The 2024 small island developing states report of the *Lancet* Countdown on health and climate change

Georgiana M Gordon-Strachan, Stephanie Y Parker, Heather C Harewood, Pablo A Méndez-Lázaro, Salanieta T Saketa, Kimalie F Parchment, Maria Walawender, Abdullahi O Abdulkadri, Paul J Beggs, Daniel F Buss, Riley J Chodak, Shouro Dasgupta, Olga De Santis, Natalie G Guthrie-Dixon, Saria Hassan, Harry Kennard, Sandeep B Maharaj, Kwesi G Marshall, Shelly R McFarlane, Kimberley S McKenzie, Maziar Moradi-Lakeh, Madhuvanti Murphy, Michelle A Mycoo, Roannie Ng Shiu, Megan B O'Hare, Christopher A L Oura, Fereidoon Owfi, Ali Owfi, Karen A Polson, Mahnaz Rabbaniha, Elizabeth J Z Robinson, David C Smith, Meisam Tabatabaei, Lanea L Tuiasosopo, Marina Romanello

Executive summary

The 2024 small island developing states (SIDS) report for the *Lancet* Countdown on Health and Climate Change expands on the global Lancet *Countdown* 2023 and 2024 reports to explore the unique contexts, geographies, vulnerabilities, and needs that shape the evolving links between health and climate change in SIDS in the Pacific, Caribbean, and Atlantic, Indian Ocean, and South China Sea regions. SIDS were first recognised as a distinct grouping of island nations at the 1992 UN Conference on Environment and Development; they share high vulnerability to extreme weather events, climate change, and global economic shocks. The message of the global *Lancet* Countdown is echoed in this *Lancet* Countdown report for SIDS: a health-centred response is essential to allay the severity of the encroaching impacts of global climate change on the health and wellbeing of populations. Such a response requires international action from high-income countries to reduce greenhouse gas emissions. This action, in conjunction with other locally and internally driven efforts, should enable a prosperous future for the SIDS, which collectively have low emissions.

The past 9 years (ie, 2015–23) have been the warmest on record globally, and populations across SIDS have been exposed to increasing summer temperatures. The consequences of heat exposure to human health are thus acutely prominent in SIDS. During the record-breaking summer heat of 2023 alone, infants (ie, aged 1 year or younger) experienced 48 times more heatwave days than the annual averages for 2000–04. Furthermore, across SIDS since 2019, there have been 14 additional days of per-person exposure to heatwaves for both infants and adults aged 65 years or older—two age groups particularly vulnerable to short-term and long-term complications associated with heatwaves. On average between 2018 and 2022, people aged 65 years or older in SIDS were exposed to 103 days per year of health-threatening heat, up from an average of 53 days per year between 1998 and 2002. As a result, this population was at increased risk for complications of mental and physical health and increased risk of death for more than 3 months per year. The number of deaths attributable to heat in 2017–22 was double that in 2000–05. These heat-attributable excess deaths can also be translated to monetary losses, with losses equivalent to US$647 million incurred across SIDS in 2020.

Addressing heat through adaptation efforts would be an extremely effective and life-saving intervention in SIDS. However, only one of the projects addressing heat-related risks that was approved by the Green Climate Fund between 2015 and 2023 was inclusive of SIDS (focused on cooling facilities). Revamping and upscaling locally appropriate heat-adaptation strategies requires accelerated implementation of surveillance and early-warning and response systems. Of 29 SIDS responding to the WHO Health and Climate survey (2021), only six had early-warning systems in place for heat-related illnesses. Surveillance of cardiovascular, neurological, and psychological conditions sensitive to heat remains inadequate. In addition to these systems, urban green spaces can provide local cooling benefits and alleviate heat exposure in cities. Exposure to greenness and spaces for leisure and physical activity can also lead to improvements in physical and mental health and reductions in overall mortality. There has been some progress in greening urban spaces across several SIDS, primarily via transforming areas of low greenness into areas of moderate greenness. However, these modest incremental improvements have not alleviated high urban temperatures.

The growing risk of heat exposure has become one of many prominent economic pressures affecting SIDS. Labour productivity and healthy lives are undermined by increasing temperatures, with more than 4·4 billion potential labour hours lost in 2023, compared with an annual average of 2·5 billion hours in 1991–2000. In 2022, reductions in labour capacity from health-threatening heat exposure brought potential earning losses equivalent to 2·1% of the average gross domestic product of SIDS. In labour-intensive sectors—eg, agriculture, construction, and tourism—profound changes in occupational standards, such as staggering work hours to reduce heat exposure, should be considered to preserve workers' health and to maximise productivity.

The burden of human-induced climate change has also affected food security and physical activity patterns across SIDS, with detrimental consequences for health. Compared with the annual average in 1981–2010, in 2022 an additional 2·6 million people reported moderate or severe food insecurity as a consequence of drought and heatwave days. The risk of undernutrition, especially in low-income and middle-income households, is being exacerbated by climate change. In SIDS, there are

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Caribbean Institute for Health Research, Tropical Metabolism Research Unit (G M Gordon-Strachan PhD, S Y Parker MSc, K F Parchment BSc, N G Guthrie-Dixon MSc, K G Marshall PhD, S R McFarlane PhD, K S McKenzie MPhil)**, and Institute for Sustainable Development** (D C Smith PhD)**, University of the West Indies, Kingston, Jamaica; Department of Preclinical and Health Sciences, Faculty of Medical Sciences** (H C Harewood DrPH)**, and Caribbean Institute for Health Research, George Alleyne Chronic Disease Research Centre** (M Murphy PhD)**, University of the West Indies, Cavehill, Barbados; Environmental Health Department, Graduate School of Public Health, University of Puerto Rico—Medical Sciences Campus, San Juan, Puerto Rico** (P A Méndez-Lázaro PhD)**; University of Puerto Rico-Comprehensive Cancer Center, San Juan, Puerto Rico** (P A Méndez-Lázaro)**; Public Health Division, The Pacific Community, Nasinu, Fiji** (S T Saketa MPH)**; *Lancet* Countdown, University College of London, London, UK** (M Walawender MSPH, M B O'Hare PhD, M Romanello PhD)**; UN Economic Commission for Latin America and the Caribbean, Subregional Headquarters for the Caribbean, Port of Spain, Trinidad and Tobago** (Prof A O Abdulkadri PhD)**; School of Natural Sciences, Faculty of Science and Engineering, Macquarie University, Sydney, NSW,**

Australia (P J Beggs PhD); Pan American Health Organization, Washington, DC, USA (D F Buss PhD, K A Polson PhD); Center on Global Energy Policy, Columbia University, New York, NY, USA (R J Chodak BEng); Euro-Mediterranean Center on Climate Change, Venice, Italy (S Dasgupta PhD); Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, London, UK (S Dasgupta, Prof E J Z Robinson PhD); Direction de la recherche, de l'innovation et de la coopération internationale, CHU de La Réunion, Saint-Pierre, Réunion, France (O De Santis MD); Department of Medicine, Emory University School of Medicine, Atlanta, GA, USA (S Hassan MD); Hubert Department of Global Health, Rollins School of Public Health, Emory University, Atlanta, GA, USA (S Hassan); University of Texas at Austin, Austin, TX, USA (H Kennard PhD); School of Pharmacy (S B Maharaj DBA), Department of Geomatics Engineering and Land Management (Prof M A Mycoo PhD), and Faculty of Medical Sciences (Prof C A L Oura PhD), University of the West Indies, St Augustine, Trinidad and Tobago; Gastrointestinal and Liver Diseases Research Center and Preventive Medicine and Public Health Research Center, Psychosocial Health Research Institute, Iran University of Medical Sciences, Tehran, Iran (M Moradi-Lakeh MD); Te Poutoko Ora a Kiwa, Centre for Pacific and Global Health, University of Auckland, Auckland, New Zealand (R Ng Shiu PhD, L L Tuiasosopo BComm); Iranian Fisheries Science Research Institute, Agricultural Research, Education and Extension Organization, Tehran, Iran (F Owfi PhD, M Rabbaniha PhD); Holcombe Department of Electrical and Computer Engineering, Clemson University, Clemson, SC, USA (A Owfi MSc); Higher Institution Centre of Excellence, Institute of Tropical Aquaculture and Fisheries, Universiti Malaysia Terengganu, Kuala Nerus, Malaysia (Prof M Tabatabaei PhD)

worrying long-term trends towards import-dependent processed diets and associated high morbidity and mortality attributable to chronic non-communicable diseases as a result of these carbon-intensive, unhealthy diets. The widespread health effects of food insecurity and increasing reliance on unhealthy foods are further compounded by the reduced potential for outdoor exercise: even low-intensity physical activity in SIDS was associated with more than three times more risk for extreme heat stress in the past 5 years compared with in 1991–2000. However, there are opportunities in SIDS to transition to more resilient and sustainable agricultural systems and to improve overall health outcomes by embracing healthier, more plant-based diets, with reduced consumption of carbon-intensive red meat and dairy products that increase the risk of chronic disease.

Health systems are not climate-ready

Total land area affected by extreme droughts in 2014–23 compared with 1961–70 has expanded by nearly 30%. More severe and frequent droughts destabilise food systems and contribute to infectious disease proliferation in SIDS, further burdening health clinics and hospitals. Of the 24 SIDS surveyed, 20 (83%) had surveillance systems for infectious and food-borne diseases, which provide essential data for climate and health assessments.

Altered temperature, rainfall, and humidity combinations across all SIDS have resulted in a 33% increase in the transmission potential for dengue compared with the 1950s, and there have been more frequent outbreaks of the disease since 2019. 24 (75%) of 32 SIDS surveyed reported having health-care systems with high or very high capacities for responding to and managing public health emergencies, such as dengue outbreaks. However, data suggest that SIDS are still lagging in the identification and management of the growing climate-related risk of infectious-disease transmission: only five (8%) of 59 SIDS have developed national health and climate strategies or plans, only nine (15%) have done climate and health vulnerability assessments, and only six (10%) have surveillance systems that integrate meteorological parameters with health. Furthermore, the few climate and health vulnerability assessments that have been done have not strongly informed health policies. Climatic shocks have the potential to overwhelm improvements in health-care provision, especially given the complex interactions with climate-sensitive diseases (eg, non-communicable diseases, infectious diseases, and mental health disorders).

Clean air and sustainability necessitate a hastened transition to renewables

An absence of data for most SIDS means that most metrics for monitoring the effects of air pollution are unreliable. In congested cities, some of the main contributors to high levels of particulate matter—ie, the industrial, transportation, and commercial sectors—are also among the largest contributors to greenhouse gas emissions. There are thus clear benefits to transitioning to clean, renewable energy both to mitigate climate change and to improve air quality. Concerningly, energy generation, distribution, and transmission capacities in SIDS tend towards heavier dependence on fossil fuels. Around 17% of populations across SIDS (and 66% of the population in Guinea-Bissau) still do not have universal energy access. Increasing fair access and use of energy is fundamental to enabling development and improving the health and wellbeing of local populations. The abundance of natural renewable energy resources presents an opportunity for SIDS to transition to renewable energy, which can be locally produced and made available off-grid. Such transitions could result in substantial reductions in air pollution-related diseases and increase energy self-sufficiency. However, international cooperation and support for funding, knowledge, and technology transfer, as well as adequate commercial conditions, are necessary. Government intervention and community engagement are essential to ensure the transition towards achieving minimal or zero-carbon emissions by 2050 is hastened. Stringent policies are needed to regulate energy-intensive sectors and the international corporations that support them.

Continued destabilisation of the marine environment

There is an intimate relationship between small islands and the marine environment (the largest natural buffer for climate change), which dictates the subsistence and vulnerabilities of SIDS. Since 2015, steady increases in 3-year average sea surface temperatures, a universally acknowledged marker of the effects of global warming on ocean basins, have been noted within coastal regions around SIDS. As marine basins and coastal ecosystems are altered by climate change, there are complex implications for various aspects of wellbeing across SIDS, including food security and displacement. Contrary to global trends, marine capture of fish for production (consumption and exportation) has markedly increased in SIDS while aquaculture has declined. The increased dependence on captured fish production could have pronounced effects on the economies and coastal communities of SIDS if global warming and overfishing decline fish stocks, as has occurred in other regions. Furthermore, changes in sea surface temperatures and other ocean properties attributed to climate change have increased the exposure of populations in low-elevation coastal zones to rising sea levels and increased the potential for *Vibrio* transmission. Oceans absorb most of the excess heat produced by human-driven global warming, but at an immense cost to the marine environment. Without global action to substantially reduce greenhouse gas emissions by 2050, the goal of keeping global average temperature increases to less than 2°C will not be attained. SIDS and non-SIDS will continue to experience the increasing effects of the

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intensification of cyclonic events, storm surges, and other associated climatological processes.

Introduction

The small island developing states (SIDS) are a group of some of the world's smallest and most remote countries with a combined population of around 65 million people (slightly less than 1% of the global population). SIDS share characteristics that make them particularly vulnerable and exposed to climate-change-related hazards, with serious implications for health, social inequities, and sustainable development (panels 1, 2). Within the past 3 years, tropical cyclones have devastated Caribbean and Pacific islands, and torrential rainfall has caused dangerous flash flooding in Samoa, St Lucia, and Haiti. Between 1975 and 2009, category 4 and 5 tropical cyclones have become more common in north Atlantic and South Pacific regions; across all SIDS, air and sea surface temperatures have increased, and a greater than average relative rise in sea levels has been noted across several marine and coastal regions.[2] These occurrences have contributed to reduced agricultural production,[3] reduced labour output,[4] increased dependence on food importation,[5] and worsened the effects of the COVID-19 pandemic.[6] Furthermore, climatic disasters have compound effects on overburdened health-care systems, the spread of infectious diseases, mental health and wellbeing, displacement, access to healthy food and safe water, the increasing burden of chronic non-communicable diseases (NCDs), and recovery and resilience.[4]

In this inaugural report of the *Lancet* Countdown Regional Centre for Small Island Developing States—a collaborative effort involving authors from SIDS around the world—we draw on data from the indicators of the 2023 and 2024 global *Lancet* Countdown reports[4] to offer deeper insight into climate-change-related impacts, mitigation, adaptation, economic capacity, and engagement specific to the 59 countries, states, and territories classified as UN member and associate-member SIDS. 25 indicators were selected based on data availability and relevance for SIDS (panel 3). Because of a lack of data, general statements were made about SIDS only for indicators for which data coverage was at least 70%. In instances when data coverage for an indicator was less than 70%, the number of SIDS with available data was specifically stated. The challenges with the coverage of data across SIDS and research gaps are also discussed, which can inform research priorities and identify areas for improvement on the range of issues monitored by the *Lancet* Countdown.

Section 1: Health hazards, exposures, and impacts

Climate change is already deeply affecting the health of people living in SIDS. In this section, we discuss how climate change not only affects health directly, but also affects livelihoods, food security, water availability, and other factors that are essential for good overall health and wellbeing. The selected indicators highlight the variety of ways that the heating world and increased exposure to heat and extreme weather can affect health, with a focus on droughts and the impact of climate change on conditions for the transmission of infectious diseases. Several indicators we discuss in this section address the unique food security concerns in SIDS and diminishing food availability in a warming climate.

1.1: Health and heat

Heat exposure is one of the most critical health risks affecting SIDS, most of which are in tropical or subtropical regions and have high year-round sunlight intensities and temperature ranges. Exposure to heat can have serious adverse health impacts, including long-term neurological or cardiovascular complications, exacerbation of respiratory disease, acute kidney failure, adverse pregnancy outcomes, negative effects on mental health, and death.[7,8] Additionally, heat can affect health indirectly by making physical activities unsafe and potentially limiting labour capacity.

Indicator 1.1.1: exposure to heat

This indicator monitors changes in population exposure to summer temperatures. From 2018 to 2022, SIDS populations were exposed to average summer temperatures that were 0·3°C higher than average summer temperature between 1986 and 2005 (figure 1A). The past 9 years (ie, 2015–23) have been the hottest on record, and heating has been greater over land than over oceans.[9,10] Additionally, cities are warming faster than rural areas.[11]

Summer temperatures were particularly high in 2020—on average 0·5°C higher than the 1986–2005 summer average across all SIDS, and up to 0·6°C higher in

Correspondence to:
Dr Georgiana Gordon-Strachan, Caribbean Institute for Health Research, Tropical Metabolism Research Unit, University of the West Indies, Kingston 7, Jamaica
georgiana.gordonstrachan@uwimona.edu.jm

Panel 1: What are the small island developing states?

The small island developing states (SIDS) are divided into three geographical subregions: the Atlantic, Indian Ocean, and South China Sea; the Caribbean; and the Pacific. Although located in varying geographical regions, they share similar challenges and vulnerabilities, such as high exposure to extreme weather events and natural disasters, climate change, and global economic shocks.[1] These challenges, coupled with low revenue and restricted borrowing opportunities, mean that SIDS are slow to invest in resilience developments, affecting their economic growth. The natural resources of SIDS are important, with tourism and fishing accounting for more than half of several states' gross domestic products. Thus, they are severely sensitive to shocks when these resources are damaged.

The SIDS were first recognised as a distinct grouping at the 1992 UN Conference on Environment and Development and are supported by several UN programmes—eg, the Barbados Programme of Action (1994), the Mauritius Strategy (2005), and the SIDS Accelerated Modalities of Action (SAMOA) Pathway (2014). These programmes, and particularly the SAMOA Pathway, recognise the impacts of climate change and rising sea levels on SIDS and the efforts of SIDS to achieve economic development and food security, reduce disaster risk, and effectively manage the oceans.[1] In this report, we present data from 59 SIDS worldwide.

Panel 2: Small island developing states, by geographical subregion

Atlantic, Indian Ocean, and South China Sea

- Cabo Verde
- Comoros
- Guinea-Bissau
- Maldives
- Mauritius
- São Tomé and Príncipe
- Seychelles
- Singapore

Caribbean

- Anguilla
- Antigua and Barbuda
- Aruba
- The Bahamas
- Barbados
- Belize
- Bermuda
- Bonaire*
- British Virgin Islands
- Cayman Islands
- Cuba
- Curaçao
- Dominica
- Dominican Republic
- Grenada
- Guadeloupe
- Guyana
- Haiti
- Jamaica
- Martinique
- Montserrat
- Puerto Rico
- Saint Kitts and Nevis
- Saint Lucia
- Saint Martin*
- Saint Vincent and the Grenadines
- Sint Maarten
- Suriname
- Trinidad and Tobago
- Turks and Caicos Islands
- US Virgin Islands

Pacific

- American Samoa
- Northern Mariana Islands
- Cook Islands
- Federated States of Micronesia
- Fiji
- French Polynesia
- Guam
- Kiribati
- Marshall Islands
- Nauru
- New Caledonia
- Niue
- Palau
- Papua New Guinea
- Samoa
- Solomon Islands
- Timor-Leste
- Tonga
- Tuvalu
- Vanuatu

*Dependent state not on the UN's list of small island developing states. Data for Bonaire were available during data collection for Aruba and Curaçao because of their geopolitical association; Saint Martin was included because it shares a border with Sint Maarten.

Caribbean SIDS. This temperature increase was reduced in 2021 and 2022 due to a cooling La Niña event.[10]

Indicator 1.1.2: exposure of vulnerable populations to heatwaves

Heatwaves—defined[4] as a period of 2 or more days in which both the minimum and maximum temperatures are higher than the 95th percentile of temperatures in 1986–2005—can have serious adverse effects on physical and mental health.[7,12] A range of risk factors increase vulnerability to adverse health effects from heatwaves, with infants (ie, aged 1 year or younger) and older adults (ie, aged 65 years or older) particularly at risk.[8] This indicator tracks the exposure of these two vulnerable age groups in SIDS subregions to heatwave days from 2000 to 2023. In 2023, across all SIDS, a record average of 41 heatwave days were experienced by each infant, whereas each older adult experienced a record average of 43 heatwave days (figure 1B), the result of a particularly brutal El Niño. These exposures were 48 and 36 times higher, respectively, than the average yearly exposure in 2000–04, and correspond to 4654% and 3517% increases, respectively.

Indicator 1.1.3: heat and physical activity

Many SIDS rank among the countries with the highest estimated risk of dying prematurely from the four main NCDs (cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases), and SIDS account for eight of the 15 countries with the highest estimated risk globally (>30%).[13] One of the most important factors for the management and prevention of NCDs is regular physical activity. However, hot weather conditions pose an increased risk of heat-related illnesses for people exercising,[14] and thus heat can reduce the ability to exercise, thereby increasing the risk of NCDs. This indicator estimates the number of hours that presented heat stress risks for people exercising outside, depending on the intensity of physical activity.

Between 2019 and 2023, on average each year there were more than 2800 h during which heat posed at least moderate heat stress risk for light-intensity physical activity (eg, walking), and more than 2900 h during which heat posed at least moderate heat stress risk for moderate-intensity physical activity (eg, jogging). By comparison, the annual average number of hours in 1991–2000 was around 2500 h for both light-intensity and moderate-intensity exercise. Thus, the average increase from 1991 to 2000 was 16% (an additional 388 h) for light-intensity physical activities and 15% (an additional 396 h) for moderate-intensity physical activities. Pacific SIDS had the highest average number of hours per year (2019–23) posing at least moderate heat stress risk when engaging in moderate physical activity: more than 3000 h.

The average number of hours annually during which there would be extreme heat stress risk from both light-intensity and moderate-intensity exercise also increased (by 262% and 197%, respectively) in SIDS in 2019–23 compared with in 1991–2000. These concerning trends suggest limits to the amount of time in which people can safely engage in physical activity and highlight a complex situation in which both exercising and not exercising can have implications for health.

Indicator 1.1.4: change in labour capacity

Exposure to heat is associated with substantial labour productivity losses globally, especially for people working outdoors or engaged in physically strenuous tasks.[4,15] Labour intensity can compound the adverse effects of humidity-induced and temperature-induced heat stress—higher metabolic work rates increase heat generation in the body and impair cooling.

This indicator tracks potential hours lost as a result of decreased productivity during exposure to humidity and heat in daylight hours, and is calculated based on wet bulb globe temperature and the proportion of populations employed in the agriculture, construction, manufacturing, or service sectors. In 2023, 4·4 billion work hours were lost across sectors in SIDS, a 71% increase in hours losses on average annually compared with 1991–2000. Between 2014 and 2023, annual losses in potential work hours increased by between 44% and 269%, depending on the sector, compared with annual work hours lost between 1991 and 2000. In the Atlantic, Indian Ocean, and South China Sea (AIS) subregion, the increase in potential labour hours lost for all sectors combined was 95%, the highest increase among the subregions. The exceptional heat exposure in 2023 resulted in major increases in work hours lost across all sectors, with around 2·7 billion work hours lost (1·7 billion h in the Caribbean, 620 million h in the AIS, and 382 million h in the Pacific subregion) from agriculture in 2023 alone (figure 2)—126% higher (ie, an additional 1·5 billion work hours lost) than the annual average lost in 1991–2000. As a result of both the increased employment in service sectors and high heat exposure,[16] more than three times as many work hours (ie, 490 million h) were lost in service sectors in 2023 compared with the average amount lost annually in 1991–2000.

Panel 3: Indicators of the 2024 small island developing states report of the *Lancet* Countdown

Health hazards, exposures, and impacts
- 1.1: Health and heat
  - 1.1.1: Exposure to heat
  - 1.1.2: Exposure of vulnerable populations to heatwaves
  - 1.1.3: Heat and physical activity
  - 1.1.4: Change in labour capacity
  - 1.1.5: Heat-related mortality
- 1.2: Health and extreme weather events
  - 1.2.1: Drought
- 1.3: Climate suitability for infectious disease transmission
- 1.4: Food security and undernutrition
  - 1.4.1: Food insecurity
  - 1.4.2: Marine food insecurity

Adaptation, planning, and resilience for health
- 2.1: Assessment and planning of health adaptation
  - 2.1.1: National assessments of climate change impacts, vulnerability, and adaptation for health
  - 2.1.2: National adaptation plans for health
- 2.2: Enabling conditions, adaptation delivery, and implementation
  - 2.2.1: Climate information for health
  - 2.2.2: Urban greenspace
  - 2.2.3: Health-adaptation-related funding
  - 2.2.4: Detection, preparedness, and response to health emergencies
- 2.3: Vulnerabilities, health risk, and resilience to climate change
  - 2.3.1: Lethality of extreme weather events
  - 2.3.2: Migration, displacement, and rising sea levels

Mitigation actions and health co-benefits
- 3.1: Energy use, energy generation, and health
- 3.2: Diet and health co-benefits

Economics and finance
- 4.1: Economic impact of climate change and its mitigation
  - 4.1.1: Economic losses due to climate-related extreme events
  - 4.1.2: Costs of heat-related mortality
  - 4.1.3: Loss of earnings from heat-related loss of labour capacity

Public and political engagement
- 5.1: Scientific engagement in health and climate change
- 5.2: Government engagement in health and climate change
- 5.3: Corporate sector engagement in health and climate change

Indicator 1.1.5: heat-related mortality

This indicator models yearly estimates of excess deaths from all causes as a result of heat exposure in older adults. Between 2000 and 2022, there were more

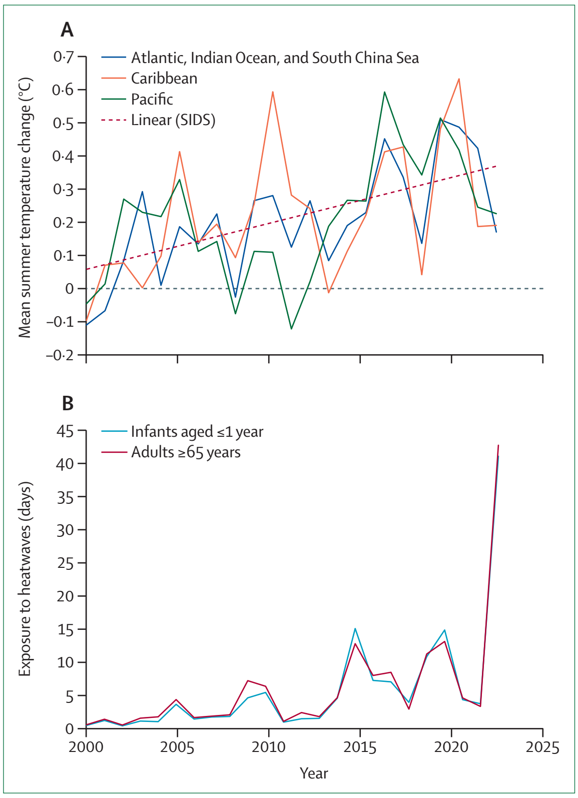

Figure 1: **Exposure-weighted change in summer temperatures, by SIDS subregion (A), and mean annual days of exposure to heatwaves in SIDS, 2000–23, in infants aged 1 year or younger and adults aged ≥65 years (B)**

In (A), data are relative to the period 1986 to 2005; data were unavailable for 2023. Linear (SIDS) is the trend line for all SIDS combined. SIDS=small island developing states.

See Online for appendix

heat-related deaths in the Caribbean subregion (around 10 000 deaths) than in the Pacific (around 2000 deaths) or AIS (around 600 deaths) subregions. During this period, the average rate of heat-attributable deaths in older adults was one per 100 000 population per year in the Caribbean and the Pacific subregions, and 0·6 per 100 000 population per year in the AIS subregion. Heat-related deaths in older adults increased by 89% in 2013–22 compared with 2000–09 across SIDS, corresponding to a 57% increase in the AIS subregion, a 49% increase in the Pacific subregion, and a 103% increase in the Caribbean subregion. A large reduction in heat-related attributable deaths was noted across all SIDS regions in 2021–22, most likely due to La Niña.

1.2: Health and extreme weather events

Indicator 1.2.1: drought

Droughts can cause severe agricultural losses, and can lead to water and food insecurity and sanitation-related diseases. Since 1976, 58 (98%) of the 59 SIDS have been affected by climate-induced or climate-exacerbated water shortages that constitute a water crisis (only Singapore has been unaffected).[17] This indicator tracks the land areas experiencing extreme droughts according to the Standard Precipitation and Evapotranspiration Index.

The proportion of land area across SIDS that was affected by at least 1 month of extreme drought per year more than doubled in 2014–23 (56%) compared with 1961–70 (23%). On average in 2014–23, 17% of total land area in SIDS experienced at least 6 months of extreme drought per year compared with 2% of total land area in 1961–70. The appendix (p 47) shows a breakdown by subregion of the proportion of land undergoing 1, 3, and 6 months of extreme drought in 1961–70 and 2014–23, with the largest increases in the Pacific subregion. In the AIS subregion, the amount of land experiencing at least 1 month of extreme drought per year decreased in 2014–23 compared with 1961–70 (appendix p 47). However, whereas no land areas experienced 6 months of drought in 1 year in 1961–70, 7% of land areas experienced 6 months of drought in a year in 2014–23. Collectively, these worrying trends could signal a worsening of water insecurity, especially in combination with rapid urbanisation and expansion of water-intensive activities.

1.3: Climate suitability for infectious diseases

Climate change is increasing the risk of transmission of many infectious diseases that threaten public health.[4,18] This indicator monitors the effect of climate change on the transmission potential of dengue, malaria, and *Vibrio*, using modelled estimates.

The increase in dengue transmission worldwide over the past 50 years poses a substantial public health threat in many countries, including SIDS.[19] The suitability for dengue transmission by *Aedes aegypti* mosquitoes, as estimated by the basic reproduction number (a measure of transmissibility), was 33% higher in 2013–22 compared with in 1951–60 across SIDS (18%, 34%, and 40% higher in the AIS, Caribbean, and Pacific subregions, respectively; figure 3). An increase of 32% was noted for transmission via *Aedes albopictus* mosquitoes (figure 3). These increases in basic reproduction numbers are particularly worrying given the outbreaks of dengue in many SIDS in the last ten years, particularly in Indian Ocean SIDS.[20]

For malaria, this indicator models the number of months per year suitable for transmission of the two most important pathogens—*Plasmodium falciparum* and *Plasmodium vivax*—by anopheles mosquitoes in highland (ie, ≥1500 m above sea level) and lowland areas based on temperature, precipitation, and humidity thresholds and land classes suitable for the vector. Although malaria is present in all SIDS subregions, we noted no distinctive trends in prevalence in 2013–22 period compared with the 1951–60 reference period. In the Pacific subregion, the climate was already suitable for malaria transmission 8–11 months per year, which could have made increased suitability for transmission difficult to detect. Many SIDS do not possess highland areas. However, the risk of transmission of *P vivax* in the Dominican Republic was higher in highland areas than in lowland areas, and thus the potential effects of increasing temperatures at higher altitudes is of concern.

The *Vibrio* indicator maps environmental suitability for transmission of pathogenic *Vibrio* species by identifying areas with sea surface temperatures higher than 18°C and salinities of less than 28 practical salinity units in coastal zones in the 11 SIDS with available data. The amount of coastline suitable for *Vibrio* transmission in 2011–22 was 27% higher than that in 1982–90. Thus, pathogenic *Vibrio* species poses an increasing risk in SIDS, especially in coastal zones where high numbers of people rely on oceans for their livelihoods.

1.4: Undernutrition and food security

Ensuring food security in SIDS is challenging. Most are highly dependent on food imports and fisheries, and poor people in these countries are particularly at risk from global food price shocks (eg, as occurred during the 2008 food crisis).[21–23] Food security in SIDS is affected by weather and climate shocks, extreme events within and outside the region, international trade, and global food prices, each of which can affect access to, and affordability and availability of, food.

Indicator 1.4.1: food insecurity

In 2022, 33% of surveyed individuals in the SIDS that responded to the UN's Food and Agriculture Organization's Food Insecurity Experience Scale survey (which tracks eight dimensions of food access, from not being able to eat a sufficient variety of food to not eating for a whole day) reported eating only a few kinds of food during the 12-month recall period, and 31% reported being unable to eat healthy and nutritious food and eating less than they thought they should.[24]

This indicator combines data from the Food Insecurity Experience Scale survey and data for the frequency of heatwave and drought for a time-varying panel regression[4,23,25] to explore the effects of climate change on food insecurity, controlling explicitly for the share of food that is imported. In 2022, an additional 2·6 million people in SIDS (accounting for 4·8% of the total population in the 30 SIDS for which data were available) were estimated to have experienced moderate or severe food insecurity due to a higher frequency of heatwaves and droughts compared with the annual average in 1981–2010. A higher number of heatwave days was associated with a 5·9 percentage point increase in people experiencing moderate or severe food insecurity in 2022 compared with in 1981–2010, and increasingly frequent droughts were associated with a 3·1 percentage point increase (figure 4). In addition, low-income people have a significantly higher risk of food insecurity than do medium-income people. SIDS that are more dependent on food imports are at higher risk of food insecurity than those less dependent on imports.[21–23]

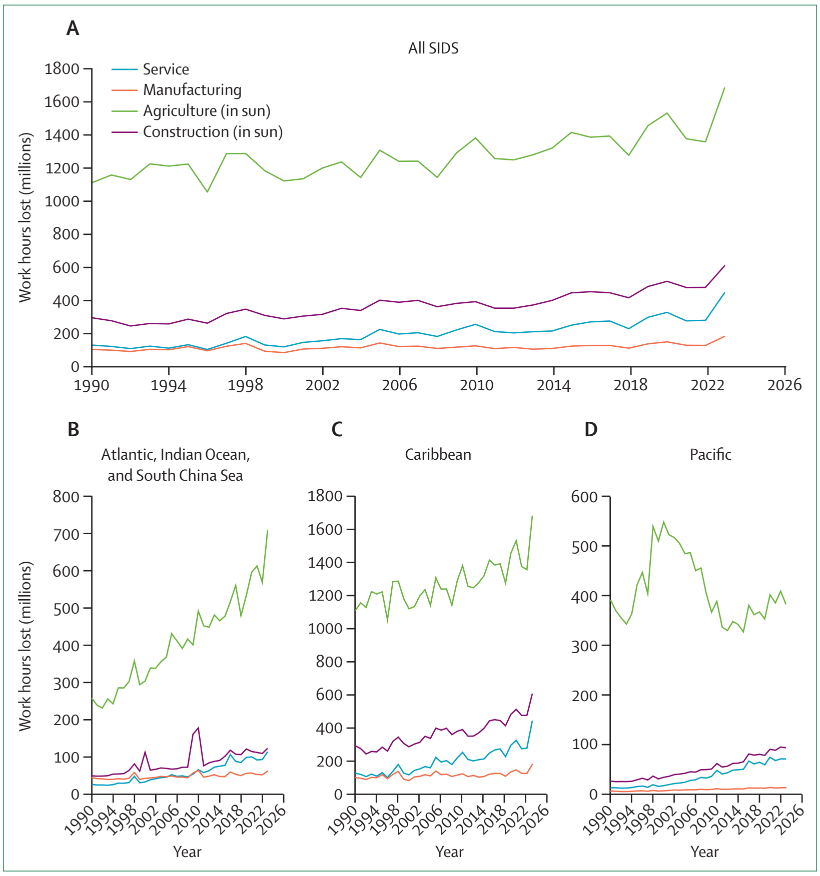

Figure 2: Potential work hours lost due to heat by employment sector, 1990–2023 in the small island developing states overall (A), and in the Atlantic, Indian Ocean, and South China Sea (B), Caribbean (C), and Pacific (D) subregions

Indicator 1.4.2: marine food insecurity

Capture fisheries are of immense importance to SIDS, particularly in the Pacific subregion, where they contribute up to 10% of gross domestic product (GDP) and are among the main means of sustaining local livelihoods.[21] These fisheries also provide 50–90% of the animal protein in the diet of coastal communities in the Pacific subregion, whose fish consumption is more than three times the global average.[21] Marine primary productivity faces a formidable challenge from climate change, including elevated sea surface temperatures along the coast, which can trigger a cascading sequence of adverse consequences, including diminished oxygen concentrations and coral reef bleaching, which threaten marine life.[26–28] This indicator monitors fluctuations in sea surface temperatures within the coastal regions of 43 SIDS between 1980 and 2023,[29] augmented by Food and Agriculture

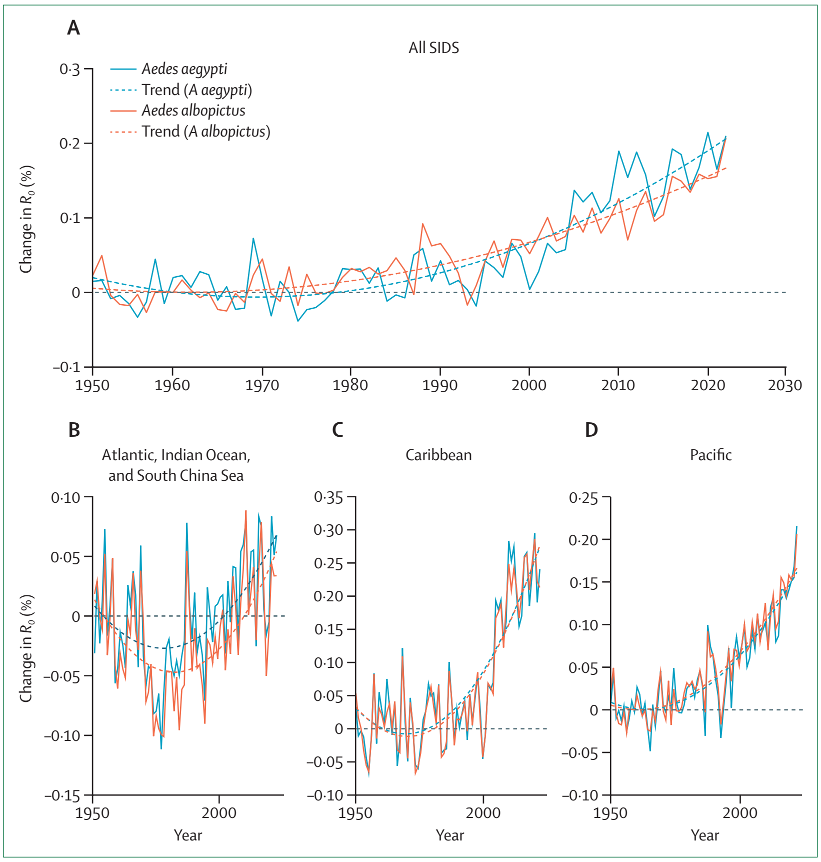

Figure 3: **Risk of dengue in small island developing states overall (A) and in the Atlantic, Indian Ocean, and South China Sea (B), Caribbean (C), and Pacific (D) subregions**
Two species of the *Aedes* vector are graphed separately by the effect on their mean R_0. Dotted lines represent polynomial trends lines for 1951–2022. R_0=basic reproduction number.

Organization data for consumption of fish from both aquaculture and capture fisheries.[30]

Sea surface temperatures in SIDS coastal regions were 0·59°C higher on average in 2023 than in 1981–2010 (appendix p 84). Although generally capture-based fish production has declined globally,[3] it has increased in SIDS, particularly since 2000. In the context of the challenges posed by climate change, including the increasing intensity of storms and rising sea levels that have adverse effects on essential fish habitats,[31] this increase in SIDS could suggest overfishing[32,33] in response to diminishing marine primary productivity. Overfishing is the predominant threat to approximately 67% of marine species on a global scale,[34] with potential repercussions that could jeopardise the sustainability of capture fisheries production in SIDS. Further research and surveillance data are essential to monitor and assess the sustainability and effects on marine primary productivity of increased capture-based fish production. Data from high-resolution coral reef maps should be analysed (specifically, the annual maximum bleaching alert area due to thermal stress) and comprehensive fish stock assessments, including biomass determination, should be done. SIDS are already highly vulnerable environmentally and economically,[35] and their heavy reliance on fisheries for economic development, food security, and livelihoods exacerbates susceptibility to changes in fisheries resources.

Conclusion

Data from the past 70 years show striking climatic changes that have put SIDS at particular risk of heat stress, drought, vector-borne diseases, and food insecurity. These hazards are particularly worrying for the most vulnerable populations in SIDS, including infants and older people. Climatic changes have also increased the risk of chronic NCDs and the risk of reduced workforces in sectors that are vital to an improved economy. Measures to prepare for these challenges need to be implemented and reinforced to build resilience in SIDS.

Section 2: Adaptation, planning, and resilience for health

Ensuring that health systems are resilient to climate change through capacity-building actions at local, regional, and global levels is imperative to protect populations.[36] In this section, we monitor progress in delivering health adaptations to the growing climate hazards, through indicators that monitor national assessments and strategies, information systems and financing, and the human consequences of action or inaction.

2.1: Assessment and planning of health adaptation

The implementation of climate adaptation plans is an essential first step to prevent the worst health impacts of climate change in SIDS. These plans should be informed by valid data gathered through periodically updated assessments of vulnerability and adaptation.

Indicator 2.1.1: national assessments of climate change impacts, vulnerability, and adaptation for health

Implementing effective health-protecting adaptation measures requires a deep understanding of local vulnerabilities, hazards, and risks, which can be gained through assessments of climate change risks and vulnerability. Of the 24 SIDS that participated in the 2021 WHO Health and Climate Change survey,[37] only nine (two each in the AIS and Pacific subregions and five in the Caribbean subregion) reported having conducted national health vulnerability and adaptation assessments. Only four participants reported that these assessments strongly informed policy development, and only three (Marshall Islands, Palau, and São Tomé and Príncipe) reported that these assessments strongly influenced resource allocation, exposing the difficulties in adequately funding crucial adaptation interventions in SIDS.

Indicator 2.1.2: national adaptation plans for health

National adaptation plans for health are essential for protecting populations from climatic hazards. In the 2021 WHO Health and Climate Change survey, only eight (33%) of 24 participating countries—three each in the AIS and Pacific subregions, and two in the Caribbean region—reported having national health and climate strategies or plans. Insufficient funding was a key barrier to implementation of plans in only two SIDS, but given how frequently limited financing hinders developmental goals, the low overall responses could suggest limited national prioritisation of the health and climate nexus.

2.2: Enabling conditions, adaptation delivery, and implementation

Vulnerability to climate change hazards is influenced by the coverage of climate and health data systems. These indicators monitor the implementation of key adaptative interventions and explore adaptation actions and financial commitments that enable adaptation, work that is crucial to identify areas of progress and gaps requiring action.

Indicator 2.2.1: climate information for health

Surveillance and early-warning systems reduce the health impacts of climate hazards.[37] This indicator examines the capacity of meteorological systems to provide climate services to health sectors and climate-information integration into health surveillance and early-warning systems. Of the 42 SIDS that reported their health sector collaboration with the World Meteorological Organization, 34 (81%) reported providing climate services to the health sector, mainly in the form of data services (32 [76%]). Only 19 (45%) SIDS reported providing climate analysis and diagnostics, and only 13 (31%) engaged in climate change projections. These low rates highlight challenges in establishing observation networks, improving data access, downscaling capabilities, and accessing climate products.[38]

One of the most important outputs of climate services for health is surveillance and early-warning systems, which help to pre-empt public health emergencies and to provide adequate lead times for intervention. Of the 24 SIDS that responded to the 2021 WHO Health and Climate Change survey, 15 (63%) have early-warning systems for vector-borne diseases, 11 (46%) have systems for food-borne diseases, and ten (42%) have systems for water-borne diseases. Only five (21%) have early-warning systems for heat-related illnesses and only four (17%) have early-warning systems for mental health. Although most SIDS have general surveillance systems for food-borne (20 [83%]), water-borne (19 [79%]), vector-borne (20 [83%]), and respiratory (18 [75%]) diseases, there is a notable scarcity of surveillance systems for heat-related diseases (five [21%]). These systems incorporate meteorological information for climate-sensitive diseases in only around 25% of SIDS.[37]

Indicator 2.2.2: urban green space

Urban green space is a form of adaptation because it provides local cooling—particularly in urban areas, which can become particularly hot due to the combined influence of climate change and the urban heat island effect.[39] This indicator uses satellite measurements of vegetation overlayed with population data to estimate greenspace exposure for urban centres with more than 500 000 inhabitants and the most populated cities in SIDS that do not have urban centres with such high populations.[4]

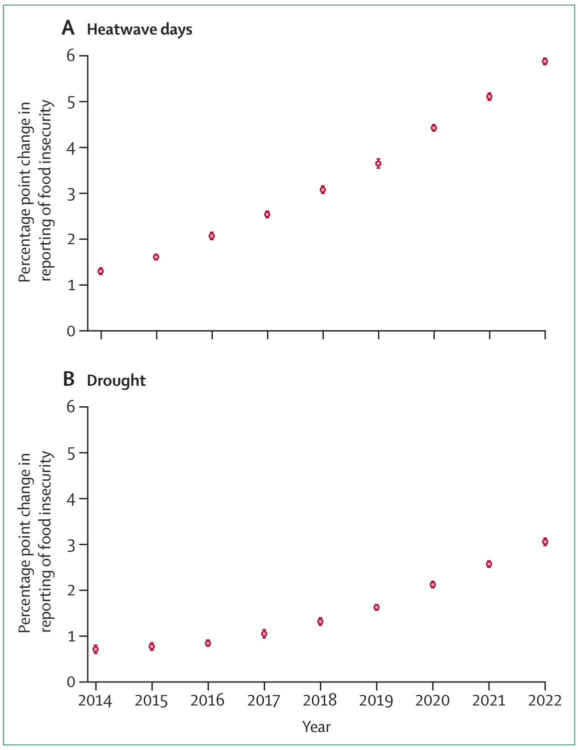

Figure 4: **Percentage point change in the proportion of the population of surveyed SIDS reporting moderate or severe food insecurity due to heatwave or drought compared with the annual average in 1981–2010**
Data for 30 surveyed SIDS are included. SIDS=small island developing states.

Data were available for 22 cities in 19 SIDS. Only Cabo Verde had a city that had a high level of urban greenness in both 2022 and 2023. One city in Fiji attained high urban greenness in 2023, an increase from moderate greenness in 2022. In 2023, ten (45%) cities had moderate urban greenness, eight (36%) had low levels of greenness, and two (9%)—Belize City in Belize and Georgetown in Guyana—had very low greenness. The Caribbean had a higher proportion of cities with low levels of urban greenness (five [42%] of 12 cities) compared with the Pacific (one [25%] of four cities) and AIS (two [33%] of six cities) subregions. These data underscore the opportunity of local adaptation to heat through the expansion of urban green spaces, which could simultaneously deliver secondary health co-benefits through the positive effects of exposure to greenness on physical and mental health.[40]

Indicator 2.2.3: health adaptation-related funding

Protecting health from the growing effects of climate change can be costly, and financing is required to ensure countries can adapt efficiently. For low-income and middle-income countries, a lack of adaptation funding is often a major limitation that exacerbates global health inequities.

This indicator monitors financial commitments by the Green Climate Fund (GCF) for health adaptation in the context of climate change. Between June, 2015 and Dec 31, 2023, around US$3 billion has been committed to 51 adaptation and cross-cutting projects that operate in multiple countries, including 34 SIDS. The financing breakdown[41] indicates that an average of $70 million has been approved for adaptation projects per SIDS. By contrast, an average of $120 million was given to each non-SIDS country. The amount allocated for SIDS is far less than what is needed to meet adaptation needs and is substantially less than the $1 billion per year that the International Monetary Fund has estimated is needed for the Pacific SIDS alone.[4,41,42]

None of the 51 major projects explicitly address health or health systems. Nevertheless, most include components that could benefit health indirectly. Among projects in areas intersecting with health, those related to improved access to microfinancing ($713·1 million) and water security ($204·5 million) had the most funds approved, whereas projects related to flood management ($80·1 million), food security ($64·6 million), and wastewater management ($70·4 million) were among the least funded (appendix pp 108–09). Cooling facilities to address unprecedented increases in heat were the focus of one project (which received $157 million of funding); although it mostly functioned in non-SIDS, a portion of the funding was approved for Saõ Tomé and Príncipe.

For the **Centre for Research on the Epidemiology of Disasters database** see https://www.emdat.be

Between 2017 and 2020, financing for development of national adaptation plans declined in SIDS. However, financing has increased since 2020. Despite this renewed focus on the importance of national adaptation plans, only one plan development project out of 26 assessed had an explicit health focus.

Indicator 2.2.4: detection, preparedness, and response to health emergencies

This indicator relates to the level of implementation of core capacity 7 of the International Health Regulations,[43] which focuses on national planning for health emergency management and systems enabling country preparedness and operational readiness to respond to international public health threats. Only 32 SIDS reported their implementation status in 2022. With regard to the management of health emergency responses, 24 (75%) SIDS reported high or very high performance in terms of implementation. The lowest performance in all indicators was in the AIS sub-region.

The success of the WHO South Pacific Division in facilitating 19 (91%) of 21 Pacific SIDS to meet International Health Regulations requirements could be a model for improving core capacity implementation and progress in other SIDS. Perhaps low-performing SIDS could be similarly supported in the development and execution of implementation plans for improving emergency management preparedness.

2.3: Vulnerabilities, health risk, and resilience to climate change

For SIDS, which collectively are low greenhouse gas emitters, adaptation is the most effective way to withstand the climatic shocks they are disproportionately exposed to. The subsequent indicators offer a view of adaptation to two of the most prominent climatic risks affecting SIDS: extreme weather events and sea level rise.

Indicator 2.3.1: lethality of extreme weather events

Extreme weather events are of major concern to SIDS, where the frequency and severity of events such as cyclones, floods, droughts, and heatwaves have increased,[44,45] increasing the risk of injury and death both directly as well as indirectly through the loss of essential infrastructure, disruption of essential services, and impacts on food and water security.[45,46] This indicator uses data from the Centre for Research on the Epidemiology of Disasters database, which records the number of deaths and persons affected by extreme weather events.

Although 25 million more people were affected by all extreme weather events in 2014–23 compared with 1990–99, the total number of associated deaths fell from 2350 in 1990–99, to 1900 in 2014–23—a 19% decrease. This reduction in deaths is likely a result of improvements in early-warning mechanisms, forecasting, and disaster preparedness.[38] However, comparing 2014–23 with 1990–99, total deaths increased from 160 to 250 (ie, by 56%) in SIDS with medium Human Development Index (HDI) scores, and from 100 to 500 in SIDS with very high HDI scores (ie, a 400% increase). These findings underscore that resilience against climatic events is not important only for SIDS with low HDI scores, but rather for all small islands irrespective of their level of socioeconomic development.

Indicator 2.3.2: migration, displacement, and rising sea levels

As the global sea level rises, SIDS are increasingly at risk of loss of habitable land, which could lead to loss of lives and livelihoods and wide-scale migration or displacement if in-situ adaptation is insufficient. Rising sea levels also increase the risk and intensity of coastal storms and erosion.[47] The salinification of land jeopardises crop productivity, and the salinification of drinking water can increase sodium intake, thereby increasing the risk of cardiovascular disease and potentially rendering water unsuitable for human consumption.[48,49] This indicator was based on data for the number of people in SIDS who lived less than 1 m above sea level, which was calculated with land elevation and population data. In the 47 SIDS with available data, an estimated 1·1 million people (approximately 2% of the SIDS population) lived less than 1 m above sea level in 2022. SIDS are thus a grouping with particularly high proportions of their populations living less than 1 m above sea level,[50] and so are at particularly high risk from rising sea levels. SIDS need to implement adaptation interventions to prevent emerging harms in at-risk populations.

Relocation policies can be implemented if land becomes inhabitable as an adaptive response to protect local populations. Carefully crafted policies that ensure the health of relocated, displaced, or migrant populations are essential to protect and preserve population health (panel 4). SIDS, primarily in the Pacific subregion, have 23 policies referencing displacement or migration due to the effects of climate change. These policies all referenced the mental health effects of displacement on wellbeing, whereas only 15 (65%) mentioned movement from a location affected by sea level and only six (26%) referred to potential dangers in migrating to locations also threatened by sea level rise—an important consideration for securing a safe place for potential climate refugees in SIDS.

Conclusion

With adaptation efforts lagging, SIDS remain highly vulnerable to the health impacts of climate change, in large part due to insufficient completion of periodic health and vulnerability risk assessments and insufficient enactment of health adaptation plans in climate policies. These issues constitute major obstacles to building effective, resilient health systems. Strategies to build resilience tend to be fragmented and short-term, largely as a result of a lack of finance. The amount of money allocated to SIDS for climate adaptation is far lower than the yearly amount estimated to be necessary by the International Monetary Fund for the Pacific subregion alone.[42] Without global, regional, and national investment and cooperation, SIDS are increasingly likely to succumb to the impacts of extreme weather events, heat-related stresses, climate-sensitive infectious diseases, and NCDs, and climate change will continue to be an existential threat to millions of people.

Section 3: Mitigation actions and health co-benefits

Despite contributing less than 1% to global greenhouse gas emissions, small islands are already facing an array of climatic effects and are likely to face some of the most catastrophic impacts in the future. Continued reliance on fossil fuels and government support through fossil fuel subsidies have perpetuated energy systems across SIDS that are difficult to transform in the short term. Energy, agriculture, food, health, and transportation systems are dependent on external oil and gas supplies, often from higher-income countries. This dependence on fossil fuels is directly associated with several health complications—specifically, respiratory illnesses from air pollution. Conversely, mitigation actions that reduce emissions could provide key health benefits.

In this section we discuss progress in reducing greenhouse gas emissions in the context of increased energy and food consumption in SIDS, and highlight the potential associated health implications. The indicators, selected on the basis of priority and availability of reliable data, track energy-usage patterns across SIDS and the dietary risks of energy-intensive and environmentally expensive food production.

3.1: Energy use, energy generation, and health

According to World Bank data,[58] the proportion of the population in SIDS with access to electricity rose from 71% to 83% between 2002 and 2020. However, this figure masks substantial differences between SIDS: 15 did not have universal energy access in 2020, with 6 million people in Haiti (52% of the population), 3·5 million people in Papua New Guinea (40% of the

Panel 4: Adapting to climate change impacts through migration with dignity in Kiribati

Kiribati is a lower-middle-income country in the Pacific region that is made up of 33 atolls and islands scattered over 3·6 million km^2. The population of Kiribati is around 125 000, 20% of whom are younger than 18 years.The country is very vulnerable to the impacts of climate change: none of the islands rise more than 2–3 m above sea level, its entire land area is close to sea level, and it is geographically isolated.

Climate change has had a substantial impact on Kiribati, resulting in incremental sea level rises, saltwater intrusion, and drought, and these effects are already experienced at the household level.[51] Ramifications of climate change include overcrowding, destruction of food crops, contamination of drinking water, and economic hardships.[52,53] As a result, some people are forced to search for new homes—either to ensure a source of income or to find land on which to live.

In the Pacific Climate Change and Migration project, among the 377 households surveyed in Kiribati that included someone who had migrated, 94 (25%) included someone who named climate change as a reason for migration decisions both internally and abroad.[52,54] Internal migration is unsustainable due to the unavailability of land sufficiently above sea level, although the number of internal migrations is five times higher than that of international migrations.[52] International migrations were initially limited to seasonal worker schemes in Australia and New Zealand. An attempt by an I-Kiribati man in 2013 to seek asylum as a climate refugee in New Zealand was denied by both the New Zealand Government (2015) and the UN Human Rights Commission (2016).[55] According to Kate Shuetze, Pacific Researcher at Amnesty International, this decision has set a global precedent.[55] “Pacific Island states do not need to be underwater before triggering human rights obligation to protect the right to life”, she stated.[55]

In 2014, the Kiribati Government produced an integrated and systematic 10-year plan for climate change and disaster risk management.[56] That year, the Kiribati Government bought land in Fiji for citizens to relocate should they permanently lose their homes due to rising sea levels.[56] Furthermore, the Government has drafted a two-phase, long-term nationwide relocation strategy: the migration with dignity policy.[57] The first phase is to create opportunities for people who wish to migrate abroad to various receiving countries, such as Australia and New Zealand, so that they can support migrants in the longer term and enhance remittances. The second phase is to improve educational and vocational qualifications that can be obtained in Kiribati to match skills needed in receiving nations before migration. The cost is largely subsidised by the Government.

population), and 1·3 million in Guinea-Bissau (66% of the population) not having electricity access. Although electricity access is a primary enabler of development and a determinant of health, electricity is often not generated using healthy, affordable, and low-carbon sources. Consumption of energy sources across SIDS is highly diversified. Singapore, for example, has the world's highest oil consumption per person due to its deep integration into global oil markets. By contrast, in less economically developed SIDS (eg, the Solomon Islands, Guinea-Bissau),[59,60] energy production is dominated by traditional biomass.

Domestic fossil fuel resources are scarce in SIDS, except for Guyana, which is developing its oil sector, and Trinidad and Tobago, which produces oil and gas. Only six SIDS—Singapore, Mauritius, Guadeloupe, New Caledonia, Puerto Rico, and the Dominican Republic—use coal, the highest polluting fossil fuel, to generate electricity. The Dominican Republic alone accounts for over half of the total 1·5 gigawatts of coal generation capacity of these six SIDS,[61] with the proportion of electricity generated by burning coal increasing from 4% in 2000 to 8% in 2022.[62] After public health campaigning by residents, the US Environmental Protection Agency has pledged to monitor coal ash disposal sites in Puerto Rico.[63]

According to data from the International Renewable Energy Agency[62] on the share of electricity generation by source since 2000 (appendix p 118), renewable energy provides only 8% of electricity in SIDS, despite plentiful potential resources. Expanding electricity access and decarbonising existing supplies are essential to increase access to clean energy, and reduce local reliance on imports of fossil fuels (which have highly volatile international prices).

3.2: Diet and health co-benefits

The global food system contributes around 30% of global greenhouse gas emissions.[64] The rearing of ruminants is a major contributor to these emissions, both due to methane emissions from ruminant digestive processes and the associated land use change-related emissions. In parallel, the overconsumption of ruminant-derived food products, including red meat and dairy, is responsible for a substantial burden of disease.[4]

Although emissions from agricultural production across SIDS are low compared with other regions,[4] methane from farming and ruminant rearing can substantially contribute to localised heat island effects and human-driven air pollution.[65] This indicator monitors the health burden (as captured in attributable death estimates) associated with food consumption, particularly for imbalanced, carbon-intensive diets. In 2019–21, across all SIDS subregions and all reported food groups (ie, fish, red meat, processed meat, poultry, milk, eggs, oils, sugar, fruits, vegetables, nuts and seeds, legumes, whole grains, processed grains, roots, and other crops), an estimated 265 500 deaths (193 000 [73%] in the Caribbean, 54 000 [20%] in the Pacific, and 19 000 [7%] in the AIS subregions) were attributable to the consumption of imbalanced diets. 41 200 deaths (16% of deaths attributable to imbalanced diets over the period) were specifically attributable to diets characterised by the over-consumption of carbon-intensive food such as red meat, processed meats, sugar, and milk.

The Caribbean subregion had the highest rate of mortality associated with imbalanced diets, with 153 deaths per 100 000 population in 2019–21, compared with 129 deaths per 100 000 population in the Pacific subregion and 115 deaths per 100 000 population in the AIS subregion. Because mortality data were not available before 2019, it is currently unclear whether these findings reflect consistent diet-related inter-regional health differences among SIDS or broader temporal health trends. Further research and analysis are warranted.

Conclusion

Persistent inaction and delays across sectors have allowed the perpetuation of carbon-intensive health-harming activities in SIDS, threatening to lock in an unsustainable future. Our findings underscore the potential for delivering interventions that offer multiple benefits, including the reduction of greenhouse gas emissions. Healthier, more plant-based diets can simultaneously benefit the health of local populations and help reduce food sector-related greenhouse gas emissions.[4]

Government and institutional support for fossil fuel-dependent systems have sometimes meant that renewable technologies have not been given sufficient opportunities to be economically viable or equitably available, which has limited capacity to develop and utilise renewables for fundamental tasks. Furthermore, as SIDS pursue transitions away from fossil fuels, they often turn to more developed countries that have developed renewable energy technologies, potentially resulting in further entrenchment of dependence on highly industrialised countries. The continued jeopardisation of local energy source development, and pursuant benefits to local communities, should be addressed with technology and funding transfers from highly industrialised, high-emitting countries as a matter of climate justice.

Section 4: Economics and finance

The health impacts of climate change have cascading economic costs, which in turn undermine the socioeconomic determinants of health. The burden is particularly high in the most vulnerable countries, including many SIDS. In addition to the immediate impact of disrupting health services, a rising incidence of climate-related extreme events has economic effects via causing damage, work disruption, and premature mortality. Furthermore, high temperatures can cause heat-related mortality and loss of labour capacity, which have economic implications. Funding for health-supporting activities is needed to protect the health of SIDS populations from climate change. In this section, we describe the economic costs of climate-driven health impacts in SIDS societies from the perspectives of climate change mitigation, the burden of heat-related mortality, and the potential loss of earnings due to heat-related losses in labour capacity.

4.1: Economic impact of climate change and its mitigation

Indicator 4.1.1: economic losses due to climate-related extreme events

Extreme weather can cause damage and losses equivalent to a substantial fraction of the GDP of individual SIDS, (and in some cases damage and losses can exceed GDP). Extreme weather events can cause substantial damage even in SIDS with high HDI scores, high per-capita GDPs, and good infrastructure, because small economies might still have limited funds, constraining the amount of infrastructure that can be made resilient to major hurricanes. Moreover, recovery from extreme weather events can take a decade or more, depending on local resilience and recovery capacity. This indicator measures the economic losses incurred from damages associated with major types of extreme weather (ie, storms, floods, and drought) using data from the Centre for Research on the Epidemiology of Disasters database.

Storms were responsible for $113 billion (94%) of the $120 billion in damages caused by extreme weather from 2000 to 2023. The Caribbean bore the heaviest burden of storm damage, with damage totalling $112 billion (93% of the total damages for the three major types of extreme weather events). Droughts resulted in higher economic losses in SIDS with low HDI and medium HDI scores ($86 million and $65 million, respectively) than in those with high HDI SIDS (around $34 million). Conversely, the cost of damage from storms and floods in SIDS with very high HDI scores (around $91 billion) and high HDI scores (about $25 billion) HDI SIDS was markedly higher than those in SIDS with medium HDI scores (roughly $1 billion) and low HDI scores (about $3 billion). Greater losses in SIDS with high HDI scores reflect the greater infrastructure and economic assets at risk in those states.

Beyond the losses from extreme events, slow-onset events (eg, increased daily temperatures or droughts) can also cause substantial economic losses, but such losses are often difficult to quantify or attribute to specific climatic events. Losses from droughts and high temperatures are infrequently reported, and their impacts can be difficult to measure. The data presented here are thus underestimates of the real economic losses associated with climate change-sensitive events.

Indicator 4.1.2: costs of heat-related mortality

In 2000–23, monetised losses in SIDS due to heat-related mortality increased by an average of $19·6 million annually. The highest total loss for any one year occurred in 2020: $647 million. The average annual income lost in 2023 in the Caribbean subregion was equivalent to around 24 600 people, whereas the loss in the Pacific subregion was equivalent to around 9600 people. In terms of HDI status, SIDS with low HDI scores lost the equivalent of the average annual income of close to 5000 people, SIDS with medium HDI scores lost an equivalent of the income of about 10 000 people, SIDS with high HDI scores had losses equivalent to the income of around 17 500 people, and SIDS with very high HDI scores lost the equivalent of the income of around 3000 persons in 2023 (appendix p 132).

Indicator 4.1.3: loss of earnings from heat-related loss of labour capacity

High heat exposure puts the health of exposed workers at risk, and reduces labour productivity, particularly in physically demanding jobs. This loss in labour productivity in turn leads to losses in economic output and incomes, affecting the socioeconomic conditions on which good health depends.[66] This indicator tracks country-level potential loss of earnings due to heat-related loss of labour capacity for work in the service, manufacturing, agriculture, and construction sectors (and specifically work undertaken in the sun for the latter two sectors). Overall, between 1990 and 2023, SIDS lost around $273 billion in potential earnings due to heat-related loss of labour capacity, with just under $100 billion (37%) lost in the agriculture sector, $91 billion (33%) lost in the construction section, $46 billion (17%) lost in the service sector, and $35 billion (13%) lost in the manufacturing sector. Agriculture was the most affected sector in the Pacific and the Caribbean subregions, whereas construction was the most affected in the AIS subregion.

The breakdown of losses across sectors has changed with time. Between 1990 and 2009, the agriculture sector incurred the greatest losses in all SIDS. However, since 2010, the construction and agriculture sectors have experienced similar economic losses (both accounting for around 34% of overall losses).

Vulnerabilities in SIDS include the reliance of local economies on strenuous outdoor labour, and limited capacity to implement optimal worksite mitigation or corrective controls, such as shade, cooling devices (eg, fans or air conditioning), and rest breaks.[67,68] Concerningly, many high-risk jobs (in terms of potential exposure to heat), including agriculture, construction, factory-based work, tourism, and sport are important drivers of SIDS economies.[16,68] These findings align with projections that, by 2030, SIDS regions will experience increasing heat-related economic losses in the industry and services sectors, which will be superimposed on losses from agriculture and construction.[16]

Conclusion

Climate change has had substantial economic impacts in SIDS, with serious implications for the wellbeing, health, and livelihoods of local populations. The small, open economies of SIDS render them vulnerable to extreme weather events that cause losses that could even exceed GDP. The lack of data on slow-onset events leads to underestimation of their potential effects, particularly as they can coincide with more extreme events. Long recovery times are a further challenge to restoration and development. The Loss and Damage Fund agreed to at the 28th UN Framework Convention on Climate Change aims to support countries that are disproportionately financially vulnerable to these events and to shorten the recovery for specific sectors such as agriculture (panel 5). Based on International Labour Organization statistics,[16] increasingly heat-related income loss will derive from the services sector rather than the agriculture sector in most SIDS in the coming years. Overall, the available data underscore that SIDS experience exorbitant climate-related economic costs and losses that hinder not only recovery but also resilience.

Section 5: Public and political engagement

Public and political engagement are crucial for the implementation of effective measures to reduce emissions and protect people affected by climate change. Although the deleterious health effects of greenhouse gas emissions have been increasingly highlighted, there has been little action to slow and stop climate change, prevent the associated impact on health, and meet national and international commitments, including the Paris Agreement—the legally binding international treaty on climate change, which sets a goal of maintaining global warming at less than 2°C by 2100.

In this section, we focus on groups who have important roles in highlighting the relationship between climate change and health and in driving climate action. The indicators track the engagement of scientists, governments, and the corporate sector with the intersection of health and climate change.

Panel 5: Loss and Damage Fund update

After the breakthrough during the 27th UN Framework Convention on Climate Change (COP27) in 2022, countries agreed to establish a fund to compensate vulnerable nations for loss and damage from climate-induced disasters. This led to the development of the Sharm el Sheik Implementation Plan, and an agreement to establish the Loss and Damage Fund was reached during the opening plenary at COP28 in 2023. The agreement of the long-awaited fund aims to financially support nations that are disproportionately experiencing the most severe and costly impacts of anthropogenic climate change—eg, droughts, rising sea levels, and extreme weather events, which have become more frequent—despite contributing the least to greenhouse gas emissions.[69]

Several high-income countries extended their support, and the fund now totals US$700 million, including US$100 million each from the United Arab Emirates and Germany. Countries such as the USA, the UK, and Japan have also committed to contribute to the fund, but so far, there is a huge disparity between the pledged amount and the true cost of the damage, which is estimated at $100 billion–580 billion annually.[70] Furthermore, it is not clear how pledged resources will be allocated to affected communities, with worries that making a claim for such allocations based on historical needs will involve a rigid process.

5.1: Scientific engagement in health and climate change

Scientific engagement is important for improving the evidence linking health and climate change and in understanding the unique contexts, challenges, and opportunities related to climate change in SIDS. This indicator uses machine learning to track the number of peer-reviewed scientific articles by lead authors based in SIDS that mention health and climate change. The number of such articles increased steadily over the past decade, from 35 in 2014, to 75 in 2023, suggesting growing interest in the topic (appendix p 147). However, the total number of articles studying SIDS remains low, and among *Lancet* Countdown regions, SIDS produce the lowest number of relevant research articles. Between 1990 and 2023, 656 peer-reviewed articles about health and climate change by authors in SIDS were published. Of these articles, 561 (86%) focused on impacts of climate change on health, 70 (11%) focused on climate change adaptations, and 25 (4%) focused on climate change mitigation. There is a need for more research focusing on adaptation and mitigation, to inform effective interventions in these areas.

5.2: Government engagement in health and climate change

Government engagement is crucial for the development of policies and laws that mitigate greenhouse gas emissions and safeguard human health.[4] This indicator tracks government engagement in two ways: statements of country leaders at the UN General Debate and the contents of countries' nationally determined contributions (NDCs).

SIDS led discussions on the links between health and climate change at the UN General Assembly, with SIDS leaders representing 64% of the national leaders who spoke on this topic in 2022.[4] SIDS governments highlighted challenges associated with climate change 306 times and health issues 194 times at the 2023 General Assembly, and issues intersecting with both climate and health were mentioned 39 times in General Assembly policy statements.

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In Nationally Determined Contributions, which are supposed to be prepared every 5 years, countries report their commitments on climate action in compliance with the Paris Agreement. These submissions reveal an increase in engagement with health, with 31 (91%) of the 34 Nationally Determined Contributions submitted by SIDS to the UN Framework Convention on Climate Change secretariat in the second and third rounds referring to health, up from 32 (84%) of 38 SIDS in the first round. In addition, the average number of health mentions from SIDS per Nationally Determined Contribution jumped from six in the first round to 19 in the second round, indicating growing concerns about the nexus of health and climate change.

5.3: Corporate sector engagement in health and climate change

This indicator measures the number of UN Global Compact Communication of Progress reports that reference climate change, health, or the intersection of health and climate change. These publicly available reports were available for companies based in ten SIDS (including six of the eight SIDS in the AIS subregion). Data were available for only three SIDS in the Caribbean subregion and one in the Pacific subregion in 2011–23. For the SIDS in the AIS subregion, 2022 had the highest number of participating companies (72) referencing the health dimension of climate change, most of which were Singaporean companies (55). Participation in UN Global Compact COP decreased overall for SIDS in 2023 to 51 companies, and only 36 (30 of which were Singaporean) referred to organisational policies covering both climate and health. A limitation of this indicator is that it requires voluntary reporting by the corporate sector. More effort is needed to increase corporate sector awareness and engagement in health and climate change among SIDS.

Conclusion

Engagement among and action by the scientific, political, and corporate sectors is crucial for climate change mitigation. Reductions in greenhouse gas emissions are not possible without government regulations and corporate responsibility. These data show that SIDS have been driving engagement with health and climate change in international forums—efforts that are essential to drive a global shift in the understanding of the intersections between health and climate change. However, although most corporations are not directly involved in the development and extraction of hydrocarbons, corporations still hold power over the sources of fuel that dominate energy consumption landscapes. Meanwhile, scientific engagement remains insufficient, and additional research on impacts of, adaptation to, and mitigation of climate change in SIDS is urgently needed to inform decision makers as they continue to raise health and climate change as an issue of concern in national and international arenas.

Section 6: Research gaps

Importance of local and regional data sources

Low data availability is one of the key challenges in measuring and monitoring climate change and health impacts in SIDS. To circumvent the absence of standardised and regionally comparable climate and health outcome data for SIDS, most *Lancet* Countdown indicators draw on datasets suitable for global analysis. Although this approach ensures that indicators are globally representative, several constraints impair the use of these indicators in SIDS, including inadequate regional discretisation. Without adequate data nodes for downscaling or disaggregation, the spatiotemporal resolution of global *Lancet* Countdown indicators tends to be too large for small countries and thus can obscure results. For this report, adjustments to account for the sparsity of data coverage had to be made to interpret indicators at three subregional levels. Rather than adopting the *Lancet* Countdown's indicator guide, which requires data availability for 80% of countries, a 70% threshold was adopted to issue representative statements on each indicator (appendix p 180).

Across the five *Lancet* Countdown thematic areas, health hazards, exposures, impacts, and vulnerabilities had the most well represented indicators across the 59 SIDS, with data available for 13 of 14 indicators. Data were available for more than 70% of SIDS for four of these indicators, which thus met adjusted population and sample representativeness. For the other indicators in this thematic area, whether the SIDS represented reflect SIDS more broadly or whether coarse spatial resolution contributed to inadequate coverage is unclear. These inadequacies underscore the urgent need for locally sourced climate and health data with fine and adequate resolution. Work to bolster sensor networks, strengthen data gathering and reporting infrastructures, and increase investment in research for climate and health is crucial to enable better understanding of the implications of climate change on health, to identify vulnerabilities and particularly vulnerable populations, and to reliably assess the rate of climate-attributable changes.

Data from SIDS were available for ten of the 11 indicators in the thematic area of adaptation, planning, and resilience for health. However, data were available for more than 70% of SIDS for only four indicators. Unlike the modelled outputs in the health hazards, exposures, impacts, and vulnerabilities thematic area, most indicators in this area are based on actual reports coming from SIDS governments or organisations. Therefore, the paucity of indicator data could reflect a failure to measure or report progress on adaptation to international organisations like WHO or the World Meteorological Organization. Sustainable adaptation is the only viable solution for SIDS given that climate pressures with devastating effects are already being felt. Increased reporting of progress can help to identify and measure what support is needed, whether technical, financial, or otherwise, and increased engagement with international organisations would help to facilitate the support needed to advance surveillance systems, early warning systems, and other health-protecting adaptation activities.

For the third thematic area, mitigation actions and health co-benefits, there were minimal data available for the eight global indicators, partly because some of the specific models and methods used in the global *Lancet* Countdown indicators were not applicable to SIDS. On the global scale, immediate and drastic reductions in greenhouse gas emissions are essential to prevent an even worse outlook for human health, especially in SIDS, by the end of the century. Although SIDS are minor contributors to global greenhouse gas emissions, local climate change mitigation efforts are important not only to meet global decarbonisation goals, but also to deliver the substantial health co-benefits and development opportunities associated with the zero-carbon transition. If SIDS do not make this transition, they risk being locked in unsustainable, unhealthy futures and being left behind in an emerging health-supporting global economy. However, as suggested by the available country data for most indicators in this thematic area, there is little monitoring in SIDS of the parameters linked to the potential health benefits of just transitions to renewable energy, including improvements in air quality. Additional local evidence highlighting the advantages of actions to reduce emissions are important to incentivise and accelerate the pace of renewable energy transitions, and to ensure that the health benefits of climate policies are maximised.

Since economic capacity underpins the pace of sustainable development across SIDS, it is perhaps the most crucial determinant of health sector adaptation. The indicators in the economics and finance thematic area are therefore fundamental to monitoring approaches that enable climate change mitigation and adaptation efforts. Financial resources tend to be scarce in SIDS, even those categorised as having high-income economies. This scarcity of resources has often represented a major limitation to the delivery of health-protecting and health-promoting climate change policies. Sufficient data to be considered representative were available in SIDS for only three of the 11 global indicators in this thematic area. Coverage for most of the other indicators was low, and some indicators were poorly suited to SIDS. New indicators should be developed to monitor economic metrics of relevance to SIDS, such as the cost of transitioning to renewable energies and the economic impact of slow-onset impacts of extreme weather. Future iterations of this report will focus on tackling this challenge.

In the final thematic area of the *Lancet* Countdown, public and political engagement, five of the seven indicators had data inclusive of SIDS, but data for more than 70% of SIDS were available for only two. Even though health in SIDS is disproportionately affected by climate effects, there is a disconnect between scientific knowledge and engagement at subnational levels that is not captured by tracking mechanisms. Establishing which are the most important and influential forms of engagement in SIDS and then adjusting indicators to better monitor these relationships could help to strengthen this thematic area in future reports.

Specific areas in need of dedicated research

Taking into account the particular vulnerabilities of local populations, the most acute health risks facing SIDS, and the health opportunities that climate action could deliver to local populations, in this section we present key priority areas for focused scientific research (panel 6) to inform health-protecting climate policies.

Panel 6: Data gaps for indicators in SIDS

Indicators for which data are available for ≥70% of SIDS

- Labour capacity and heat
- Heat and physical activity
- Climate suitability to infectious diseases
- Lethality of extreme weather events
- Exposure to heating
- Migration, displacement, and sea-level rise
- Detection, preparedness, and response to health emergencies
- Multilateral funding
- Government engagement

Indicators for which data are available for <70% of SIDS

- Heat-related mortality
- Exposure of vulnerable populations
- Urban green space
- Economic impact of climate and its mitigation
- Corporate sector engagement
- National plans and assessment of climate change for health
- Transition to net zero carbon economies
- Drought
- Scientific engagement

More research needed

- Air quality and pollution
- Water, sanitation, and hygiene
- Cost of energy provision and production from renewable resources
- Legal framework for the adoption of renewables
- Climate-related adverse mental health outcomes
- Climate threats to vulnerable groups (disabled people, people with low incomes, people who are marginalised)
- Economic burden of slow-onset weather events
- Import dependence, food security, and tropical cyclones
- Non-communicable diseases and climate change

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Mental health

Exposure to the devastation of extreme weather events that climate change is making increasingly frequent and intense could lead to acute psychological distress through stress and anxiety disorders within affected communities, with people potentially unable to cope or recover within the short or medium term. Climate change-related migration and forced displacement can also have adverse mental health consequences for migrant populations, particularly if they are not adequately supported throughout the migration or displacement journey (panel 4).

Surveys in the aftermath of devastating hurricanes suggest that children are particularly susceptible to longer-term post-traumatic stress disorder after displacement secondary to extreme weather events.[71,72] Apart from post-disaster rapid assessments, there is a dearth of scientific or technical publications exploring the extent to which flooding, droughts, tropical cyclones, and other hazards affect the mental health and wellbeing of the vulnerable people in SIDS. In addition, there is also a major knowledge gap related to how slow-onset events, such as rising sea levels, loss of labour productivity, food insecurity, and increased infectious disease transmission, affect mental health. More research is needed to clarify the mental health risks associated with climate change, and to identify effective measures to minimise these adverse impacts and support the mental and psychosocial health of local populations.

People with special vulnerabilities

People with disabilities are especially disadvantaged in terms of access to support during extreme weather events, dissemination of early warnings, and post-disaster aid. Around 1 million people in the Caribbean subregion,[73] 1·7 million in the Pacific subregion,[74] and 230 000 people in the AIS subregion are disabled.[75–78] The additional vulnerabilities of these often-overlooked groups need to be properly studied, understood, and accounted for in all climate-related adaptive interventions. Incorporating specialised interventions, such as registries and technology-based solutions addressing the needs of disadvantaged people, including people with disabilities, minorities, and Indigenous people, are crucial for effective long-term sustained climate action. Research that includes these populations is still scarce, but is acutely necessary to inform policies that can efficiently support their health and wellbeing in the face of growing climate hazards.

Co-benefits of water, sanitation, and wastewater management

Climate change is worsening the intensity, frequency, and extent of flooding. Additionally, flooding has been a major driver of water-borne, vector-borne, and food-borne disease outbreaks in SIDS.[79] Improper water and wastewater management have confounding effects on the prevalence and emergence of infectious diseases after flooding and other climatic events.[17] In SIDS with endemic transmission of cholera, gastrointestinal disorders, and leptospirosis, outbreak occurrence is thought to be increasing despite suspected under-reporting. According to the WHO/UNICEF Joint Monitoring Programme for Water, Sanitation, and Hygiene,[80] 95% of populations across SIDS have access to improved drinking water. However, there are major income-related disparities in access, and local water security is increasingly threatened by climate-change-related sea water intrusion and extreme weather events. Additionally, as much as 30% of the total population of the Pacific subregion SIDS do not use at least basic sanitation services (the average for all SIDS is around 20). As of 2022, only 26% of SIDS populations are connected to sewer networks, which can help prevent near-source water pollution. Furthermore, in SIDS with centralised wastewater-collection systems, over 87% of wastewater on average is not treated before being discharged into the environment. Poorly managed wastewater systems are of particular concern in the Pacific subregion, where only 5% of the population's wastewater is treated to at least a secondary level. Climate change threatens to worsen already fragile water and wastewater systems, underscoring the need for adaptation using locally appropriate technologies. Furthermore, mismanaged wastewater contributes around 3·5% of global greenhouse gas emissions.[81] Among the co-benefits to be derived from this adaptation is a reduction in waterborne diseases exacerbated by flooding. Given the complexity and interconnectedness of the effects of climate change on water security, sanitation, and transmission of infectious diseases, and the compounding of effects with other climate change-related hazards, there is an urgent need to increase understanding of this relationship. More research is also needed to identify effective wastewater-management interventions that can simultaneously contribute to climate change mitigation, reduce water insecurity, and reduce the local risk of disease transmission.

For **data for sewer networks in SIDS** see https://data.unicef.org/resources/dataset/drinking-water-sanitation-hygiene-database/

How things stand

SIDS are at a critical stage: vulnerabilities to climatic and external shocks have been regionally and internationally acknowledged but effective action is yet to be taken. Although not always at the forefront of policy and planning discourse, the health dimension of climate change is becoming more prominent in strategic actions and regional priorities. The most recent report to the UN General Assembly's Secretary-General on the SIDS Accelerated Modalities of Action Pathway has shown that, as a region, SIDS have moderately progressed towards decreasing undernourishment and maternal and child mortality, and improving water-use efficiency.[82] However, many SIDS have regressed or stagnated in their efforts to ensure food security, nutrition, proper sanitation and water systems, and effective waste management.

More needs to be done to address the huge data gaps in SIDS, and to increase efforts towards downscaling global data. Although WHO has launched a consultation for the development of the Research for Action on Climate Change and Health 2035 agenda, SIDS also need to keep working—both independently and collectively—towards the development and improvement of data systems that increase understanding of climate-related health challenges. Remote access and data capture and the incentivising of local institutions, perhaps through pushing for research and innovation in development grants, are likely to be important.

Conclusion

SIDS are increasingly vulnerable to heat stress, drought, vector-borne diseases, and food insecurity. Climate change has heightened vulnerability to the risks of developing chronic NCDs and endangered workforces in areas crucial to economic growth. There is a strong need to strengthen and build resilience to address these difficulties. Due to inadequate completion of regular health and vulnerability risk assessments and inadequate implementation of health adaptation strategies in climate policies, SIDS continue to be particularly susceptible to the health consequences of climate change. These limitations pose a major barrier to the construction of efficient and robust health systems. Strategies aimed at developing climate resilience are often fragmented or have short-term focuses, mainly as a result of insufficient financial resources. Funds promised by the international community to SIDS fall far short of the billions that have been estimated to be required each year. In the absence of global, regional, and national investment and cooperation, the implications of climate change will persist as a substantial threat to SIDS' very existence.

Lack of action and delays in several sectors have enabled the continuation of activities in SIDS that are both carbon-intensive and detrimental to health, and there is a risk of perpetuating an unsustainable future. Renewable energy sources generate only 9% of all power in SIDS, despite the abundance of potential resources available. Reliance on fossil fuels remains very high. The capacity to develop and use renewable energy for essential purposes is limited by a reliance on high-income nations to provide established renewable energy technologies. SIDS need to examine the legal framework within which energy is procured and distributed to ensure that it is not a barrier as they transition to renewable energy.

The economic consequences of climate change in SIDS have been substantial, with severe repercussions for the welfare, health, and livelihoods of local communities. The small, open economies of SIDS are particularly susceptible to catastrophic climatic events. The scarcity of data for slow-onset events prevents full recognition of potential consequences, especially when such events occur simultaneously with more abrupt events. The time taken to return to normal activities after an extreme climate event poses an additional challenge to restoration and growth. Available data highlight that SIDS have excessively high economic costs and losses due to climate-related factors, which impede recovery and resilience.

Scientific, political, and corporate sectors need to participate in and take action regarding climate mitigation measures. The desired reductions in greenhouse gas emissions are unattainable in the absence of government regulations and corporate accountability. Our findings indicate that SIDS have been at the forefront of discussions on health and climate change in international forums, which is crucial for bringing about global awareness of, action on, the interconnections of health and climate change. There is insufficient scientific involvement in SIDS, and therefore, there is an urgent need for further research on climate impacts and actions that will enable adaptation and mitigation. Above all, cohesion among these critical components is essential to provide decision-makers with the knowledge they require for ensuring health resilience in the face of climate change.

Contributors

This report is an academic collaboration that builds off the work of the 2015 Lancet *Commission* on Health and Climate Change, convened by *The Lancet*. The 35 authors contributed their expertise to five working groups. RNS (leader), PJB, SD, ODS, NGG-D, SBM, KGM, KSM, MM-L, MM, CALO, FO, AO, SYP, EJZR, MT, MRa, and LLT contributed to working group 1; STS (leader), DFB, ODS, HCH, MAM, KFP, SYP, and KAP contributed to working group 2; PAM-L (leader), RJC, HK, SBM, KGM, KSM, MM, and SH contributed to working group 3; HCH (leader), AOA, and DCS contributed to working group 4; and GMG-S, SRM, and KFP (leader) contributed to working group 5. MRo, GMG-S, MBO'H, KFP, SYP, and MW contributed to indicator analysis, coordination, strategic direction, and editorial support. All authors contributed to the drafting, review, and interpretation of their relevant indicator and section. GMG-S is the Executive Director of the *Lancet* Countdown SIDS Regional Centre, is the lead author of this report, and contributed to the executive summary, introduction, research gaps, and conclusion. SYP wrote parts of the executive summary, introduction, and research gaps sections; and contributed to indicators 1.1.3, 1.1.4, 1.2, 2.2.1, and 2.2.3. HCH provided oversight and led the write-up of section 4 and contributed to indicators 2.2.4 and 4.1.3. PAM-L provided oversight and led the write-up of section 3. STS provided oversight and led the write-up of section 2, and contributed to indicators 2.1 and 2.3.2. KFP provided oversight and led the write-up of section 5 and contributed to indicators 2.3.1, 2.3.2, 5.1, 5.2, and 5.3. MW contributed to various sections of the report. AOA contributed to indicator 4.1.2. PJB provided editorial support and contributed to indicators 1.1.1 and 1.1.2. RJC contributed to indicator 3.1. SD contributed to indicator 1.4.1. ODS provided directional support for working groups 1 and 2 and contributed to indicators 1.3 and 2.2.1. NGG-D contributed to the analysis and write-up for indicator 1.3. HK contributed to indicator 3.1. SBM contributed to indicator 1.2.1. KGM contributed to indicators 1.1.5 and 3.2 and provided editorial support for working groups 1 and 3. SRM contributed to the section on research gaps and several section conclusions, provided editorial support, and reviewed various versions of the report. KSM contributed to indicators 1.1.3 and 3.2. MM-L contributed to indicator 1.4.2. MM contributed to indicators 1.4 and and 3.2. MAM contributed to indicator 2.2.2. RNS provided oversight and led the write-up of section 1. MBO'H reviewed various versions of the report, provided editorial support, and contributed to indicator 2.2.3. CALO contributed to indicator 1.3. FO contributed to indicator 1.4.2. AO contributed to indicator 1.4.2. KAP provided editorial support. MRa contributed to indicator 1.4.2. EJZR contributed to indicator 1.4.1. SH contributed to indicator 3.2. DCS contributed to indicator 4.1.1 and provided editorial support and analysis. MT contributed to indicator 1.4.2. LLT provided coordination and support for section 1. MRo is the

Executive Director of the Global *Lancet* Countdown on Health and Climate Change, provided data support and editorial support, contributed to various sections, and reviewed several drafts of the report.

Declaration of interests

We declare no competing interests.

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References

1 UN. About small island developing states. 2020. https://www.un.org/ohrlls/content/about-small-island-developing-states (accessed Dec 8, 2023).

2 Mycoo M, Wairiu M, Campbell D, et al. Small islands. In: Pörtner H-O, Roberts DC, Tignor M, et al, eds. Climate change 2022: impacts, adaptation and vulnerability. Cambridge University Press, 2022: 2043–121.

3 Government of Dominica. Post-disaster needs assessment Hurricane Maria September 18, 2017. A Report by the Government of the Commonwealth of Dominica. Commonwealth of Dominica, 2017.

4 Romanello M, di Napoli C, Green C, et al. The 2023 report of the *Lancet* Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms. *Lancet* 2023; **402:** 2346–94.

5 Food and Agriculture Organization. Global action programme on food security and nutrition in small island developing states. 2017. http://www.fao.org/3/a-i7297e.pdf (accessed Jan 25, 2024)

6 Fletcher ER. Small island developing states at nexus of climate, unhealthy foods and mental health challenges. 2023. https://healthpolicy-watch.news/small-island-developing-states-at-nexus-of-climate-unhealthy-foods-and-mental-health-challenges/ (accessed Jan 23, 2024).

7 Liu J, Varghese BM, Hansen A, et al. Heat exposure and cardiovascular health outcomes: a systematic review and meta-analysis. *Lancet Planet Health* 2022; **6:** e484–95.

8 Ebi KL, Capon A, Berry P, et al. Hot weather and heat extremes: health risks. *Lancet* 2021; **398:** 698–708.

9 Gulev SK, Thorne PW, Ahn J, et al. Changing state of the climate system. In: Masson-Delmotte V, Zhai P, Pirani A, et al, eds. Climate change 2021—the physical science basis: Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 1st edn. Cambridge University Press, 2021: 287–422.

10 World Meteorological Organization. State of the global climate 2023. 2024. https://library.wmo.int/records/item/68835-state-of-the-global-climate-2023 (accessed Oct 29, 2024).

11 Liu Z, Zhan W, Bechtel B, et al. Surface warming in global cities is substantially more rapid than in rural background areas. *Commun Earth Environ* 2022; **3:** 219.

12 Bouchama A, Abuyassin B, Lehe C, et al. Classic and exertional heatstroke. *Nat Rev Dis Primers* 2022; **8:** 8.

13 WHO. Noncommunicable diseases and mental health in small island developing states. 2023. https://www.who.int/publications/m/item/ncds-and-mental-health-in-sids-report (accessed July 22, 2024).

14 Balmain BN, Sabapathy S, Louis M, Morris NR. Aging and thermoregulatory control: the clinical implications of exercising under heat stress in older individuals. *BioMed Res Int* 2018; **2018:** 8306154.

15 Flouris AD, Dinas PC, Ioannou LG, et al. Workers' health and productivity under occupational heat strain: a systematic review and meta-analysis. *Lancet Planet Health* 2018; **2:** e521–31.

16 International Labour Organization. Working on a warmer planet: the impact of heat stress on labour productivity and decent work. 2019. https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_711919.pdf (accessed Nov 13, 2024).

17 Parker SY, Parchment KF, Gordon-Strachan GM. The burden of water insecurity: a review of the challenges to water resource management and connected health risks associated with water stress in small island developing states. *J Water Clim Change* 2023; **14:** 4404–23.

18 Epstein PR. Climate change and emerging infectious diseases. *Microbes Infect* 2001; **3:** 747–54.

19 Wilder-Smith A. Dengue infections in travellers. *Paediatr Int Child Health* 2012; **32** (suppl 1)**:** 28–32.

20 Hafsia S, Haramboure M, Wilkinson DA, et al. Overview of dengue outbreaks in the southwestern Indian Ocean and analysis of factors involved in the shift toward endemicity in Reunion Island: a systematic review. *PLoS Negl Trop Dis* 2022; **16:** e0010547.

21 Food and Agriculture Organization. Global blue growth initiative and small island developing states. 2014. https://www.fao.org/3/i3958e/i3958e.pdf (accessed Jan 22, 2024).

22 Dasgupta S, Robinson EJZ. Improving food policies for a climate insecure world: evidence from Ethiopia. *NIER* 2021; **258:** 66–82.

23 Dasgupta S, Robinson EJZ. Attributing changes in food insecurity to a changing climate. *Sci Rep* 2022; **12:** 4709.

24 Cafiero C, Viviani S, Nord M. Food security measurement in a global context: the food insecurity experience scale. *Measurement* 2018; **116:** 146–52.

25 Romanello M, Di Napoli C, Drummond P, et al. The 2022 report of the *Lancet* Countdown on health and climate change: health at the mercy of fossil fuels. *Lancet* 2022; **400:** 1619–54.

26 Comeau S, Cornwall CE, DeCarlo TM, Doo SS, Carpenter RC, McCulloch MT. Resistance to ocean acidification in coral reef taxa is not gained by acclimatization. *Nat Clim Chang* 2019; **9:** 477–83.

27 Barange M, Bahri T, Beveridge MCM, Cochrane KL, Funge Smith S, Poulain F, eds. Impacts of climate change on fisheries and aquaculture: synthesis of current knowledge, adaptation and mitigation options. Food and Agriculture Organization, 2018.

28 Bruno JF, Côté IM, Toth LT. Climate change, coral loss, and the curious case of the parrotfish paradigm: why don't marine protected areas improve reef resilience? *Annu Rev Mar Sci* 2019; **11:** 307–34.

29 Copernicus Climate Change Service. ORAS5 global ocean reanalysis monthly data from 1958 to present. 2021. https://cds.climate.copernicus.eu/datasets/reanalysis-oras5?tab=overview (accessed Nov 12, 2024).

30 Food and Agriculture Organization. Fisheries and aquaculture: activities—introduction. https://www.fao.org/fishery/en/activities (accessed Nov 12, 2024).

31 Monnereau I, Oxenford H. Impacts of climate change on fisheries in the coastal and marine environments of Caribbean small island developing states (SIDS). *Sci Rev* 2017: 124–54.

32 Vianna GMS, Hehre EJ, White R, Hood L, Derrick B, Zeller D. Long-term fishing catch and effort trends in the Republic of the Marshall Islands, with emphasis on the small-scale sectors. *Front Mar Sci* 2020; **6:** 828.

33 Fache E, Pauwels S. Tackling coastal "overfishing" in Fiji: advocating for indigenous worldview, knowledge, and values to be the backbone of fisheries management strategies. *Maritime Studies* 2020; **19:** 41–52.

34 Dulvy NK, Pacoureau N, Rigby CL, et al. Overfishing drives over one-third of all sharks and rays toward a global extinction crisis. *Curr Biol* 2021; **31:** 4773–87.

35 UN Conference on Trade and Development. Revisiting development strategies for small island developing states in the post-pandemic competitive landscape. United Nations, 2022.

36 WHO. Operational framework for building climate resilient health systems. 2015. https://www.who.int/publications/i/item/9789241565073 (accessed Feb 4, 2024).

37 WHO. 2021 WHO health and climate change global survey report. 2021. https://www.who.int/publications/i/item/9789240038509 (accessed Jan 10, 2024).

38 World Meteorological Organization. Early warnings for all: the UN global early warning initiative for the implementation of climate adaptation. 2022. https://library.wmo.int/idurl/4/58209 (accessed Jan 23, 2024).

39 Gago EJ, Roldan J, Pacheco-Torres R, Ordóñez J. The city and urban heat islands: a review of strategies to mitigate adverse effects. *Renew Sustain Energy Rev* 2013; **25:** 749–58.
40 Braubach M, Egorov A, Mudu P, Wolf T, Ward Thompson C, Martuzzi M. Effects of urban green space on environmental health, equity and resilience. In: Kabisch N, Korn H, Stadler J, Bonn A, eds. Nature-based solutions to climate change adaptation in urban areas: linkages between science, policy and practice. Springer International Publishing, 2017: 187–205.
41 Green Climate Fund. Green Climate Fund Open Data Library. 2023. https://data.greenclimate.fund/public/data/projects (accessed Dec 11, 2023).
42 Fouad M, Novta N, Preston G, Schneider T, Weerathunga S. Unlocking access to climate finance for Pacific Island countries. 2021. https://www.imf.org/en/Publications/Departmental-Papers-Policy-Papers/Issues/2021/09/23/Unlocking-Access-to-Climate-Finance-for-Pacific-Islands-Countries-464709 (accessed Nov 14, 2024).
43 Bertrand S, Carr Z, Chungong S, et al. Core capacity workbook. 2015. https://iris.who.int/bitstream/handle/10665/190819/WHO_HSE_GCR_2015.13_eng.pdf?sequence=1 (accessed Jan 16, 2024).
44 Thompson E, Alvarado Quesada C, Miller B, et al. High-Level Working Group on Climate Change in the Caribbean: extreme weather events and resilience. 2023. https://theglobalamericans.org/wp-content/uploads/2023/05/Extreme-Weather-Events-and-Resilience-in-the-Caribbean.pdf (accessed Feb 5, 2024).
45 Organisation for Economic Co-operation and Development. Managing Climate Risks, Facing up to Losses and Damages. 2021. https://www.oecd-ilibrary.org/content/publication/55ea1cc9-en (accessed Feb 5, 2024).
46 Intergovernmental Panel on Climate Change. Summary for policymakers. In: Lee H, Romero J, eds. Climate change 2023: synthesis report. Intergovernmental Panel on Climate Change, 2023: 1–34.
47 McMichael C, Dasgupta S, Ayeb-Karlsson S, Kelman I. A review of estimating population exposure to sea-level rise and the relevance for migration. *Environ Res Lett* 2020; **15:** 123005.
48 Lassiter A. Rising seas, changing salt lines, and drinking water salinization. *Curr Opin Environ Sustain* 2021; **50:** 208–14.
49 Wade T. Health risks associated with sea level rise. 2022. https://ncceh.ca/resources/evidence-reviews/health-risks-associated-sea-level-rise (accessed Feb 5, 2024).
50 Vousdoukas MI, Athanasiou P, Giardino A, et al. Small island developing states under threat by rising seas even in a 1·5°C warming world. *Nat Sustain* 2023; **6:** 1552–64.
51 Oakes R, Milan A, Campbell J, Warner K, Schindler M. Climate change and migration in the pacific: links, attitudes, and future scenarios in Nauru, Tuvalu and Kiribati. 2017. https://i.unu.edu/media/ehs.unu.edu/news/11747/RZ_Pacific_EHS_ESCAP_151201.pdf (accessed Jan 10, 2024).
52 UN Economic and Social Commission for the Pacific. Pacific Climate Change and Migration Project. https://www.unescap.org/subregional-office/pacific/pacific-climate-change-and-migration-project (accessed Nov 13, 2024)
53 Iqbal N, Ejaz SM, Altmash M. Climate change as a key contributor to migrant crisis: a case study of developmental & environmental challenges to Kiribati people (Sept 30, 2020). *OIDA Int J Sustain Devel* 2020; **13:** 43–54.
54 Oakes R, Milan A, Campbell J. Kiribati: climate change and migration: relationships between household vulnerability, human mobility and climate change. 2016. https://repository.unescap.org/bitstream/handle/20.500.12870/2897/ESCAP-2016-RP-Kiribati-climate-change.pdf?sequence=1&isAllowed=y (accessed Nov 12, 2024).
55 Amnesty International. UN landmark case for people displaced by climate change. 2021. https://www.amnesty.org/en/latest/news/2020/01/un-landmark-case-for-people-displaced-by-climate-change/ (accessed Jan 21, 2024).
56 Government of Kiribati. Kiribati joint implementation plan for climate change and disaster risk management. 2014. https://www.mfed.gov.ki/sites/default/files/KJIP%20BOOK%20WEB%20SINGLE_0.pdf (accessed Jan 21, 2024).
57 McNamara K. Cross-border migration with dignity in Kiribati. *FMR* 2015; **49:** 1.
58 World Bank, International Energy Agency, International Renewable Energy Agency, UN Statistical Division, WHO. Access to electricity (% of population). 2023. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS (accessed Jan 25, 2024).
59 Ritchie H, Roser M, Rosado P. Solomon Islands: energy country profile. 2023. https://ourworldindata.org/energy/country/solomon-islands (accessed Jan 22, 2024).
60 Government of Guinea-Bissau. Updated nationally determined contribution Guinea-Bissau. 2021. https://www.undp.org/guinea-bissau/publications/updated-nationally-determined-contribution-framework-paris-climate-agreement (accessed Jan 30, 2024).
61 Global Energy Monitor. Global coal plant tracker. 2023. https://globalenergymonitor.org/projects/global-coal-plant-tracker/ (accessed Jan 23, 2024).
62 International Renewable Energy Agency. IRENASTAT. 2024. https://www.irena.org/Data/Downloads/IRENASTAT (accessed Jan 18, 2024).
63 Duncan K. EPA promises action on Puerto Rico coal ash, but residents are tired of waiting. 2023. https://energynews.us/2023/05/08/epa-promises-action-on-puerto-rico-coal-ash-but-residents-are-tired-of-waiting/ (accessed Jan 18, 2024).
64 Vermeulen SJ, Campbell BM, Ingram JSI. Climate change and food systems. *Annu Rev Environ Resour* 2012; **37:** 195–222.
65 Shah K. Air pollution in small island developing states: a growing but avoidable challenge requiring multilevel interventions. *SSRN* 2024; published online Jan 21. http://dx.doi.org/10.2139/ssrn.3776750 (preprint).
66 UN Trade and Development. Income, poverty and employment. 2021. https://dgff2021.unctad.org/social-development-issues/income-poverty-and-employment/ (accessed Oct 4, 2023).
67 Spector J, Sheffield P. Re-evaluating occupational heat stress in a changing climate. *Ann Occup Hyg* 2014; **58:** 936–42.
68 Marchetti E, Capone P, Freda D. Climate change impact on microclimate of work environment related to occupational health and productivity. *Ann Ist Super Sanita* 2016; **52:** 338–42.
69 UN. COP28 talks open in Dubai with breakthrough deal on loss and damage fund. 2023. https://news.un.org/en/story/2023/11/1144162 (accessed Dec 7, 2023).
70 Richards J-A, Jowahir T. The loss and damage fund and pledges at COP28: shall I compare thee to a summer's day? Or to the annual earnings of a megastar footballer? 2023. https://www.lossanddamagecollaboration.org/pages/the-loss-and-damage-fund-and-pledges-at-cop28-shall-i-compare-thee-to-a-summers-day-or-to-the-annual-earnings-of-a-megastar-footballer (accessed Jan 30, 2024).
71 International Medical Corps. Hurricane Maria Emergency Response in Dominica. 2017. https://www.mhinnovation.net/sites/default/files/content/document/IMC%202017%20Dominica%20MHPSS%20Assessment.pdf (accessed Jan 23, 2024).
72 Orengo-Aguayo R, Stewart RW, De Arellano MA, Suárez-Kindy JL, Young J. Disaster exposure and mental health among Puerto Rican youths after Hurricane Maria. *JAMA Netw Open* 2019; **2:** e192619.
73 UNESCO. Advancing the rights of persons with disabilities in the Caribbean. 2021. https://www.unesco.org/en/articles/advancing-rights-persons-disabilities-caribbean (accessed Jan 22, 2024).
74 Gatellier K. The Pacific Community supports discussions on disability inclusion in the Pacific. 2023. https://www.spc.int/updates/blog/interactive-story/2023/03/the-pacific-community-supports-discussions-on-disability (accessed Jan 22, 2024).
75 de Carvalho-Freitas MN, Marques AL. Social inclusion of people with disabilities in Brazil and in Cape Verde–Africa. *REAd-Revista Eletrônica de Administração* 2007; **13:** 433–54.
76 Singapore Ministry of Social and Family Development. Total number of persons with disabilities in Singapore. 2018. https://www.msf.gov.sg/media-room/article/Total-number-of-persons-with-disabilities-in-Singapore (accessed Jan 22, 2024).
77 Government of Mauritius. National policy paper & action plan on disability: valuing people with disabilities. 2007. https://www.un.org/development/desa/disabilities/wp-content/uploads/sites/15/2019/10/Mauritius_National-Policy-Paper-and-Action-Plan-on-Disability.pdf (accessed Jan 22, 2024).

78 Riyaza F. Demographic characteristics by disability. National Bureau of Statistics, 2019.

79 Funari E, Manganelli M, Sinisi L. Impact of climate change on waterborne diseases. *Ann Ist Super Sanita* 2012; **48:** 473–87. (accessed Nov 12, 2024)

80 WHO. Progress on drinking-water, sanitation and hygiene in schools: 2000–2021 data update. 2022. https://www.who.int/publications/m/item/progress-on-drinking-water--sanitation-and-hygiene-in-schools--2000-2021-data-update (accessed Jan 23, 2024).

81 Iacuaniello J, Bretschger O. How tackling wastewater can help corporations achieve climate goals. 2022. https://www.weforum.org/stories/2022/10/wastewater-corporations-climate-goals/ (accessed Nov, 13, 2024).

82 UN Secretary-General. Follow-up to and implementation of the SIDS Accelerated Modalities of Action (SAMOA) pathway and the Mauritius Strategy for the further implementation of the programme of action for the sustainable development of small island developing states: report of the Secretary-General. 2022. https://documents-dds-ny.un.org/doc/UNDOC/GEN/N22/437/07/PDF/N2243707.pdf?OpenElement (accessed Jan 23, 2024).