air pollution) and who is likely to be affected (e.g., pregnant women) increases cognitive and affective engagement *(7)*. Suggesting practical, feasible actions and steps people can take will assist in involving them. Use local, relatable Caribbean information and examples if possible.
7. **Be clear and concise.** Use simple, short, clear messages. Have a variety of trusted messengers repeat them often. Use the language and usual means of communication of your audience.
8. **Present "win-win" scenarios.** Show the health co-benefits of climate mitigation and other ways that action on CC&H can benefit your audience *(7)*. Include success stories.

Government and private sector actions



Develop public education strategies on CC&H

CC&H awareness and skills-building activities are needed to build resilience across society. CC&H should be integrated into school curricula and examinations, with age-appropriate course content and teaching methodologies. Community influencers, including teachers, doctors,

nurses, faith leaders, journalists, sportspeople, people in the creative sector, and civil society advocates, should receive training in strategic communication about CC&H *(32, 34)*. Information should be presented concisely, in ways useful for them to create compelling and accessible content. Dissemination can take place through CSOs, including community groups, faith-based organizations, youth groups, and professional organizations.

The involvement of influencers and CSOs in the design of content and delivery and in broader policy development can strengthen their motivation for action and the effectiveness of their communication. Continuation of leadership capacity-building such as the CC&H Leadership Fellowship Program can assist. Mechanisms should be established for those in authority to receive input from community members, employees, customers, and vulnerable populations.



Build workforce capacity in CC&H

Health professional capacity-building initiatives that have demonstrated success, such as the Caribbean CC&H Responder Course, should receive sustainable funding. It is critical that CC&H be systematically included in health professional training curricula at higher education institutions *(24)*. Information and communication products, such as Caribbean scientific publications (see Chapter 11), toolkits, and videos, can assist in education and sensitization.

Joining up the silos requires that climate change professionals, in fields such as meteorology and environmental management, receive sensitization and training on how CC&H is connected to their fields and avenues for supporting CC&H initiatives. Capacity-building is also needed for workers in health-determining sectors, such as WASH (see Chapter 3), and in occupations especially affected by climate change (e.g., construction workers exposed to extreme heat). Again, audience-appropriate information and communication products are needed, showing how workers can make a difference and enhance safety in their respective fields.

Workers' commitment to CC&H action can be enhanced by managerial and peer support *(11, 13)*, sensitization, and team-building activities. Designation of responsibilities and management systems are needed, including incentives and rewards for CC&H action. Accreditation of courses can help establish professional standards and attract students.

What do we need to know?

Research gaps and how to address them



Evaluate CC&H awareness and skills-building interventions

Efficient allocation of resources would benefit from formative, process, and outcome evaluations of awareness and skills-building interventions. Formative research should be conducted, involving identifying and generating understanding of audiences to assist with design of effective communication and education. This may include conducting qualitative research



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to understand values and motivations, and KABP surveys. To build on existing knowledge, formative research should include systematic review of international studies of education, training, skills-building, and communication and media-based interventions on CC&H.

Caribbean-based studies are needed to guide implementation strategies to reduce the impact of climate change on health. Process evaluations involve examining the inputs (resources and methods), how they are implemented in specific settings, and why these worked or did not work in the local setting.

Outcome evaluations start with the identification of measurable education/communication goals. Experimental and/or longitudinal studies are needed to compare outcomes of CC&H interventions with control conditions and to identify barriers to, and facilitators of, desired outcomes.

Surveillance gaps and how to address them

Monitor CC&H awareness and skills-building

Qualitative and quantitative indicators, defined according to the goals and strategies of awareness and skills-building interventions, are needed for inputs (e.g., costs of training materials), processes (e.g., deliberations of planning committees), outputs (e.g., number of people trained), and outcomes (e.g., KABP). Indicators should be specific, measurable, achievable, relevant, and time-bound (SMART). For example, an aim of health professional training may be to increase understanding of the role of extreme heat in cardiovascular disease. A SMART outcome indicator could be the percentage of doctors in the health authority who, in the past three months, asked their cardiovascular disease patients about their exposure to extreme heat. Data from awareness and skills-building monitoring systems should be used in research and strategy development.

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DOMAIN 3

Mitigation action and health co-benefits

14. Marine resources

What is happening?

The ocean provides crucial ecosystem services that mitigate climate change and its harmful environmental effects. It absorbs over 25% of annual carbon dioxide emissions, acting as the planet's main "carbon sink," and is the largest net supplier of oxygen *(1)*. Coastal plants such as mangroves and seagrasses also store carbon and protect coastlines *(2)*. The ocean stores excess heat and provides breezes that make tropical islands cooler than larger land masses in the tropics. Coral reefs provide coastal protection, dissipating about 97% of incoming wave energy, protecting coastal communities and infrastructure from storm surges *(3)*. Often called "rainforests of the sea," coral reefs are home to over 25% of all marine species, providing fish, shellfish, and marine plant sources of protein and other nutritional benefits *(4)*, and unique chemicals for medicines *(5)*. The white and pink sandy beaches that attract tourists and provide mental health benefits are mostly composed of coral fragments *(3)*.

Oceans are also important in providing potential alternative sources of energy, contributing to climate change mitigation and improved air quality. Oceanic alternatives to fossil fuels include offshore wind energy, floating solar energy, sea water air conditioning, ocean thermal energy conversion, tidal energy, wave energy, salt gradient energy, and bioenergy *(6)*. Marine renewable energy frees up land for other purposes, including agriculture and thus enhanced food security *(7)*.

Climate change and increasing GHG emissions are causing major oceanic disruptions, including ocean warming, acidification, deoxygenation, and sea level rise *(4)*. These changes result in increased hurricane intensity, species loss, biodiversity reduction, coastal flooding, shoreline retreat, and contamination of water supplies and agricultural land from saltwater intrusion. Coral reefs and marine biodiversity face catastrophic threats from climate change and oceanic pollution *(1)*. Projections indicate that 70–90% of reef-building corals will be lost globally with 1.5 °C warming, rising to 99% with 2 °C warming *(2)*. Ocean warming, and chemical agricultural fertilizer runoff to the sea (aggravated by extreme rainfall), are leading to the proliferation of algal blooms that can damage health *(8, 9)*.

The Caribbean situation and evidence

Food security

Seafood is a major source of protein and other nutrients (e.g., polyunsaturated fatty acids, iodine, and vitamins) for people in the Caribbean. The damage to marine ecosystems, especially coral reefs, caused by ocean warming and acidification, along

with overfishing, will likely make seafood less available and more expensive. 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 will become extinct *(2)*. Species distributions are predicted to shift, with suitable habitats for a range of species projected to decline across most of the Caribbean, resulting in substantial local loss of species, decline in fisheries catch potential, and changes in catch composition. Food security is further compromised by more intense hurricanes and coastal flooding, damaging fishing boats and equipment, crops, and livestock *(4)*.

Coastal livelihoods and infrastructure

The region is highly vulnerable to climate change impacts on the oceanic ecosystem, since about 70% of the Caribbean population live along coastlines *(10, 11)*, and 22 million live below six meters elevation *(2)*. Low-lying Caribbean countries and cities are at particular risk from sea level rise, such as The Bahamas, Belize, Cayman Islands, Guyana, Suriname, Turks and Caicos Islands, Kingston in Jamaica, and Port of Spain and Mayaro in Trinidad and Tobago. These impacts are made worse by pollution and overexploitation of marine resources. Sectors that are critical to Caribbean economies and livelihoods, such as tourism and fisheries, are extremely dependent on coastal and oceanic resources *(4)*. Thus, most Caribbean people, and key economic sectors, are affected by climate change impacts on marine resources *(2, 3, 12, 13)*. These vulnerabilities, which may in the extreme include submergence of land, can lead to population displacement *(2)* (see Chapter 8).

Since about 70% of the Caribbean population live along coastlines, health and livelihoods are highly affected by oceanic events such as flooding, storm surges, biodiversity losses, and sargassum seaweed proliferation.

Coral damage and biodiversity

Severe coral bleaching and declining coral abundance have been observed in the Caribbean *(14–19)*. Decline in the biodiversity of species living in reef environments is also apparent *(20–21)*.

Harmful algal blooms

The warming ocean, combined with phosphorus and nitrogen from agricultural runoff, increase the risk of harmful algal blooms. A toxin (ciguatoxin) produced by harmful algal blooms bioaccumulates in carnivorous fish regularly caught and eaten in the Caribbean, such as barracuda, grouper, and mackerel. Consumption of contaminated fish causes ciguatera fish poisoning, which represents the second largest number of laboratory-confirmed foodborne disease cases in CARPHA Member States *(12)*.

FIGURE 8
Sargassum on a beach in Barbados



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Every year since 2011, massive blooms of *Sargassum* seaweed (macroalgae) have accumulated along Caribbean coastlines *(22)*, causing disastrous ecological and economic impacts. Sargassum smothers sea grass and corals, renders tourist beaches unusable (see Figure 8), and damages fishing gear. Decomposing sargassum releases harmful hydrogen sulfide and ammonia gases *(8, 23)* and absorbs and becomes contaminated with heavy metals and pesticides, particularly arsenic, posing poisoning risks *(9)*.

Caribbean evidence of health impacts

There is little Caribbean research on direct health impacts of climate-change induced oceanic and coastal changes. A team based in Martinique found negative health effects of exposure to sargassum seaweed, including neurological conditions (e.g., central sleep apnea), hypertension disorders among pregnant women, and digestive and respiratory disorders *(24–27)*. CARPHA collects data on foodborne diseases, including ciguatera poisoning.

Examples of regional and international organizations working on coastal and marine ecosystem and livelihood protection and conservation include the Barbados government Coastal Zone Management Unit and UWI's Centre for Marine Sciences. Such organizations have not had health as a primary focus and generally do not conduct health research and surveillance.

They nevertheless provide useful information for strengthening health determinants such as availability of fish species and livelihood resilience. Their work on biodiversity is important, since biodiversity loss can have complex impacts on health via its effects on species number, genetic variation, and interactions among remaining species. An example of a project for livelihood resilience is the Fisheries Early Warning and Emergency Response system, which provides fishing communities with access to information on fisheries-related threats and sources of support via a web-based dashboard and mobile phone alerts *(4)*. Fishing communities have also been included in a Caribbean parametric insurance scheme to protect their livelihoods from climate change *(28)* (see Chapter 17).

What should be done?

Individual and community actions and how to support them



Collaborate to strengthen marine resources

Meetings between affected communities, such as tourism employees, and experts, such as marine scientists, can help develop strategies to strengthen marine ecosystems and coastal infrastructure *(3)*. Collaborative ventures can include beach cleanups, pollution reduction, coral restoration, mangrove and sea grass cultivation, establishment of marine protected areas, ocean-based renewable energy, and resilient infrastructure design. Larger and longer-term projects may need government, private sector, and development community collaboration.

Targeted education and communication (see Chapter 13) can help mobilize community action and support from relevant stakeholders.

Government and private sector actions



Strengthen coastal disaster preparedness and response

People whose homes and workplaces are exposed to potential coastal disasters like hurricanes and floods, especially those with other vulnerabilities such as low income or NCDs, should be involved in development and implementation of disaster preparedness and response plans. This includes reinforcement of infrastructure; ensuring adequate post-disaster food, shelter, medication, and access to health care; EWSs; and evacuation plans. Disaster preparedness and response should also involve employees of coastal healthcare facilities and include simulation exercises *(29)*. Consulting communities and employees about preparedness and response, alongside supporting resilience measures (see Chapters 15 and 16), can strengthen their motivation and capacity for successful rollout *(29)*.

Sea level rise is a slow-onset disaster that should also be addressed through consultation with affected communities. *In situ* adaptation options include mangrove planting, ever-higher hard barriers such as sea walls, and raising dwellings (e.g., on stilts). Adaptation may eventually involve managed internal or external migration, including relocation of coastal cities *(2)* (see Chapter 8). Governments must support relocation, with a focus on poorer and marginalized communities.



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Support legislation and policy to sustain marine resources

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, a legally binding regional treaty to protect the marine environment, with a focus on reducing pollution and establishing protected areas *(30)*. In addition to continuing these efforts, updating the treaty would be beneficial, to cover ocean climate change impacts such as health and livelihood threats, food insecurity, and biodiversity loss, as well as marine energy *(6)* and regulation of the blue economy. Support for law enforcement is needed, along with public communication campaigns to highlight the importance of marine conservation and the reduction of marine pollution.

Global agreements relating to sustainability of marine environments should be upheld and enforced. Examples include UN SDG 14: Life below water, the International Convention for the Prevention of Pollution from Ships, the Global Program of Action for the Protection of the Marine Environment from Land-Based Activities, and the Sustainable Oceans Initiative associated with the Convention on Biological Diversity. Identifying supportive resources is important.

Support is needed for sustainable tourism and fishing practices, including coral reef conservation, and to assist transition to alternative livelihoods where necessary.

Reef-to-ridge ecosystem management can protect coastal and marine environments. Measures include reforestation; coastal planting of trees and plants including mangrove and seagrass; reducing use of the ocean to deposit waste; preventing runoff of agricultural fertilizers; and implementing marine protected areas *(2–4, 9)*.

What do we need to know?

Research gaps and how to address them

Conduct research on health effects of alterations in marine resources due to climate change

Understanding how climate change-driven alterations in marine ecosystems – such as coral reef degradation, declining fisheries, and shifting oceanic conditions – affect health is necessary to inform targeted interventions and climate-resilient health system strategies. Research should address both direct and indirect effects, including exposure to algal blooms *(8)*, mental health *(31, 32)*, nutritional risks, effects on fish stocks, the spread of waterborne diseases, effects on healthcare provision, and threats to livelihoods. Potentially beneficial studies also include health co-benefits of mitigation strategies, such as marine energy production, and repurposing sargassum seaweed into medicines and for air- and water-purification *(9, 33)*.

Surveillance gaps and how to address them

Monitor oceanic climate change indicators and their health effects

Oceanographic indicators of warming, acidification, deoxygenation, sea levels, biodiversity, coral bleaching, fish stocks, algal blooms, wave power and height, tropical storm intensity, and coastal flooding should be monitored and used in studies to assess effects on health and health systems. These indicators can be included in EWSs to prevent negative outcomes for exposed communities *(4)*.



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15. Climate-friendly health-promoting infrastructure

What is happening?

Infrastructure, such as housing, other buildings, and physical structures for transport, water, sanitation, electricity, cooling, and telecommunications, is a key determinant of health. It is usually constructed on the assumption of stable climatic conditions, but climate change challenges this assumption *(1, 2)*. Infrastructure also contributes to climate change, since energy consumed in its construction and operation often generates GHG emissions. Climate-resilient, energy-efficient infrastructure is a key component of health promotion.

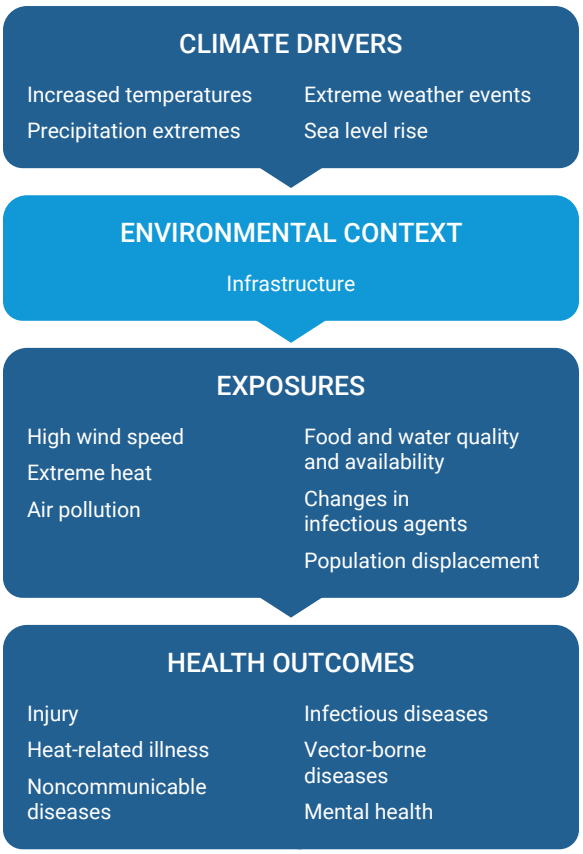
Climate change can severely damage or destroy infrastructural facilities, by driving extreme weather events, increasing temperatures, and rising sea levels *(2)*. Especially in low-income areas, Caribbean infrastructure is generally not built to climate-resilient standards. Infrastructure is a major environmental mediating factor between climate drivers and exposure pathways that affect health outcomes, as illustrated in Figure 9.

Caribbean case study

In 2017, Hurricane Maria damaged roads and bridges in Dominica, resulting in delays in truck-borne removal of 1.5 million m² of solid waste. Water pipes and power lines above ground, wastewater treatment facilities, sewer systems, agriculture, and food distribution facilities were

FIGURE 9

The mediating role of infrastructure in pathways between climate change and health



Source: Adapted from U.S. Global Change Research Program. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. Crimmins A, Balbus J, Gamble JL, Beard CB, Bell JE, Dodgen D, et al., editors. Washington, D.C.: USGCRP; 2016. Available from: https://www.healthandenvironment.org/docs/ImpactsClimageChangeHumanHealthUSGlobalChangeResearchProgramSmall2016.pdf.

damaged. Surveillance data showed a rise in gastroenteritis cases compared with previous years, potentially linked with the breakdown in sanitation *(3, 4)*.

Urban vulnerabilities

In urban areas narrow spaces between buildings trap heat, and artificial surfaces such as roads absorb and re-emit more heat than plants and water do *(5)*. This "urban heat island effect" amplifies extreme heat exposure (see Chapter 6).

Buildings close to each other, dense populations, and warm conditions also provide ideal conditions for multiplication of *Aedes aegypti*, the mosquito responsible for most cases of vector-borne diseases in the Caribbean *(6)*. Air pollution is aggravated by traffic congestion in hot conditions.

Much infrastructure in the Caribbean is dedicated to the use of private vehicular transport and does not encourage active transport (walking and cycling) and other physical exercise. Most roads do not have sidewalks. There are few green spaces and even fewer cycle lanes.

The coastal location of most inhabited areas in the Caribbean creates additional infrastructural risk from sea level rise and storm surges *(7)*.

Caribbean evidence

While researchers have projected likely health scenarios from information on climate change and infrastructure in the Caribbean, primary research is severely lacking. A study in Barbados examined how infrastructure design, such as the provision of shaded walkways, influenced walking behavior and risk of NCDs *(8)*.

What should be done?

Individual and community actions and how to support them



Address inequities in access to climate-resilient infrastructure

Many people in the Caribbean live in substandard housing in hazardous locations with limited access to basic utilities. Inequitable access must be addressed as part of infrastructural mitigation and adaptation strategies *(9)*. Local, traditional, and indigenous involvement in decision-making can help optimize environmental conservation and health *(10)*. Coordination between national and local government and civil society can help multiply health gains and distribute them fairly *(11)*.

Modern building designs should incorporate traditional Caribbean architectural features to adapt to climate change, such as ventilation, shade, and elevated structures to mitigate flooding.

Empower communities to have safe, green facilities

Education, financial grants, and incentives should be provided to enable communities to build and maintain climate-resilient (safe) and environmentally sustainable (green) homes and other facilities. For instance, homeowners can use resilient materials, install solar panels, and harvest rainwater. Collective education and action, such as preventing dumping of solid waste in waterways, can prevent health hazards such as flooding.

Government and private sector actions

Adapt infrastructure and building codes to climate change in the Caribbean

Infrastructure in the Caribbean must be constructed to safe, sustainable standards, to withstand severe weather events and ever hotter and drier conditions without cracking, melting, or crumbling. These considerations should inform revisions to building codes and other legal requirements for design and modification of infrastructure.

Modern building designs should incorporate traditional Caribbean architectural features, such as ventilation, shade, and elevated structures to mitigate flooding (Figure 10).

Invest in environmentally sustainable infrastructure with health co-benefits

Adding plants and water features to public buildings (e.g., rooftop gardens) and spaces – also known as "green" and "blue" infrastructure development – mitigates climate change while promoting health by reducing heat and air pollution and encouraging exercise *(12)*. Walking and cycling reduce reliance on automobiles, reducing vehicle emissions and improving public health. Infrastructure should include parks, playgrounds, cycle lanes, and shaded footpaths *(8, 11)*. Governments should incentivize renewable energy adoption and recycling through tax breaks and public education. Wastewater recycling should be required to reduce climate change-induced water stress.

Include infrastructure in disaster preparedness and response

Safeguarding infrastructure is one of the five pillars of the Caribbean Resilience Framework *(13)*. Disaster preparedness and response must include resilience-building for public utilities, health facilities, shelters, and facilities for storing and distributing medication and food.

Design should be sensitive to social vulnerabilities. For instance, hurricane shelters should be designed with separate areas and entrances for men and women, to prevent violence against women.

Form multisectoral partnerships for infrastructural development

Partnership and coordination between environmental, health, transport, urban planning, design, and construction agencies across public and private sectors are essential for securing climate financing and ensuring projects enhance both health and resilience. Insurance companies can incentivize climate-resilient construction. Economists should be involved in cost-benefit analyses.

FIGURE 10

Climate adaptation in old and new architectural styles in the Caribbean

Adaptation to heat

- Jalousie windows
- Verandas
- Porticos
- Gable windows
- Short piers for air flow

A traditional "gingerbread" house in Trinidad and Tobago



© C. James Hospedales

Adaptation to flooding

- Elevation of the house on stilts

A house on stilts in Trinidad and Tobago



© Himawatee Baboolal

Housing ill-adapted to climate change

- Single-story houses built on flat land, with poor drainage
- Small windows with little natural ventilation

Typical housing construction in the twenty-first century for low-income neighborhoods in the Caribbean



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What do we need to know?

Research gaps and how to address them



Build the Caribbean body of knowledge on infrastructure, climate change, and health

Research gaps include:

- Longitudinal studies to identify the health impacts of infrastructure projects in relation to climatic conditions.
- Archiving and reviewing health and environmental impact assessments.
- Identifying health hazard hotspots arising from climate change and opportunities for infrastructural adaptation.
- Developing safe, green housing options for low-income and geographically vulnerable communities.
- Assessing the suitability of traditional Caribbean building models in the current context.
- Identifying green mobility and exercise infrastructure solutions for tropical climates.



Conduct policy research

The policy environment can be enhanced by:

- Examining the framework of laws and regulations concerning infrastructure through a climate and health lens.
- Cost-benefit analyses of infrastructure, including "green" and "blue" urban redevelopment projects.
- Measuring health and environmental impacts on subpopulations.
- Identifying and documenting finance strategies and sources.
- Conducting implementation research on how best to adapt global good practice to Caribbean contexts.
- Researching how to connect health and infrastructure experts and officials to build multisectoral strategies.
- Using tools to assess the costs and health-related benefits of infrastructure development, including the Health Economic Assessment Tool for walking and cycling (HEAT) *(14)* and the GreenUr tool *(15)*.

Surveillance gaps and how to address them



Develop and use integrated environmental and health monitoring of infrastructure

To assess the effects of infrastructure on the climate change/health nexus, longitudinal data are needed on health, including impacts on vulnerable groups; weather/climate conditions; energy use and water consumption by facilities; and air and other environmental pollution from facilities. In the absence of preexisting longitudinal data, data should be collected before and after infrastructure construction and at regular time points during use of facilities, including savings in energy and water use. Environmental impact assessments should include health and meteorological data.

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16. Smart health facilities

What is happening?

In the face of climate change, it is essential that health facilities remain places of safety and effective health care. However, climate change itself may compromise health facilities, via hurricanes, sea level rise, extreme heat, and other manifestations. The need for climate-resilient health infrastructures, technologies, and supply chains, accessible and capable of functioning during and after extreme weather events, is ever more urgent *(1)*.

The health system contributes an estimated 5.2% of global carbon emissions *(2)* and therefore has an important role in mitigation. There are major opportunities for the health sector to minimize its environmental footprint, conserve resources, reduce pollution as a cause of ill-health, and reduce GHG emissions *(3)*.

Smart health facilities unite disaster resilience with sustainability, combining adaptation and mitigation measures to safeguard against climate impacts while minimizing environmental harm. A facility that is both resilient and eco-friendly is considered "Smart" (Safe + Green = Smart) *(4)*.

The Caribbean situation and evidence

In Latin America and the Caribbean 67% of hospitals are in areas assessed to be at high risk of disaster *(5)*, often near coasts, exposed to storm surge and sea level rise, flooding, and landslides *(6)*.

The Smart Health Care Facilities in the Caribbean Project (2012–2022) was implemented by PAHO, supported by the United Kingdom Government's Foreign, Commonwealth and Development Office across seven countries. Initially focusing on hospitals' disaster resilience, it evolved to include other health facilities and an additional focus on environmental sustainability. Components of the project included a Smart toolkit to guide action and measure progress on disaster resilience (using the Hospital Safety Index [HSI]) and sustainability (using the Green Checklist); employment of contractors to retrofit 55 facilities across seven countries; use of "check consultants," experts who monitored progress throughout the project; and training of staff in emergency planning and the new systems *(4, 7–9)*. Areas of action included:

- Adaptation to hurricanes, e.g., enhancement of infrastructural wind resistance;
- Adaptation to drought and heavy rainfall, e.g., rainwater harvesting in response to drought and to direct and control heavy rainfall runoff;
- Adaptation to high temperatures, e.g., use of ventilation and sustainably powered cooling equipment;
- Mitigation, e.g., reduction in water and electricity consumption, using sustainable energy;
- Maintenance, e.g., use of a specific budget for preventive maintenance.



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HSI data showed that there were statistically significant pre-post Smart improvements across all 55 retrofitted facilities *(9)*. Twenty-eight facilities had reached the project "gold standard," meaning that they attained an A grade on the HSI (indicating that they can protect occupants and function during disasters) and a minimum 70% score on the Green Checklist *(5)*. Significant reductions in water and energy consumption were also demonstrated *(10, 11)*.

Further observations from project evaluation included:

- Ongoing monitoring, evaluation, and preventive maintenance of Smart infrastructure are vital for sustainability. The Smart toolkit *(4)* provides useful guidance.
- Retrofitted facilities included health centers serving fewer than 50 patients, elder- and child-care homes, and hospitals of various sizes, showing model applicability across diverse settings.
- The Smart concept is evolving into a movement. It was adopted by other sectors (e.g., education) and additional Caribbean countries. Countries received funding from other funders to scale up the program.
- The model is not yet fully or formally adopted by governments or supported by Smart building codes for health facilities *(7–9, 11)*.

The project focused on health facilities, and it is important to note that other aspects of the healthcare system can benefit from implementing

The need for climate-resilient health infrastructures, technologies, and supply chains, accessible and capable of functioning during and after extreme weather events, is ever more urgent.

climate resilience and sustainability strategies. For example, most GHG emissions from the health sector (71%) are from the healthcare supply chain, through production, transport, and disposal of goods and services, such as pharmaceuticals and other chemicals, food and agricultural products, medical devices, hospital equipment, and instruments *(3)*. This highlights the need for collaboration between agencies (see Chapter 10) to build low carbon and climate-resilient health systems *(1)*.

What should be done?

Individual and community actions and how to support them



Provide public information on Smart health facilities

Information from Smart health facilities to surrounding communities can empower them to use the facilities effectively, and to be better at anticipating, predicting, responding to, and recovering from climate extremes *(6)*. In the Smart Health Care Facilities in the Caribbean Project, welcome billboards and banners on health centers, press releases, and social media were used to inform the public about the Smart facilities *(12)*. Opportunities can be taken to educate the public about health consequences of climate change, such as heat-related illness, and how features of the facility (e.g., green cooling technology) can help address health and sustainability issues. How facilities can assist in the event of a disaster should also be communicated (see Chapter 13). Health facility managers, healthcare professionals, and the ministries responsible for urban planning, the environment, and health could also benefit from education about Smart health facilities.

Government and private sector actions



Develop and implement Smart health facility policies and legislation

Policy and legislative measures are needed to enhance public and private health facilities' climate resilience and environmental sustainability. The following actions are suggested.

- Scale up the PAHO Smart Hospitals Initiative in the Caribbean, building on the lessons learned from the PAHO Smart Health Care Facilities in the Caribbean project.
- Set regional and national standards, with monitoring, evaluation, inspection, and accreditation systems based on frameworks such as the HSI and the Green Checklist *(4, 5, 7)*.
- Include Smart standards in health facility building codes and regulations, and in terms of reference for building and retrofitting projects.
- Assign responsibilities for Smart standards at national, municipal, and health facility levels.



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- Establish systems and resources for maintenance of Smart facility features so that they stay Smart *(10, 11)*.
- Involve associations of professional engineers and ministries responsible for public works and the environment in planning Smart projects, including ensuring access to facilities by enhancing the climate resilience of roads, transport, and utilities *(7)*.
- Maintain a Caribbean regional network of check consultants to support the program *(7)*.
- Incorporate the development of Smart health facilities into Health National Adaptation Plans, disaster preparedness and response plans, with funding strategies to support these plans *(13, 14)*.
- Provide and sustain training on standard operating procedures for staff and contractors showing how to maintain Smart standards and what to do in the event of disaster.
- Multiply the impact of existing Smart facilities by involving their leaders and staff in mentoring, training, and planning to expand the initiative *(6)*.
- Minimize the health facility supply chain's environmental impact by procuring from suppliers that minimize waste and use sustainable energy and materials *(3)*.
- Use local resources whenever this can be done without compromising resilience and sustainability.
- Consult local communities and health facility staff about features that would facilitate the use and efficacy of Smart facilities. For example, offering appointments in the early morning and evening may reduce extreme heat exposure in traveling to facilities, for both patients and staff, and can reduce energy needs for cooling during the hottest parts of the day.
- Maximize health co-benefits of mitigation for patients and staff; for example, by providing more green areas with trees, and plant-based foods *(6)* (see Chapter 15).

What do we need to know?

Research gaps and how to address them



Conduct research on health outcomes of Smart health facilities

Research should explore the effectiveness of Smart health facilities to improve public health outcomes, e.g., by examining mortality and morbidity outcomes, or continuity of provision of key services, using longitudinal designs that compare outcomes before and after facilities become Smart, as well as facilities with and without Smart features, controlling for other factors that may affect outcomes *(9)*. Strengthening of surveillance of climate-sensitive diseases is needed to facilitate such research (see Chapter 11). Cost-effectiveness studies can further enable policy decisions.



Evaluate Smart health facility strategies

Both quantitative and qualitative research are needed to identify operational and behavioral factors associated with Smart achievements, as measured by extent of damage in the event of disaster, environmental and health indicators, and instruments such as the HSI and Green Checklist. Potential areas of study include:

- Government leadership in implementing Smart health facilities;
- Changes in the policy environment, such as building codes and their enforcement;
- The existence, coverage, and quality of standard operating procedures and staff training;
- Perceived strengths and weaknesses of Smart versus other facilities according to key constituencies such as staff, patients, local communities, suppliers of goods and services to facilities, and vulnerable populations such as PLWNCDs and Indigenous people;
- Funding strategies and budgetary allocations;
- Engagement of the private sector in Smart health facility projects;
- Communication to mobilize political and popular support for Smart projects;
- The efficacy of local materials in building resilient facilities; e.g., the use of local timber rather than aluminum for storm shutters *(10, 11)*;
- Value for money of preventive maintenance *(7)*;
- Strategies for efficient water, electrical, and cooling systems in resource-constrained Caribbean settings *(11)*.

Surveillance gaps and how to address them



Monitor inputs, processes, outputs, and outcomes of Smart health facilities

Effective management of Smart health facilities requires strong information systems, including recording, costing, and measuring inputs (e.g., materials used), processes (e.g., preventive maintenance, supervisory systems), outputs (e.g., number of people trained), and outcomes (e.g., HSI and Green Checklist scores, morbidity, and mortality). Monitoring of potential cost savings from use of sustainable technologies, e.g., for electricity and water, should also be conducted. These information sources should be combined with meteorological data to assess the resilience of facilities under Caribbean climate conditions. Findings should be shared in public information initiatives, as recommended above.

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DOMAIN 4

Resources and engagement for action

17. Funding streams

What is happening?

In policy and public discussions and plans on climate change in the Caribbean, there is limited focus on health (see Chapters 13 and 18), although a large percentage of national resources is spent on health. Finances to address climate change impacts in the region are, likewise, rarely directed to health. However, there are positive developments, such as the inclusion of resources and finance as a Strategic Line of Action in the *Caribbean Action Plan on Health and Climate Change (1)* and its proposed second version. Health is mentioned in Nationally Determined Contribution (NDC) documents submitted by Caribbean countries as part of their Paris Agreement commitments *(2)*, and SIDS representatives are global leaders in highlighting costs of addressing CC&H challenges *(3)*.

Fulfilling these promising developments requires not only orienting finances toward CC&H *(4)* but substantially increasing overall funding, which has been highly dependent on external sources. This chapter presents the troubling scale of Caribbean climate finance challenges, initiatives to address these, and the extent to which CC&H considerations are addressed.

The scale of the challenge

Caribbean countries' small size and limited resources create acute economic vulnerability, as climate-related disasters generate progressive financial losses that trap countries in cycles of debt and rebuilding *(5–7)*, placing the region at risk of falling into greater poverty if durable climate change adaptation measures are not implemented.

The financial burden is staggering. Dominica experienced Tropical Storm Erika in 2015 and Hurricane Maria in 2017, which collectively caused losses equivalent to 300% of its GDP, with housing, transport, education, agriculture, and electricity – all health-determining sectors – sustaining the greatest damage *(8, 9)*. The country's Climate Resilience and Recovery Plan *(10)* requires approximately USD 3.3 billion, with ambitious 2030 targets including restoring 90% of power within three days and ensuring no more than 5% of healthcare facilities are severely damaged by weather events. By 2020, only 19% of required funding had been secured, and it was estimated that by 2030, a 33% funding gap would remain, even with identified sources *(10)*.

Jamaica's experience with Hurricane Melissa in October 2025 further illustrates the challenge, even for larger islands. Jamaica was still recovering from Hurricane Beryl in 2024 when Melissa struck, indicating the potentially growing challenge, also illustrated by Dominica above, of not having recovered from one event before another hits. Despite Jamaica's disaster preparedness measures, including

parametric insurance[6] that triggered immediate payouts of USD 241 million *(6, 11, 12)*, recovery and resilience costs associated with Hurricane Melissa were estimated at a staggering USD 10 billion; yet only USD 1 billion in funding sources had been identified by November 2025 *(12)*. While the Government of Jamaica has discussed post-hurricane financial needs with development banks and international financial institutions, most of the proposed solutions consist of loans, which are conditional and add to the country's debt burden *(13)*.

Climate change also destabilizes the financial sector itself. Post-hurricane deposit withdrawals force banks to reduce lending to households and businesses, hindering economic recovery and increasing reliance on government assistance *(14)*. The emerging international trend of insurance companies withdrawing from high-risk areas threatens to compound these vulnerabilities *(15)*. At least one Caribbean central bank has indicated concern about the economic impacts of climate change and is adapting internal operations and external investment strategies, and expanding public dialogue *(16)*.

Caribbean health system resilience should be included in wider climate adaptation and mitigation initiatives, with dedicated plans and budgets for climate change and health at national, municipal, and international levels.

Global finance gaps

Despite successive United Nations climate conferences setting finance targets, pledged funding remains largely unfulfilled, creating disillusionment across low- and middle-income countries. Funding for The Fund for Responding to Loss and Damage *(17)*, established in 2022 after three decades of advocacy by the Alliance of Small Island States, represents less than 0.2% of the annual need *(6, 18, 19)*. Its voluntary nature and lack of explicit compensation mechanisms severely limit its effectiveness, with most funding directed toward adaptation rather than addressing losses *(18)*.

The amount of funding available from climate funding entities for individual projects is generally up to a few million dollars, forcing countries to seek funding from various sources to meet the full costs of adaptation and mitigation. Health initiatives are rarely included in funders' portfolios *(20)*. Caribbean climate change adaptation projects by the Adaptation Fund, Climate Investment Fund, and Global Environment Facility focus on

6 Parametric insurance pays out fixed amounts immediately for the occurrence of a predefined event, such as a hurricane of a specified strength, offering fast, transparent claims processing compared to traditional insurance.



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health determinants (e.g., flooding resilience, coastal rehabilitation, pollution, food security, and water management) but not health systems directly. Few of the Caribbean projects supported by these entities focus on energy *(21–26)*. PAHO's Smart Health Facilities initiative stands as one of few programs explicitly dedicated to health system resilience (see Chapter 16).

Systemic barriers

Caribbean SIDS encounter multiple obstacles in accessing available finance: complex eligibility criteria, lengthy preparation timelines, and limited institutional capacity *(9)*. Most Caribbean nations are classified as high- or middle-income countries, disqualifying them from concessional loans and grants despite their extreme climate vulnerability. This income-based categorization creates what one Caribbean researcher described as "almost like a segregation system" that prevents collaborative regional studies *(27)* and comprehensive responses to shared vulnerabilities (see Chapter 10).

Despite four international conferences on SIDS and persistent advocacy *(18, 28)*,

efforts to establish special development finance conditions for SIDS have achieved limited success. Caribbean SIDS receive proportionally less international climate finance than other regions and rely heavily on bilateral aid and individual country applications rather than coordinated regional mechanisms *(29)*.

Caribbean innovation and optimization strategies

Caribbean leaders have expressed their deep concern about the economic impacts of climate change *(30)* and responded with innovative financial self-help initiatives. The Bridgetown Initiative, launched in 2022 by Barbados Prime Minister Mia Amor Mottley, proposes radical global financial system reforms to increase climate funding, channel more resources to vulnerable countries, and reduce debts *(9, 31, 32)*. It has achieved significant successes, including debt pause clauses for SIDS and rechanneling USD 100 billion in International Monetary Fund reserves toward global resilience funding *(32)*.

As of 2025, the Caribbean Catastrophe Risk Insurance Facility (CCRIF), the world's first multicountry risk pool, has made 82 payouts totaling USD 483 million, offering parametric insurance for multiple disaster types *(33)*. Its 2025 Livelihood Protection Policy extends microinsurance to vulnerable populations including fisherfolk and farmers *(34)*. Jamaica's USD 150 million Catastrophe Bond added to its USD 91 million payout from the CCRIF following Hurricane Melissa, demonstrating the value of innovative financial instruments *(11)*.

The Caribbean Development Bank uses resources from Caribbean Borrowing Member Countries and external donors to support climate resilience projects, investing mostly in resilient infrastructure, water management, and agriculture. In 2024, it secured accreditation from the Green Climate Fund to increase its project development capacity to USD 250 million per project *(35)*.

Some Caribbean banks and insurance companies are funding health promotion and climate resilience projects as part of their environmental, social, and governance strategies *(36–39)*.

Critical gaps

Analysis of 16 Caribbean countries' NDC documents reveals that most climate activities depend on international financing *(40)*, yet countries provide minimal information on financing health goals *(2)*. Caribbean governments generally lack dedicated CC&H policy strategies and budgets *(2, 29, 40)*, highlighting the urgent need for integrated financial planning that explicitly addresses health system resilience within broader climate adaptation strategies.

What should be done?

Individual and community actions and how to support them



Increase community organizations' access to funding

CSOs play a vital role in developing and implementing locally appropriate, equitable, and effective CC&H

strategies (see Chapters 9 and 10), but funding is scarce and difficult to access. Governments, donors, and technical agencies should increase funding availability; simplify application processes; create databases of financial opportunities; build skills in grant writing and project management; provide training and support in community risk assessment; and accelerate payments.

Government and private sector actions



Advocate at the international level for CC&H funding for Caribbean SIDS

Caribbean leaders and civil society should continue their stalwart advocacy for climate justice in global allocation of adaptation, mitigation, and loss and damage resources (see Chapters 9 and 18) and promote strategies for systemic reform in climate and development funding (e.g., funding based on country vulnerability rather than income classification) such as the Bridgetown Initiative. There is also a need to include CC&H in advocacy *(4)*. Funding should be sought through regional bodies such as CARICOM, the Caribbean Community Climate Change Centre, CARPHA, and UWI. Capacity to mobilize resources may be enhanced by awareness-raising with policymakers, the private sector, and CSOs on CC&H and available funding opportunities (see Chapter 13), and by developing regional and national grant writing expertise. Research and surveillance are needed (see Chapter 11) to orient strategies and present convincing information to funders. Costing of CC&H strategies should be included in NDCs *(40)*.



Enhance regional CC&H resilience through financial self-sufficiency

Given the deficiencies in international CC&H financing, CC&H funds must be generated and dedicated locally to enhance sovereignty and CC&H resilience. Recommendations include:

- Dedicate portions of national and municipal budgets to CC&H adaptation, mitigation, and disaster preparedness and response.
- Sustain regional and national parametric insurance initiatives *(6, 11, 33, 36)*, involving public and private investors, including products that protect health and livelihoods of vulnerable populations from disasters, such as PLWNCDs and farmers *(34)*.
- Develop banking resilience strategies, such as raising reserve requirements during hurricane season and lowering them in response to hurricanes and during times of lower risk *(14)*.
- Include costing and identify national, regional, and international funding sources for activities proposed in NDCs and Health National Adaptation Plans (H-NAPs) *(2)* (see Chapter 18).
- Leverage relationships with the Caribbean diaspora to involve them in CC&H strategies and finance.
- Develop fiscal strategies to encourage resource conservation and transition to sustainable energy *(40)*.
- Nurture public–private partnerships and develop investment and sponsorship opportunities for CC&H projects and activities, ranging from infrastructure to health fairs *(37)* (see below).



Encourage private enterprise involvement and partnerships

Involvement of the private sector is critical to enhance delivery, innovation, finance

mobilization, and the scale of the CC&H response. Adaptation roles of the private sector include construction of climate-resilient infrastructure and utilities; provision of insurance products *(39)*; supply chain continuity planning; and technology and data management for EWSs, analytics, interoperability of information systems, and telemedicine *(41)*. The sector can play a critical role in mitigation through application of renewable energy solutions and circular economy models. Governments should play a coordinating role and facilitate appropriate private sector involvement *(42)* through partnership agreements with criteria to exclude companies with conflicts of interest and health-harming practices; fiscal and trade policies; environmental and public health regulation and legislation; and maintenance of their own public health responsibilities (see Chapter 18). To unlock private sector finance, the ease of doing business should be improved (e.g., reduce regulatory bureaucracy), access to credit for green investments expanded, and knowledge and training increased on CC&H investment opportunities *(29)*.

What do we need to know?

Research gaps and how to address them



Conduct economic research on CC&H

Providing cost information is critical to seeking and organizing funding *(40)*. Areas for economic research include:

- Risk assessment, modeling, and cost calculations of health outcomes, damage, and loss scenarios relating to CC&H, including damage to health facilities and health-determining infrastructure such as water supply; biodiversity loss; infectious disease outbreaks; additional morbidity and mortality from NCDs; reduced food security; pollution; and loss of livelihoods.
- Costs and cost savings of adaptation and resilience measures and "building back better"; i.e., costs of implementing recommendations put forward in this report, including processes such as community involvement, and establishing and maintaining assets such as Smart health facilities.
- Cost-benefit and cost-effectiveness analyses at all levels – from regional and national initiatives to individual projects, taking account of health, environmental, and social outcomes.
- Identification of funding streams and appraisal of their suitability.

Surveillance gaps and how to address them



Monitor funding and costs of CC&H action

Management and accounting systems should be put in place to record information about funding and costs of every stage of CC&H action, including:

- Sources and amounts of funding and other resources;
- Processes – how and why resources were allocated;
- Outputs – e.g., number and type of resilient facilities constructed.

Monitoring data should be made accessible to facilitate the research recommended above.

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18. Government engagement

What is happening?

Effective leadership and governance are essential for addressing the impact of climate change on health *(1)*. These involve developing evidence-based strategies, resourcing and coordinating them across the health system, including areas such as training, service delivery, health information, public health, and procurement. Strategies must also encompass health-determining sectors such as energy and transportation (see Chapter 10) *(2)*.

Caribbean government and civil society leaders are active on the global stage in advocating for action to protect SIDS from climate change. They have emphasized the importance of the 1.5 °C climate change target that was eventually incorporated into the Paris Agreement *(3)*. They continue to call for climate justice in the allocation of resources to SIDS to adapt and recover from the damage arising from GHG emissions from the industrialized North *(4, 5)*. Most of the national leaders who discussed links between CC&H at the United Nations General Assembly in 2022 were from SIDS *(6)*. There are frequent and increasing references to health in Caribbean NDC documents, where governments set out their climate change action plans *(7, 8)*.

Until 2015, political action on climate change was separate from that on health. In the Caribbean, the 2009 Liliendaal Declaration and the 2009–2015 Caribbean Regional Framework for Achieving Development Resilient to Climate Change *(9, 10)* did not speak to health issues. In 2014, the SIDS Accelerated Modalities of Action (SAMOA) Pathway, prescribed at the Third International Conference on SIDS, focused on climate change *(11)*.

In 2015, the preamble of the Paris Agreement indicated that, when taking action to address climate change, parties to the agreement should respect, promote, and consider their respective obligations on the right to health *(12)*. The UN SDGs *(13)* and the Sendai Framework for Disaster Risk Reduction *(14)* provide guidance and support for sustainable development while presenting health issues and strategies.

Launched by WHO in 2017, the Special Initiative on Climate Change and Health in SIDS aims to make health systems in SIDS resilient to climate variability and change by 2030 *(15)*. In 2018, as part of this initiative, a meeting was held in Grenada at which the *Caribbean Action Plan on Health and Climate Change* was developed by Caribbean governments *(16)*. This plan aims to protect the health of Caribbean populations from climate change via Strategic Lines of Action: Empowerment (supporting health leadership), Evidence (strengthening evidence for action), Implementation (implementing mitigation and preparedness actions), and Resources (facilitating access to climate and health finance). As part of this initiative, PAHO provides support

Governments play critical roles in strengthening the health systems response and addressing health determinants in areas such as building, pollution, sanitation, air, and food quality standards, protecting biodiversity, and equal opportunities.

to countries for the development of H-NAPs *(16)*. In 2016, Phase IV of the Caribbean Cooperation in Health Initiative included "Safe, resilient, healthy environments" as a strategic outcome, including commitment to improve regional health security through actions to manage and mitigate the effects of climate change *(17)*.

While Caribbean leaders articulate CC&H challenges and sign international CC&H agreements, transposing these into effective domestic policy appears difficult. A minority of the NDCs of Caribbean countries provide health targets aimed at increasing climate resilience and there is almost no information on how they intend to meet their health goals *(8)*. Some Caribbean countries have completed Health Vulnerability and Adaptation Assessments *(18)*, but fewer have developed H-NAPs as part of their climate change adaptation strategies *(19, 20)*. Challenges identified include lack of integration of the health sector and evidence of health impacts in climate change policymaking processes, as well as lack of expertise, data, and funding *(6, 18, 21)*. Another outcome of the Caribbean Action Plan, the European Union/CARIFORUM project, Strengthening Climate Resilient Health Systems, has provided resources for CC&H capacity-building projects implemented by six Caribbean regional institutions *(21)*. However, climate change policymaking and health policymaking continue generally to follow separate paths.

Caribbean evidence

Information on government engagement in CC&H in the Caribbean is mostly in documents provided by agencies on their own work and in commentaries by experts, such as those presented at the 2021 Conference on CC&H in the Caribbean.

Empirical research on Caribbean governments' work to address CC&H includes monitoring of leaders' statements in United Nations meetings and the inclusion of health in national climate change strategy documents *(6, 8, 22)*. Caribbean countries are included in a global review of progress in conducting vulnerability and adaptation assessments *(18)*.

A couple of studies point to lack of integration of health into climate change planning and policy processes as impediments to CC&H action *(8, 18)*. Original research and monitoring must increase to enable evaluation of the implementation of plans and their effectiveness.

What should be done?

Individual and community actions and how to support them



Empower leaders with knowledge

Policymakers generally recognize climate change but often do not appreciate the connections to health. Professional bodies and NGOs can raise awareness through advocacy and involving policymakers in community events.

Strengthening the evidence-base is critical to promoting action that will be effective in the Caribbean context (see Chapter 11). Evidence must be presented in accessible formats for policymakers, using policy briefs with language and infographics that appeal to the "head, heart, and pocket." Briefs should include information on effective interventions and health care, and labor productivity costs of inaction.

CC&H education for government members can assist. For example, in Argentina, under "Yolanda's Law," there is mandatory education on climate and environment for members of the government's executive, judiciary, and legislature *(23)*.

Government and private sector actions



Join up siloes and coordinate action

Collaboration between agencies is critical (see Chapter 10). Government leaders must ensure that the health sector is integrated in climate change decision-making and that health policies address climate change *(6, 18)*. The *Caribbean Action Plan on Health and Climate Change* includes institutional strengthening measures to be taken *(16)*. Leaders should also pioneer and support joint approaches between health and health-determining sectors such as public utilities. Effective collaborative mechanisms should be established between national and local government entities responsible for implementation on the ground *(24)*.

The private sector can significantly influence health determinants through partnerships with government in areas such as health insurance, transportation, energy, telecommunications, and tourism *(25, 26)*. Private sector involvement is crucial for adaptation and mitigation *(27)*.

CSOs often serve as environmental champions and first responders to emergencies. Governments should build their capacity, improve their access to funding, ensure community outreach components of policies are met, and promote bottom-up approaches to environmental issues *(28)*.

Given their small size, Caribbean countries should establish data-sharing agreements and share evidence, so that each country can build on collective knowledge.

International collaboration is also critical. Leaders must optimize national self-sufficiency and sustainability while leveraging appropriate international partnerships with political, technical, financial, and academic institutions *(29)*.



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Establish and enforce legislation

Caribbean governments must protect citizens' health through laws and regulations addressing environmental and social determinants of health *(6)*. Areas needing stronger legislation and enforcement include building codes, climate-resilient housing, pollution controls, water and sanitation services, air and food quality standards, protection of land and ocean biodiversity, environmental impact assessments, and equal opportunities for all.

Treaties must be transposed into national law to have legal force. Appropriate legislation can be developed by referring to national constitutions of Caribbean countries which assert the right to an environment that is not harmful to health *(30)*. Health standards must be integrated in laws concerning climate change adaptation and disaster management *(31)*. The Caribbean Public Health Law Forum, which brings together Caribbean professionals from ministries responsible for both health and legal affairs, can assist in legal development *(32)*.

Invest in green initiatives with health co-benefits

Studies calculating the cost savings from including climate change adaptation and mitigation in infrastructural design have shown that benefits, including healthcare savings, outweigh the costs *(24–33)*. National and local governments should invest in blue-green infrastructure, incentivize electric vehicles,

promote renewable energy, encourage active transport through urban planning, reduce oceanic pollution, and protect coastal zones (see Chapters 14 and 15).



Address inequities

Vulnerable populations should be protected through legislation (see above) and their rights addressed through bottom-up approaches to environmental and health issues and community participation in impact assessments *(28, 34)*. Research and surveillance data should be disaggregated by area, gender, and age to enable tailored interventions (see Chapter 9).

What do we need to know?

Research gaps and how to address them



Strengthen research and surveillance capacity

Leaders should support the recommendations from Chapter 11: "Research and surveillance," to provide the evidence base they need for action. Strategic control and sustainability will be enhanced by increasing national and regional investment in research and surveillance skills-building, personnel, institutions, equipment, technology, projects, and programs.



Conduct policy research

Policies enacted and regional initiatives should be documented, monitored, and evaluated for effectiveness. Cost-benefit analyses and intervention trials are needed. There is a pressing need for research to discover how best to adapt good practice in local contexts through implementation science.

For example, research can enhance understanding of progress toward fulfilling components of the Caribbean Action Plan *(16)*, such as the completion of health vulnerability and adaptation assessments *(18)* and the implementation of H-NAPs. Evaluation of the regional project, Strengthening Climate Resilient Health Systems *(21)*, would help enable Caribbean countries to build on lessons learned and the intersectoral and multidisciplinary networks established. Evaluation enhances sustainability.

Surveillance gaps and how to address them



Monitor government engagement

Chapter 11: "Research and surveillance" provided recommendations to develop integrated CC&H surveillance, which can help governments assess the extent to which climate change impacts on health have been addressed. The Lancet Countdown SIDS Centre tracks Caribbean progress on internationally established CC&H indicators, including monitoring CC&H statements and commitments by political leaders *(6)*.

Documentation and monitoring of policy processes and outcomes are also needed. Each H-NAP should include a monitoring, evaluation, and reporting plan that specifies output, process, outcome, and impact indicators, with defined roles, responsibilities, time frames, and reporting requirements *(35)*.

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Caribbean small island developing states (SIDS) face ubiquitous climate change hazards, including flooding, drought, increased hurricane intensity, extreme heat, and sea level rise. The health of Caribbean people is threatened directly by these hazards, and indirectly by features of SIDS that affect health systems' capacities to respond, including the small human resource base, economic fragility, and concentration of populations and infrastructure near coastlines. Climate change impacts disproportionately affect vulnerable groups, such as children, older adults, people living with noncommunicable diseases, low-income families, and outdoor workers.

This publication is a resource for policymakers, health professionals, civil society, and researchers, offering guidance on evidence-informed strategies for strengthening the response to climate change and health challenges. It is based on a regional stakeholder consultation process, which identified 18 priority areas for action, and a review of Caribbean research and surveillance evidence on each of the priority areas.

The *Research for Action Agenda on Climate Change and Health in the Caribbean* includes chapters on each priority area that represent what is happening, what should be done, and what needs to be known in order to achieve climate-resilient health systems. The chapters are organized under four domains: Climate Change Health Impacts, Exposures, and Vulnerability; Adaptation, Planning, and Resilience for Health; Mitigation Action and Health Co-benefits; and Resources and Engagement for Action. Areas for strengthening research and surveillance are identified. The Agenda enables understanding of health effects of climate change and ways to address these in the Caribbean context.

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