

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

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11. RESEARCH AND SURVEILLANCE ON CLIMATE CHANGE AND HEALTH

11.1. WHAT IS HAPPENING?

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

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

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

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

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

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

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

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

Health outcomes

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

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

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

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

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

Exposure pathways

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

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

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

Vulnerabilities to health impacts of climate change

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

Conference papers have identified behavioural, social and economic vulnerabilities of specific populations to social and health impacts of climate change in the region. However, there is a lack of empirical data and research

to identify and pinpoint needs. This prevents the development of action to address inequities in health and achieve climate justice. More precision in identifying populations and areas at risk is needed (Lichtveld, 2021).

Surveillance data for research on health impacts, exposures and vulnerabilities

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

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

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

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

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

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

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

Adaptation, planning and resilience for health

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

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

There is a small but growing body of research on **awareness- and skills-building** on climate change and health in the Caribbean. The number of knowledge, attitudes and practice (KAP) studies is increasing, with some being general population surveys and some using quantitative or qualitative methods to assess the KAP of health professionals. A few studies look at the availability of climate change training for health professionals in the

region. Welcome developments include the emergence of studies that present and evaluate training courses and other capacity-building for health professionals, and research on the effectiveness of media, communications and social influencer methods in altering KAP.

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

Vulnerability

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

Capacity

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

Adaptation

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

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

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

Mitigation actions and health co-benefits

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

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

Resource management and stakeholder engagement

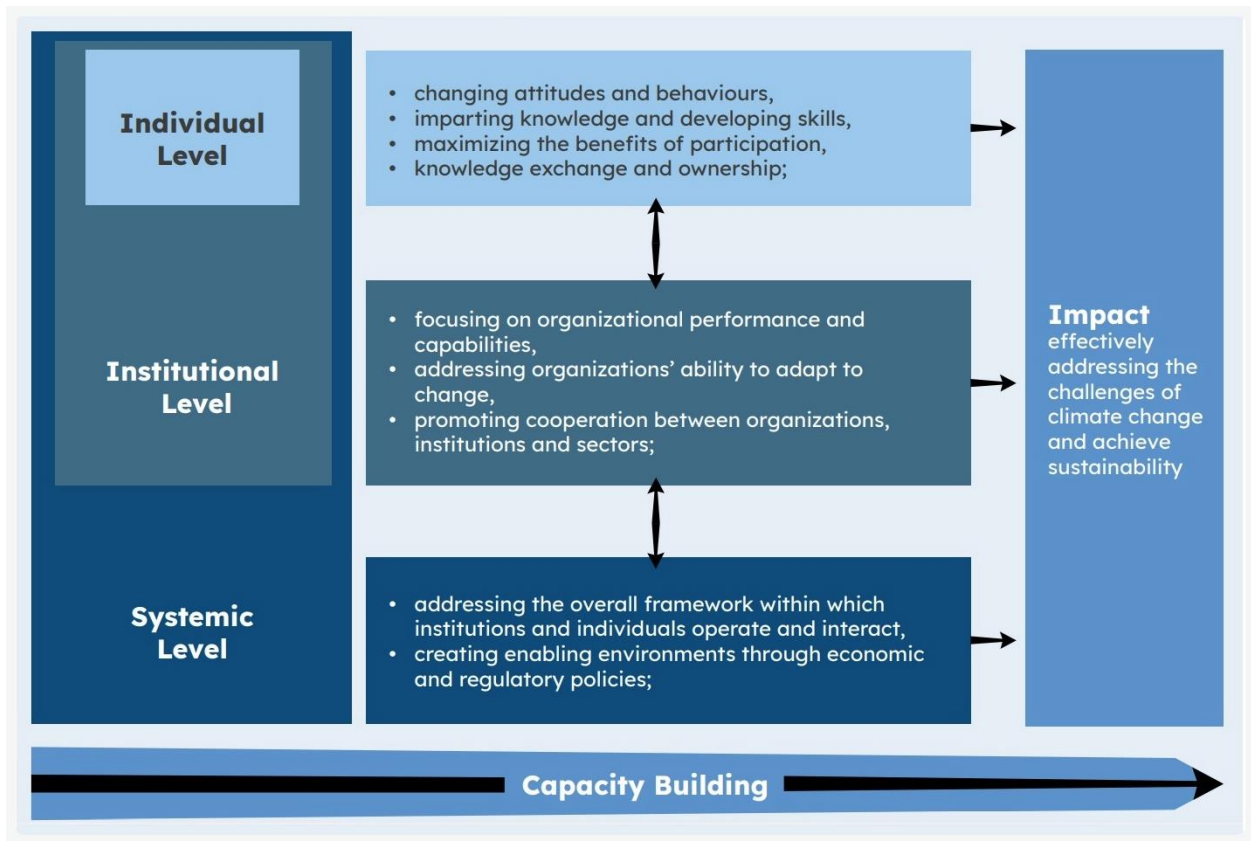
There is very little research on **funding streams** for research and action on climate change and health. As part of regional initiatives to increase access to finance, indicators are being developed to monitor financial flows. There are studies of the economic impact of hurricanes and other tropical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

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

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

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

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



Source: UNFCCC (2021).

Capacities at the individual level

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

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

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

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

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

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

Capacities at the institutional level

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

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

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

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

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

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

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

Data is only collected when there is a programme to collect the data for a particular reason. For example, if there is an outbreak of leptospirosis, we collect data on rodents; if there is a problem with gastro, we do water quality analysis.

Interviewee from the Environmental Health Department, Ministry of Health, Dominica, in Allen et al. (2021a)

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

What we lack in the region are integrated surveillance systems to bring together information from health and climate services.

Interviewee from CARPHA, in Allen et al. (2021a)

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

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

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

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

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

Caribbean region... We have a strong Caribbean community of scientists working on a common agenda for what needs to be achieved to keep [the] Caribbean climate at the level of the other global discussions.

Interviewee from the Climate Studies Group, UWI, in Allen et al. (2021a)

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

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

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

Caribbean nations need to have laws and regulations around data sharing. Some countries have started legislation, particularly Barbados and Jamaica. I'm not sure what's happening with the Eastern Caribbean states. That's a critical thing where we have to talk about the ethics of data sharing.

Interviewee from GA-CDRC, UWI, in Allen et al. (2021a)

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

Interviewee from IGDS, UWI, in Allen et al. (2021a)

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

There are deficiencies in the capacity of some institutions to protect the human rights of research subjects through ethics review procedures. Regional bodies such as CARPHA and CCHSRD have made considerable strides in providing technical support for the establishment of national research ethics review boards or procedures in Caribbean countries. Chief medical officers are generally supported by a panel of local experts in reviewing and approving local health research. Other agencies, such as CARPHA, UWI and PAHO/WHO have their own institutional review boards (IRBs) to review research conducted by or with these institutions. Ministries of health sometimes call upon these IRBs to conduct additional reviews of research proposals, and some proposals are

reviewed by more than one ethics committee. In some of the smallest Caribbean SIDS, there may be a lack of local ethics review skills. Regional institutions such as CARPHA and UWI are among the bodies that can provide support when local ethics review skills are lacking, with the understanding that chief medical officers make the final decision on research proposed for their countries.

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

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

What the Caribbean tended to experience over previous years was data loss. So lots of small studies happen around the region that are really important, but the data is then shipped back off to the US or Europe, and nothing is left behind. There's no system of continuity with respect to data across the board.

Interviewee from GA-CDRC, UWI, in Allen et al. (2021a)

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

Capacities at the systemic level

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

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

One of the challenges we have with the Caribbean governments is that they view research as an expense item. Therefore ideally it is something that they try to keep off their books, and so a lot of the research that is actually done in the Caribbean is being funded primarily by external agencies. Therefore, in a sense as researchers we have to tailor our agendas, not so much for the Caribbean-specific needs, but to suit the external agenda.

Professor Marvin Reid, Deputy Dean for Research, UWI Mona campus, at the Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (Reid, 2021)

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

The Ministry of Health does not have a budget for climate change and health research. Funding has to be sourced externally, through projects, writing proposals, through PAHO and other agencies.

Interviewee from the Ministry of Health, Dominica, in Allen et al. (2021a)

In SIDS, there are also some fundamental resource constraints to research and surveillance, compared with large, industrialised countries of the global North.

You will not get data on everything from all the countries in the SIDS. You also will not get them for the Least Developed Countries either. The problem is this. It's easy to collect data for the OECD [Organisation for Economic Co-operation and Development], but frankly we don't need those data. The OECD are already developed. The less developed countries, the SIDS, the landlocked developing countries and all the ones that have development problems don't collect data, not because they don't want to, but because it's too expensive, because they don't

have the technology, because they may not have the access to science, maybe because they only have two people in that speciality in the entire country, so the data are not collected.

Interviewee from the Institute for Sustainable Development, UWI, in Allen et al. (2021a)

In SIDS, lack of financial and other resources is compounded by challenges relating to small size (such as few or no qualified people with requisite skills in a single state) and other SIDS characteristics. One of these is the precariousness and volatility of financial flows; this may be caused by global fluctuations in the price of the few commodities and services they produce, or by climate change itself, through which climate drivers devastate, or at least damage, entire economies or sectors. The impacts on health can also be extremely damaging economically, as, for example, when Zika and chikungunya epidemics severely reduced the number of tourists coming to the Caribbean in 2015¹⁶. Each of these SIDS characteristics reduces the amount of resources available for research and surveillance. The situation has been aggravated by the global economic downturn associated with the COVID-19 pandemic and the war in Ukraine, which have raised the prices of the imports on which SIDS depend.

Global research funding to address challenges affecting developing countries tends to be channelled according to levels of national income per capita. Some Caribbean SIDS fall into the middle- to high-income categories, and thus miss out on important sources of funding. It has been argued that access to research funding should not be based solely on the measure of income per capita. The vulnerabilities of SIDS to climate change should be taken into account in allocating research and surveillance funding and other forms of support. This is important for climate justice, as a move towards addressing inequities caused by the level of greenhouse gases emitted by developed countries and other practices. It also helps avoid unhelpful divisions between Caribbean countries with shared vulnerabilities regarding climate change and health.

So, the problem with data is not that we don't have the capacity, intellectual or otherwise, to collect it, but the way that funding is set up in the Caribbean – everyone thinks the Caribbean is low middle income, but it's not. So, you always get a patchwork of information and data and studies, because you can't get continuity, you can't get studies that are collaborative enough. So, you know, we have to go and check with the Wellcome Trust, or the MRC [Medical Research Council], to say, well, 'Can Barbados be included in this study?' So, for example this year we are looking to do studies in Saint Vincent and Haiti, but we can't get money to do studies in Barbados ... It's almost like, a segregation system that is not helpful, particularly for the small island states. It does not matter to the World Bank that focuses on larger countries like India while here we are struggling with things like the blue economy and we get decimated. We're always excluded.

Interviewee from GA-CDRC, UWI, in Allen et al. (2021a)

11.2. WHAT SHOULD BE DONE?

Individual and community actions and how to support them

Involve individuals and communities in research and build research and surveillance capacities

There is tremendous potential to draw on the experiences and skills of Caribbean people in addressing climate change and health through research. Involving vulnerable communities in “bottom-up” research for action projects is also critical to achieving health equity and climate justice. There is a need to move from seeing people as victims to recognising their agency and ability to work with others on research projects (MacGuire and Ng Shiu, 2021). Indigenous knowledge and traditional medicine, which are threatened by biodiversity loss associated with climate change, should be drawn on in designing research to develop practical, locally appropriate and acceptable solutions (Boston et al., 2021; R4ACCHC, 2022a).

There should be a two-way rather than top-down exchange between academic experts and local communities (R4ACCHC, 2022b; Reid, 2021). Academic experts should help develop the research skills of local communities and provide them with tools and methodologies for citizen data collection and analyses. For instance, the use of cell phone apps can empower people to record and analyse their findings (R4ACCHC, 2023). The scale of the climate and health challenge is too large for research to be left to a small group of academic researchers. Involving and training community members creates potential for them to be climate and health ambassadors, as well as to contribute to research findings (Lichtveld, 2021; R4ACCHC, 2023). It is important to identify key people in each community who can help organize activities to build the capacity of community members to contribute to research (R4ACCHC, 2023).

An example of good practice from Pacific SIDS is the collaboration between youth organisations and 350 Pacific (www.350.org/pacific/) to design research in line with young people’s priorities. This involved dialogues and focus groups with young people to share knowledge, identify priorities and carry out environmental mapping and literature reviews, with the results shared in research design workshops. Young people were themselves involved in conducting the research (MacGuire and Ng Shiu, 2021).

Professional groups can act as bridges between citizens and conventional experts by collecting data and translating and disseminating findings. For instance, primary-care physicians can play an important role in community-based research and implementation by acting as a link between research findings and implementing these findings within the community (Reid, 2021).

Build and strengthen skills in climate and health research among professionals and laypeople

Colleges and universities can play a critical role in training and accrediting people in applied disciplines and skills areas related to health and climate change research, such as data management, geographic information systems, information technology, laboratory science, meteorology, microbiology, nursing, public health inspection, remote sensing and vector control. Caribbean agencies and governments need to make a concerted and coordinated effort to reach out to more of the many higher educational institutions to encourage their involvement in developing the necessary skillsets. Targets for the number of professionals needed in key areas should be established, and progress in attaining these targets monitored. Graduates of the Climate Change and Health Leaders Programme based at UWI can assist in increasing the number of skilled people through collaboration with a range of higher education institutions.

It is also important to build research skills among people in the general population to facilitate the development of “citizen science” and community-based participatory research. Doing this will strengthen evidence-based practice at community level and increase the amount of information generated for local and national decision-

making. Higher education, academic and technical agencies should offer short courses and conduct outreach to increase the involvement of citizens in research (R4ACCHC, 2023).

Improve communication of scientific information

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

Lalla (2021)

Sustaining good health in the face of climate change depends on providing evidence in ways that large numbers of people, and populations with different characteristics, can access, understand and use. Effective communication can widen access to existing knowledge and facilitate involvement in current research (R4ACCHC, 2023). Attention should be given to the language, presentation and means of communication delivery. Further development of climate information services for health is recommended. This should include EWs for health and environmental outcomes, while noting that communication must be tailored to each audience. Health professionals, schools and civil society organisations can help convey messages in understandable and engaging ways for various audiences. Messages tailored to different audiences should indicate how climate change is likely to affect the health of each audience. Media companies and journalists should receive training in science communication (R4ACCHC, 2023).

Climate information services for health, well, the messaging and language has to resonate with the local context. With a lot of the information that is being disseminated, there is no connect. Dissemination could be done through meetings and forums, reporting back to communities and families. Youth forums and churches are important ways of disseminating information.

Interviewee from University of Auckland, New Zealand, in Allen et al. (2021a)

Mobile apps and social media can be important platforms for the transmission of scientific information in accessible ways (see Chapter 13, “Awareness- and skills-building”).

Structural/governmental and private sector actions

Convince Caribbean governments and the private sector of the value of research as an investment in the future

To be sustainable, dependency on foreign research funds and expertise needs to be reduced, and reliable and consistent local sources of funding need to be developed. National governments have primary responsibility for developing such funding and can help leverage resources from the private sector as well. They must appreciate that developing the evidence base is essential for climate resilience and economic development (R4ACCHC, 2023). Advocacy and possibly technical support from regional and academic institutions, such as presenting cost–benefit analyses of research, may help (R4ACCHC, 2022c). The need to act within the next 10 years to avoid catastrophic climate impacts should be underlined (MacGuire and Ng Shiu, 2021).

If we can convince Caribbean governments of the value of research as an investment in our own future, then we can move towards the kind of national investment that we need to get this effort to be successful.

Professor Marvin Reid, Deputy Dean for Research, UWI Mona campus, at the Conference on Climate Change and Health in Small Island Developing States: Focus on the Caribbean (Reid, 2021)

The scale of the challenge is vast, but academics can help policymakers by identifying strategic interventions for research that will have multiplying effects. For instance, research on methods to reduce air pollution can bear fruit in reducing greenhouse gases and respiratory, cardiovascular and other diseases while promoting environments conducive to exercise and reducing NCDs (MacGuire and Ng Shiu, 2021). Capacity-building among

policy-makers may be needed so that they are better able to use research to inform decision-making (R4ACCHC, 2023).

The private sector can be encouraged to support climate change and health research by framing it as part of corporate environmental, social and governance (ESG) initiatives. To date, many ESG initiatives have been led by multinational companies in the tourism sector, focusing on reducing greenhouse gas emissions. There is a need to extend this to local and smaller companies and increase the support for research relating to health (R4ACCHC, 2023).

Build regional solidarity, mutual support and collaboration in research

Given the small size of individual Caribbean states and territories and the low levels of human and other types of resources, it is essential to develop collaborative mechanisms to share and build expertise (Lichtveld, 2021). An important aspect of this is developing data-sharing protocols among countries, including protocols on how to ensure data security. Standardised data collection forms and research methodologies should be developed to facilitate a regional picture, with each country enabled to measure progress relative to other countries. Short courses in climate and health research should be offered at the regional level (R4ACCHC, 2023).

Countries should also seek funding collectively, and develop Caribbean sources of research funding. Regional agencies such as CARPHA should continue and increase their provision of research training and funding (R4ACCHC, 2023).

The recently established *Lancet* Countdown Small Island Developing States Regional Centre can help establish such protocols. Its plans to establish a regional hub for information-sharing should be supported. Specialist equipment such as research boats and laboratory facilities should be shared wherever possible. National rivalries and turf disputes must not get in the way of building the evidence base for action and ensuring no state gets left behind. Countries presenting a united front can help leverage financial and technical resources for research and surveillance at the regional and international levels (MacGuire and Ng Shiu, 2021; R4ACCHC, 2023).

Make research facilities and products climate resilient

Research facilities, including laboratories, and equipment must themselves be designed and built to climate-resilient standards. This includes the safe storage of electronic and hard-copy data. One important strategy is the decentralisation of equipment and supplies (CARPHA, 2019; Lichtveld, 2021).

Strengthen the research–policy interface

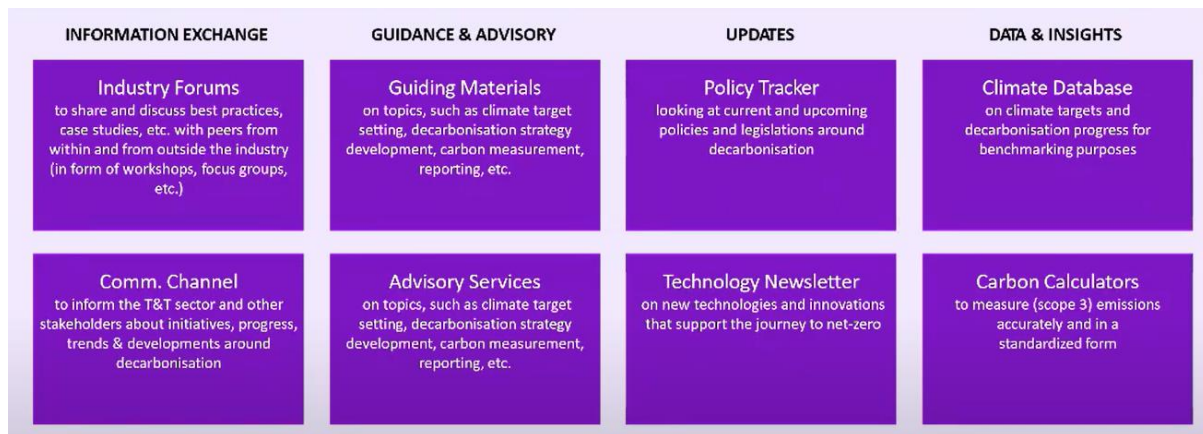
The research community can improve the use of research and surveillance by policy-makers through improved and accessible communication methods. Specialised training and tools are needed to promote the science literacy of policy-makers, and the policy literacy of scientists (MacGuire and Ng Shiu, 2021).

Governments can help researchers understand the kinds of problems that need to be solved from their perspective, ultimately improving the uptake of evidence (Glasgow, 2021). Science needs to be translated and applied to real-world problems as perceived by the policy-makers (Lichtveld, 2021; Reid, 2021). Researchers and policy-makers should collaborate in the development and implementation of monitoring and evaluation systems for climate change and health projects (Lichtveld, 2021).

Support and collaborate with the private sector by providing climate information services for health

To develop practices that support health in the face of climate change, businesses need information to guide their decision-making. Alliances between the agencies that produce the evidence and the businesses that can usefully consume it would be mutually beneficial. Figure 2 presents a range of information services suggested by the Caribbean Alliance for Sustainable Tourism.

Figure 2: Climate information services to support sustainable business practices



Note: T&T, travel and tourism.

Source: Williams (2021).

Businesses should also be supported in developing guidelines, checklists and metrics to monitor their progress in attaining environmental sustainability and public health goals (R4ACCHC, 2023; Williams, 2021).

Build capacity in higher education and other research/surveillance institutions

A range of institutions engaged in research and surveillance, including Caribbean universities, colleges, national healthcare provider agencies and regional and multilateral entities (such as CARPHA and PAHO/WHO) can benefit from the following actions:

- Create an institution-based climate change and health research policy.
 - This may be hinged on a regional and international policy agenda, such as the United Nations Sustainable Development Goals or national climate resilience plans.
 - The mandate should apply across all levels of learners, faculty and other staff and administrators.
- Build climate change and health into curricula across disciplines.
- Invest in climate change and health research centres of excellence.
 - Develop institutional infrastructure for managing grants, personnel, coordination and outcomes.
 - Recruit experts on part- and full-time contracts.
- Cultivate the research culture and talent in the institution.
 - Provide coaching and mentoring. One area where mentoring is important is how to write for peer-reviewed journals (R4ACCHC, 2023).
 - Incorporate roles for students, faculty and other staff and administrators.
 - Present research in a relatable way to all staff.
- Establish institution-wide structures for seeking funding.
 - Support and incorporate young researchers/students and new faculty members.
 - Leverage expertise across departments.
- Provide results to key stakeholders and beneficiaries.
 - Formalise partnerships with policymakers, climate change organisations and representatives from populations most affected by climate change.
 - Provide results to key technical agencies such as PAHO, WHO, UNFCCC, the United Nations Environment Programme and the United Nations Development Programme.
- Develop hard and soft capacity for science-oriented research.
 - Purchase and maintain equipment, laboratories, and tools.

- Incorporate climate change and health research in promotion criteria.
- Cater for succession planning for climate change and health research (Glasgow, 2021).

Strengthen capacity for ethics review in climate change and health research

Efforts to develop ethics review procedures for health research at regional and national levels should continue. Ethics review of health research considers ways to minimise risk to the individual research participant. In the context of climate change, it may be necessary to also consider the environmental impacts of the research, which can affect research participants and the communities they inhabit. This would be consistent with the One Health approach (Oura et al., 2017).

Research and surveillance gaps and how to address them

Move towards real-time reporting of health conditions and associated socioeconomic data

Health surveillance in the Caribbean currently continues to rely mostly on handwritten records. The data are then entered into computers, analysed and then reported at health authority, national and (for certain conditions) Caribbean regional levels. This process creates an often months-long delay between the health incident and reporting. Electronic information systems involving the use of electronic devices to input and possibly conduct analyses at sentinel sites and while in the field can cut down the reporting time considerably (Golden, 2023a). They also increase the frequency of reporting, enabling more integration with climate and other environmental information systems and thus permitting more analyses of climate and health associations. More timely and frequent reporting of health information, along with the capacity for timely reporting about emerging issues of concern, is crucial as a basis for evidence-based climate-responsive health practice.

To enable equity and justice, health information systems should include sociodemographic, economic and location data to help identify vulnerable communities and populations and enable targeted interventions. These additional data should also be integral to climate-smart health surveillance systems (see below).

Develop climate-smart health surveillance systems

Climate-smart health surveillance has been defined as a new type of health surveillance that will weave together epidemiological, climate, agricultural and environmental information systems. It integrates these disparate data streams to examine the climate-related drivers of ill health. Health data are linked with data from meteorological agencies and satellites (Golden, 2023a). Remote-sensing data from satellites are increasingly used to assess the risk of health conditions arising from environmental factors such as air quality, precipitation and ocean characteristics (Haynes, n.d.).

For example, in Madagascar, a project is using remote-sensing data from satellites on climate change-associated phenomena, such as droughts, deforestation, tropical cyclones, sea temperature and coral bleaching, in conjunction with health data. The new information platform combines remotely sensed satellite observations with community-based sentinel health surveillance to enable health research, rapid prediction and public health planning. It looks at associations between (1) drought-induced crop failures and malnutrition; (2) deforestation and vector-borne disease transmission; (3) natural disasters and mental health; (4) sea temperature-driven harmful algal blooms and diarrhoeal disease; and (5) coral bleaching-induced seafood scarcity and malnutrition. Predictive algorithms are then developed linking climate and health data to develop early warning systems (Golden, 2023a). The observations and predictions are then translated into interministerial policy action across health, agriculture, the environment, rural development and other sectors to create systemic interventions that promote health and well-being (Golden, 2023b).

Remote sensing has also been used to monitor climate variability and environmental conditions and their impacts on the dynamics of infectious diseases, specifically vector-borne diseases. Geographical information

systems and Earth observation satellites have been used to monitor the climate, environmental and anthropogenic factors that influence the reduction or the reemergence of vector-borne diseases. This work is part of the WHO Special Programme for Research and Training in Tropical Diseases–International Development Research Centre Research Initiative on Vector-Borne Diseases and Climate Change (Ceccato et al., 2018).

Build a rigorous body of surveillance data and research on priority topics

The limitations of current research and surveillance within each of the Priority Areas covered by the Caribbean Research for Action Agenda on Climate Change and Health were outlined in Section 11.1, “What is happening?”. In this subsection we discuss surveillance and research together, as longitudinal and comparative research often depends on the existence of standardised and regularly and systematically collected surveillance data.

To address existing limitations, some general recommendations can be made (Dubrow, 2021; Glasgow, 2021; Lichtveld, 2021; R4ACCHC, 2022a,c; Reid, 2021). Some of these are being actively pursued in regional projects such as the EU/CARIFORUM Project on Strengthening Climate Resilient Health Systems and the EWISACTs project. The *Lancet* Countdown Small Island Developing States Regional Centre potentially provides an institutional hub for implementing these recommendations, but sustainable funding is needed for this:

- Invest in strengthened and expanded surveillance for climate-sensitive health conditions.
 - It is particularly important to strengthen surveillance in resource-constrained settings, such as SIDS, where large research grants for surveys are not frequently available.
 - Key health conditions that may be initiated or aggravated by climate drivers should be selected, and local agencies should be provided with technical and financial support to collect data on them at regularly defined intervals (R4ACCHC, 2023).
 - Protocols for data-sharing among researchers across the Caribbean region and beyond should be strengthened (R4ACCHC, 2023).
 - Standardised forms and methodologies should be developed for collecting data on climate-sensitive health conditions (R4ACCHC, 2023).
 - Levels of access to different types of data should be established to ensure information security (R4ACCHC, 2023).
 - Employers should develop and implement policies that allow staff the time to develop and employ their research skills, and encourage dissemination of research findings (R4ACCHC, 2023).
- Integrate climate/weather and health surveillance data and test associations between them.
 - Agencies responsible for collecting health surveillance and meteorological data should continue to collaborate and present evidence of associations between health and climate indicators. Methodological research guidelines should be developed to facilitate this.
 - Health and meteorological/climate scientists should continue to collaborate in the development of EWSs and in making the findings accessible to key audiences (R4ACCHC, 2022d).
- Develop ways to collect data on key aspects of the climate change and health nexus. This should include:
 - Greenhouse gas emission accounting. Levels of emissions from the driving forces, such as industry, energy, transport and agriculture, should be measured.
 - Risk modelling. How are populations exposed and what are the probabilities of spatial and temporal impacts?
 - Disaggregated data. Assess the differences in impact of climate change by population and identify key characteristics that increase vulnerability.
 - Future projections. Identify key features of the region that influence the probability of adverse outcomes (Glasgow, 2021).
- Develop research protocols that propose models of the pathway of causation from climate drivers to health outcomes. Collect data and test associations for each step.

- For instance, when examining associations between increasing ambient temperatures and heat-related illness in the Caribbean, it is important to look at a range of contextual variables, such as variations in temperatures and health outcomes between urban and rural areas. Contextual factors can serve as sites for intervention. For instance, how can infrastructural design appropriate for urban and rural settings moderate the effects of rising temperatures on health? Can we create low-cost, sustainable and resilient infrastructure/housing that protects low-income communities from heat stress?
- Conduct qualitative research to enable people to explain how and why actions are taken that aggravate or alleviate climate change impacts on health.
- Conduct systematic reviews of evidence on health outcomes and selected risk factors.
 - The scope of the current report is too wide to cover every study conducted on each of the Priority Areas. More detailed study is needed to establish and probe the evidence base between health outcomes and specific climate-related risk factors.

Develop climate and health indicators appropriate to Caribbean Small Island Developing States

Developing indicators to track climate-related health outcomes, adaptation in the health sector and mitigation measures with health co-benefits can enable the development of evidence-based policy and initiatives. It is important to develop indicators appropriate to the Caribbean.

A start has been made with the *Lancet* Countdown assessment of climate change and health in SIDS (Allen et al., 2021a,b). The assessment aimed to determine the relevance of existing *Lancet* Countdown global indicators for monitoring climate change and health in SIDS, and propose Priority Areas for the development of indicators in the Caribbean and Pacific SIDS. Following consultations with stakeholders, four health and environmental outcomes emerged as priorities for measurement: (1) the health impact of severe weather events; (2) WASH; (3) vector-borne diseases; and (4) NCDs. Interviewees also emphasised the need to measure intersectoral collaboration, research and surveillance capacities, investment in climate and health research and surveillance, and government engagement (Allen et al., 2021a,b).

These Priority Areas were included, along with others, in the current research agenda. There is a need now to develop appropriate Caribbean metrics to measure progress in addressing each Priority Area. Dedicated workshops involving experts and stakeholders in each of the Priority Areas should be held to select ways to measure progress, for example, progress in establishing sustainable WASH systems and measuring their health outcomes. Responsibility for leading the data collection and monitoring progress in each Priority Area should be allocated to agencies in the Caribbean, with external resources and technical assistance employed when necessary.

Research and surveillance capacity-strengthening needs

Increase funding and support from developed countries for climate and health research in Caribbean Small Island Developing States

Developed countries, who have benefited economically from their long history of greenhouse gas emissions, have to some extent accepted their responsibility to channel some resources to SIDS and other developing countries to assist their adaptation and mitigation efforts (see Chapter 17, “Funding streams for climate and health action”). Similarly to other components of development aid, this tends to be channelled according to definitions of development based on levels of national income per capita. Research funds are no exception. As some countries in the Caribbean do not fall into the low- and middle-income bracket, they tend to receive very little research funding. This creates disparities between countries and difficulties in developing collaborative and comparative research.

Criteria for research grants need to be modified in recognition of the vulnerabilities of SIDS to climate change and other challenges associated with their small size. Special grants and funding for institutions and staff should be dedicated to Caribbean SIDS.

A positive example is the funding and technical support the *Lancet* Countdown is providing in setting up a climate and health research hub at UWI (Allen et al., 2021a; Parker et al., 2022). Further work is required to redress the balance in research funding and publications between developed and developing countries (Hamilton, 2021; MacGuire and Ng Shiu, 2021).

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