COP24 SPECIAL REPORT

HEALTH & CLIMATE CHANGE

World Health Organization

COP24 SPECIAL REPORT HEALTH AND CLIMATE CHANGE

This report is a contribution from the public health community to support the negotiations of the United Nations Framework Convention on Climate Change (UNFCCC). It was written at the request of the President of the 23rd Conference of the Parties to the UNFCCC (COP23), Prime Minister Bainimarama of Fiji, to the World Health Organisation (WHO) to prepare a report on health and climate change, to be delivered at COP24. The three aims of this report are to provide:

- Global knowledge on the interconnection between climate change and health.
- An overview of the initiatives and tools with which the national, regional and global public health community is supporting and scaling up actions to implement the Paris Agreement for a healthier, more sustainable society.
- Recommendations for UNFCCC negotiators and policy-makers on maximizing the health benefits of tackling climate change and avoiding the worst health impacts of this global challenge.

The report is based on contributions from over 80 health professionals, academic experts, representatives of civil society and international agencies who have worked on climate change and health for over three decades.

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ACKNOWLEDGEMENTS

Preparation of this report involved contributions from numerous individuals and organizations. The World Health Organisation expresses its deep appreciation to all who supported the project with generous contributions of expertise, content development, data collection, analysis, design, review, consultation and funding.

The main authors of the report at WHO headquarters were Diarmid Campbell-Lendrum and Nicola Wheeler (consultant); Marina Maiero, Elena Villalobos Prats and Tara Neville were co-authors.

Other colleagues and partners who contributed to the content of the report were Heather Adair-Rohani (WHO), Elaine Fletcher (WHO), Sophie Gumy (WHO), Maria Neira (WHO), Alice McGushin (World Organization of Family Doctors Working Party on the Environment), Cristina Romanelli (Convention on Biological Diversity), Jeni Miller (Global Climate and Health Alliance),Yassen Tcholakov (World Medical Association) and Arthur Wyns (Climate Tracker).

WHO expresses its deepest gratitude to all ministries of health and WHO regional and country offices that assisted in preparation and review of this report. The contributors from WHO regional offices were: Magaran Bagayoko (WHO Regional Office for Africa); Daniel Buss, Sally Edwards and Elida Vaught (WHO Regional Office for the Americas); Hamed Bakir (WHO Regional Office for the Eastern Mediterranean); Vladimir Kendrovski, James Creswick and Oliver Schmoll (WHO Regional Office for Europe); Lesley Onyon and Alexander von Hildebrand (WHO Regional Office for South-East Asia); and Mohd Nasir Hassan and Rokho Kim (WHO Regional Office for the Western Pacific).

WHO is also grateful to the following, who provided invaluable comments and support in reviewing the document: Joy St John, Annette Pruss-Ustun, Nathalie Roebbel, Nicole Valentine, Carolyn Vickers, Jonathan Abrahams, Jorgen Johnsen, Rania Kawar, Lina Mahy, Thiago Herick De Sa, Manjulaa Narasimhan, Kim Peterson, Pierpaolo Mudu and Agnes Soares (WHO); Corinne Capuano (WHO Representative, Fiji); Fiona Armstrong (Climate and Health Alliance); Carlos Corvalan (Sydney University); Drew Shindell (Duke University); Amir H. Delju (World Meteorological Organization); Carlos Dora (Columbia University); Howard Frumkin (Wellcome Trust); Sam Bickersteth (Rockefeller Foundation Economic Council on Planetary Health); Sandra Cavalieri (Climate and Clean Air Coalition); Pam Pearson (International Cryosphere Climate Initiative network); Lourdes Sanchez and Hanjie Wang (Global Subsidies Initiative of the International Institute for Sustainable Development); Wael Al-Delaimy (University of California San Diego); Lujain Alqodmani and Clarisse Delorme (World Medical Association); Joy Shumake-Guillemot (WHO and World Meteorological Organization); Isobel Braithwaite and Lori Byron (Citizens Climate Lobby); Marion Carey (Monash Sustainability Institute); Kris Ebi (University of Washington, USA); Charles Ebikeme (International Science Council); Valentin Foltescu (United Nations Environment Programme); Renzo Guinto (Harvard University); Andy Haines (London School of Hygiene and Tropical Medicine); Tiffany Hodgson (UNFCCC); Suvi Huikuri, Natalia Linou and Mariana Simoes (United Nations Development Programme); Josh Karliner and Susan Wilburn (Health Care Without Harm); Dominic Kniveton (University of Sussex); Samantha Pegoraro (WHO consultant); Xavier Mari, Maxime Thibon (French National Research Institute for Sustainable Development); Jelena Milos (Directorate-General for Climate Action, European Commission); Rinaldi Roberto and Dorota Tomalak (European Committee for the Regions, European Commission); Sonia Roschnik (National Health Service, United Kingdom); Ben Schachter (Office of the United Nations High Commissioner for Human Rights); Jutta Stadler (German Federal Agency for Nature Conservation); Cristina Tirado (Loyola Marymount University); Nick Watts (Lancet Countdown); Alistair Woodward (University of Auckland); Madeleine Thomson (Columbia University); and Genon Jensen and Anne Stauffer (Health and Environment Alliance), Robin Stott.

Communication support was provided by Nada Osseiran, Sarah Cumberland, Dawn Lee and Aleksandra Kuzmanovic (WHO), Phillip Johnson, Lloyd Hofmeyr (Multiplied).

Design and layout were provided by Climate Tracker, and the design concept was supported by Duncan Mills, USA.

The project was supported by Carine Cruz Payan and Emilie Rose Gile Tabourin (WHO).

Finally, we express our sincere apologies to any individuals or agencies who were unintentionally omitted.

EXECUTIVE SUMMARY

The severity of the impact of climate change on health is increasingly clear. Climate change is the greatest challenge of the 21st century, threatening all aspects of the society in which we live, and the continuing delay in addressing the scale of the challenge increases the risks to human lives and health.

The drivers of climate change – principally fossil fuel combustion – pose a heavy burden of disease, including a major contribution to the 7 million deaths from outdoor and indoor air pollution annually. The air pollutants which are causing ill-health, and the greenhouse gases (GHGs) that are causing climate change, are emitted from many of the same sectors, including energy, housing, transport and agriculture. Short-lived climate pollutants (including black carbon, methane and ozone) have important impacts on both climate and health.

If the mitigation commitments in the Paris Agreement are met, millions of lives could be saved through reduced air pollution, by the middle of the century. More stringent mitigation policies would result in greater health benefits. There are important additional opportunities for synergy between health and climate change mitigation in energy, households, food systems, transport and other sectors, particularly in stemming the burden of noncommunicable diseases (NCDs).

Economic valuation of health decisively favours more aggressive climate mitigation. The most recent evidence indicates that the health gains from energy scenarios to meet the Paris climate goals would more than meet the financial cost of mitigation at global level and would exceed that in countries such as China and India by several times.

Climate change already has negative health effects and undermines the "right to health" cited in the Paris Agreement. Climate change undermines the social and environmental determinants of health, including people's access to clean air, safe drinking-water, sufficient food and secure shelter. It is affecting health particularly in the poorest, most vulnerable communities such as small-island developing States (SIDS) and least developed countries, thus widening health inequities.

The health impacts of climate change could be greatly reduced by proven interventions in climate-resilient health systems, including climate-resilient health facilities, and through health-determining sectors such as water, sanitation and food systems and disaster risk reduction. At present, however, only 3% of health resources are invested in prevention, and only 0.5% of multilateral climate finance has been specifically for health projects.

City Mayors and other subnational authorities are critical actors in reducing carbon emissions, improve health and increasing resilience. Local authorities are often wholly or partly responsible for energy provision, transport, water, sanitation and health. Continuing urbanization makes cities, in particular, important foci of action for climate and health.

The health community is highly trusted, globally connected and increasingly engaged in reducing climate change and air pollution. WHO is working with leading health professional bodies, nongovernmental organizations, journals and the wider health community to mobilize behind stronger climate mitigation and adaptation. The call to action on climate and health for COP24 was issued by organizations representing over 5 million doctors, nurses and public health professionals and 17 000 hospitals in over 120 countries. Mobilization of the health sector is also necessary to reduce the growing contribution of health care to GHG emissions, which currently represents 5–8% of the total in high-income countries.

Monitoring of progress in health and climate change is improving, but there are weaknesses in coverage and in stakeholder engagement. The indicators of the Sustainable Development Goals (SDGs) for climate change do not include health, although the situation is being remedied in academic research initiatives, by WHO and by the Secretariat of the UN Framework Convention on Climate Change (UNFCCC), in partnership with countries. Such indicators could be used for formal reporting to the UNFCCC, broader outreach to the public and monitoring of the achievement of the Sustainable Development Goals (SDGs).

The report includes the following recommendations:

1

Identify and promote actions to reduce both carbon emissions and air pollution, with specific commitments to reduce emissions of short-lived climate pollutants in Nationally Determined Contributions (NDCs) to the Paris Agreement.

2

Include the health implications of mitigation and adaptation measures in the design of economic and fiscal policies, including carbon pricing and the reform of fossil fuel subsidies.

3

Include the commitments to safeguard health from the UNFCCC and Paris Agreement, in the rulebook for the Paris Agreement; and systematically include health in NDCs, National Adaptation Plans and National Communications to the UNFCCC.

4

Remove existing barriers to investment in health adaptation to climate change, especially for climate-resilient health systems and "climate-smart" health care facilities.

5

Facilitate and promote the engagement of the health community as trusted, connected and committed advocates for climate action.

6

Mobilize city Mayors and other subnational leaders, as champions of intersectoral action to cut carbon emissions, increase resilience, and promote health.

7

Systematically track progress in health resulting from climate change mitigation and adaption, and report to the UN Framework Convention on Climate Change, global health governance processes and the monitoring system for the SDGs.

1. INTRODUCTION

Climate change is the greatest health challenge of the 21st century, and threatens all aspects of the society in which we live. The severity of the impacts of climate change on human health are increasingly clear, and further delay in action will increase the risks. Climate change threatens to undermine over half a century of global improvements in health achieved with dedicated, targeted action by policy-makers and the health community. This situation is in direct contravention of government commitments to support progressive realization of the human right to health for all *(1)*.

The public health community has rapidly increased its engagement on climate change and health in recent years, providing better understanding of the links between climate change and health, raising awareness of the significant health threats, offering solutions to avoid the worst impacts and assessing the health benefits of climate actions, including the degree to which these will offset the costs of mitigation. This work now involves a large community of organizations, including United Nations agencies, academia, all levels of government and nongovernmental organizations, which are working together to meet the commitments made by governments during the climate change negotiations within the UNFCCC and international negotiations at the World Health Assembly. Their work is broadly aligned with a common action agenda, reflected in the outcomes of high-level political meetings and joint statements by health professional associations and wider civil society *(2)*.

The report presents the central role of the 2015 Paris Agreement in good health, means of addressing the health risks of climate change and the opportunities for health offered by tackling climate change. The report also addresses engagement by the health community and civil society, measuring national progress in addressing climate change and means of ensuring economic support for action on health and climate change. Recommendations for UNFCCC negotiators are made both to meet the goals of the Paris Agreement and to maximize the benefits for health.

2. THE PARIS AGREEMENT: THE STRONGEST PUBLIC HEALTH AGREEMENT OF THE CENTURY

The Paris Climate Agreement, signed at COP21, is a global safeguard for human health. It specifies that "Parties should, when taking action to address climate change, respect, promote and consider their respective obligations on the right to health" and recognizes the central role of "mitigation actions and their co-benefits for adaptation, health and sustainable development" in enhanced action before 2020 *(3)*.

The 2015 Paris Agreement is the first climate agreement to gain strong global support, having now been ratified by 183 countries*(4)*. The Agreement sets clear targets: to limit global temperature rise to well below 2°C and to pursue efforts to minimize warming to no more than 1.5 °C above pre-industrial levels. It also provides mechanisms to help countries not only to meet their mitigation targets but also to effectively adapt to climate change. The NDCs allow each country to set nationally relevant, attainable commitments to meet the targets of the Agreement. Low- and middle-income countries (LMICs) are supported by funding mechanisms, with a commitment to mobilize US$ 100 billion in climate funding annually by 2020 (3). This will allow countries more flexibility in finding the most appropriate ways of tackling climate change, while ensuring that all Parties contribute to meeting global goals.

Its objective is to "strengthen the global response to climate change, in the context of sustainable development", thereby linking the climate change agenda to Agenda 2030 and the SDGs*(3, 5)*. Achieving the SDGs could improve health now and for future generations. Yet, truly sustainable development is not possible without climate mitigation and adaption, which should be included in development programmes. "Climate action is development action"*(6);* as social resilience and economic productivity depend on the good health of populations, health must be central to climate change policy. Work with countries to achieve zero-carbon development and improve adaptive capacity and resilience concurrently is central to improving health. The dual focus of the Paris Agreement on mitigation and adaptation is important for two reasons. First, countries contribute to differing extents to climate change: high-income countries (HICs) emit cumulatively more GHGs than LMICs. Secondly, countries are affected differently by climate change: those that have contributed least to anthropogenic climate change are often the most vulnerable and the most severely affected. Adaptation and mitigation are therefore essential to any successful accord, including to protect health.

Thus, the Paris Agreement is potentially the strongest health agreement of this century, as it addresses not only the health risks associated with climate change through mitigation and adaptation but also helps ensure attainment of the SDGs, which are integral to good health. Health should therefore be formally integrated within the UNFCCC negotiations and the Paris Agreement itself (see below).

HEALTH

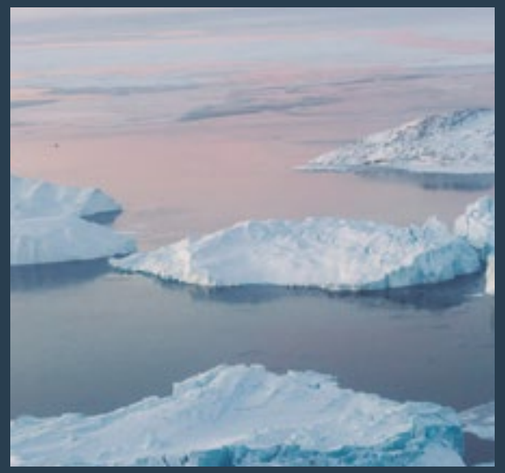
IN THE UN CLIMATE NEGOTIATIONS

Key elements and opportunities for human health advocacy in the UN climate negotiations

1 Health in the UNFCCC legal framework

- Health is a key element in UNFCCC articles 1 & 4.1.f
- Right to health is a key human right in the preamble of the Paris Agreement (PA)
- Human Rights key elements of PA work programme: Article 6 (Action for Climate Empowerment); 8 (Loss and Damage) and 10 (Technology transfer)

Opportunity to take up health in all negotiating streams with a Human Rights focus, as well as in the indigenous peoples platform, Talanoa Dialogue, and in ACE.



2 Health in Climate Science

- Health is a key element in the IPCC Special Report on 1.5°
- Climate Change impacts on health
- The greater the warming, the greater the risks for human health
- The speed and type of mitigation has a direct health effect

Opportunity to engage health professionals in science-based impact assessments and climate policies

3 Health in Mitigation

- Health in the NDCs: Health cobenefits from climate mitigation actions
- Social Cost of Carbon & Social Value of Mitigation both increase when considering human health
- Climate-smart healthcare: need for mitigation within the healthcare sector

Opportunity for inclusion of health in all NDCs

4 Health in Adaptation

- Health in the NDCs: Half of all current NDC´s mention health in relation to adaptation
- The longer it takes to reduce emissions, the greater the adaptation needed to protect population health
- The managing of climate impacts by health systems is unavoidable, no matter the extent of mitigation
- Health as an overarching adaptation strategy

Opportunity for health measures to be integrated in all National Adaptation Plans (NAPs)

5 Health in Mitigation

- Health is a non-economic impact under L&D
- Health is an action area under the WIM (Warsaw International Mechanism) workplan

Opportunity for health to be included in the WIM Executive Committee on climate-induced migration & the Nansen Iniciative

6 Health in Climate Finance

- Some finances from GEF already support health projects
- All World Bank development aid to be screened for pollution prevention

Opportunity to add human health & development as both requirements and measures for all climate finance streams

2.1 The strong linkage between climate change, air pollution and health

The human activities that are destabilizing the Earth's climate also contribute directly to ill health. The most direct link between climate change and ill health is air pollution. Burning fossil fuels for power, transport and industry is the main source of the carbon emissions that are driving climate change and a major contributor to health-damaging air pollution, which every year kills over seven million people due to exposure inside and outside their homes *(7)*. Over 90% of the urban population of the world breathes air containing levels of outdoor air pollutants that exceed WHO's guidelines. Air pollution inside and outside the home is the second leading cause of deaths from NCDs worldwide; it is responsible for 26% of deaths from ischaemic heart disease, 24% of those from strokes, 43% from chronic obstructive pulmonary disease and 29% from lung cancer.

The sectors that produce most GHGs – energy, transport, industry, agriculture, waste management and land use – are also the main sources of fine particulate matter and other important air pollutants (Fig. 1). These include short-lived climate pollutants such as black carbon, methane and ground-level ozone, which also threaten human health. Approximately 25% of urban ambient air pollution from fine particulate matter is contributed by traffic, 15% by industrial activities including electricity generation, 20% by domestic fuel burning, 22% from unspecified sources of human origin and 18% from natural sources *(8)*. Effectively all exposure to indoor air pollution, which causes almost four million deaths a year, is from use of solid fuels for cooking in poor households. Global contributions of different sectors to the GHG emissions that drive climate change are 14% from transport, 34.6% from energy for electricity generation and heat, 21% from industry, 6.4% from buildings and 24% from agriculture and land use change *(9)* (Fig. 2). The sources of climate change and air pollution are therefore broadly the same: polluting energy systems.

Figure 1 Impacts of different air pollutants and greenhouse gases on climate and health (10)

AIR POLLUTANT / GHG	LIFETIME/ SCALE	CLIMATE IMPACT	HEALTH/ECOSYSTEM IMPACTS
Carbon Dioxide (CO_2)		↑	
Fluorinated Gases (F-gases)		↑	⊘
Methane (CH_4) Nitrogen Oxides (NO_x)		↑	
Nitrogen Oxides (NO_x)		↑↓	
Nitrous Oxides (N_2O)		↑	⊘
Particulate Matter (PM)		↑↓	
Sulfur Dioxide (SO_2)		↓	
Tropospheric Ozone (O_3)		↑	
Volatile Organic Compounds (VOCs)/ Carbon Monoxide (CO)		↑	

Lifetime in Atmosphere = days/weeks
Impact Scale=local/regional

Lifetime in Atmosphere= years
Impact Scale=global

Warming

Cooling

Human Health Impact

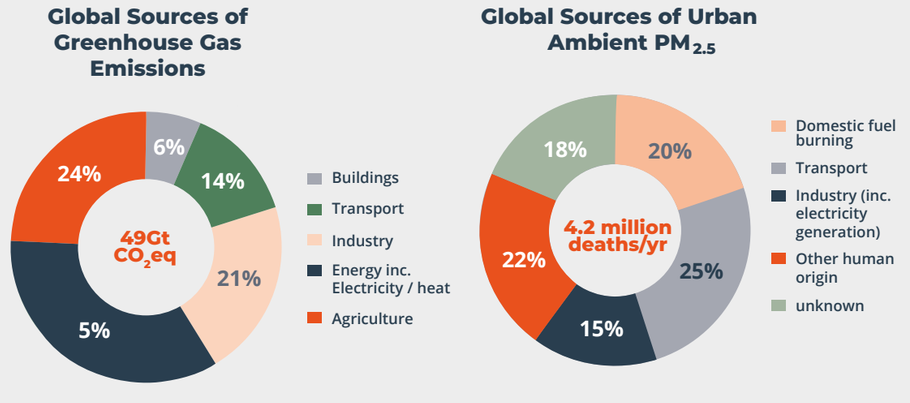
Ecosystem Impact

No direct impact on human health or ecosystems*

*No direct impact implies the substance in question either does not directly cause human health or ecosystem impacts or it does not go through a chemical process to create a substance that directly impacts human health and ecosystems

Figure 2

Main sources of (a) greenhouse gas emissions and (b) urban ambient air pollution *(8, 9)*



Some of the same pollutants contribute to both climate change and local air pollution. Black carbon, produced by inefficient combustion in sources such as cookstoves and diesel engines, is the second greatest contributor to global warming after CO2. Black carbon also affects regional climate systems, accelerating glacier retreat in mountainous regions and the Arctic and disrupting the South Asian monsoon (10). It is also a significant contributor (5–15%) of urban exposure to fine particulate matter. The next largest contributor to global warming is methane, which reacts with other pollutants to form ozone; it is responsible for 230 000 deaths from chronic respiratory disease each year.

A warming climate will worsen air quality. If current emissions continue, ground-level ozone events are expected to intensify, especially in densely populated areas, leading to more respiratory illness. In certain areas, the frequency and extent of wildfires – and with them, emissions of particulate matter and other pollutants – are projected to increase. In other areas, a drier climate will lead to more dust storms; in others, pollen and other airborne allergens are likely to become more prevalent.

Air pollution crosses borders, and pollution in other regions or countries can contribute to local levels. Concerted action is therefore required at urban, national, regional and international levels to make a meaningful impact on health (11). International mechanisms exist, notably the Convention on Long-range Transboundary Air Pollution, with 51 Parties mainly in Europe and North America. For the most part, however, air pollution is regulated locally, resulting in gaps in monitoring, data collection and enforcement of emission controls. Fragmented policies present a particular challenge for reducing short-lived climate pollutants, as there are currently no national or international regulatory obligations to monitor, measure or report black carbon emissions. Under the Paris Agreement, each country regularly submits reports on its activities to mitigate climate change, but they are not required to report on steps to reduce short-lived pollutants, even though it will probably be impossible to meet the targets of the Agreement unless those emissions are reduced.

Most measures to mitigate climate change will strengthen and promote health and sustainable development. As the measures become more aggressive, the synergy will be closer: gains in air quality will, overall, lead to significant improvements in health. In some cases, there may be trade-offs between climate mitigation, sustainable development and health objectives. Reducing such trade-offs will require policies to ensure that the most vulnerable people do not suffer from unintended consequences.

The recent report from the Intergovernmental Panel on Climate Change (IPCC) (12) revealed a rapidly closing window of opportunity to maintain global warming under 1.5 °C stimulated a renewed sense of urgency among decision-makers. Growing public awareness of the health burden associated with air pollution may be a powerful catalyst for collective ambition to mitigate climate change. Greater coordination among the health, energy, transport, agriculture, urban planning and other sectors will be necessary to set priorities that ensure maximum benefits for both health and climate. The health sector could support countries in conducting evidence-based analyses and estimating the benefits to health and the climate. The effect would be maximized by a unified governance and policy framework in which reducing air pollution and promoting the right to clean air are recognized as drivers of efforts to mitigate climate change and reduce the related health risks (Box 1).

Box 1

First WHO Global Conference on Air Pollution and Health

The first WHO Global Conference on Air Pollution and Health took place on 30 October–1 November 2018 in Geneva. The conference was held in response to World Health Assembly resolution 68.8 (2015) in which ministers of health requested a significant increase in the response to air pollution, including associated diseases, exposure and the costs to society. The "road map for an enhanced global response to the health impacts of air pollution", adopted by the World Health Assembly in 2016 requested WHO to organize a global conference to review progress and set targets for further action.

The Conference set the aspirational goal of reducing the number of deaths from air pollution by two thirds by 2030. Participants recognized that the response should be multisectoral, and synergy among health, climate and development should be ensured. The "Geneva Action Agenda to Combat Air Pollution" lists 17 activities that would increase countries' ability to achieve the goal (13). They include: scaling up and mobilizing action (particularly through the BreatheLife campaign); providing clean energy and transport alternatives; strengthening action to protect the most vulnerable populations (particularly children); extending clean energy access in Africa and to other populations in need; enhancing interventions to prevent NCDs; establishing a monitoring and evaluation mechanism on governance and health impacts; and improving gender equity by increased access to clean household energy and technologies.

2.2 Health impacts of climate change

Warming trends are continuing worldwide, accompanied by increasing numbers of extreme weather events, by 46% between 2000 and 2013 *(12, 14)*. A changing, more variable climate is now recognized as the most likely, highest-impact global risk to society as a whole and which presents a clear and present danger to health security *(15, 16)*. In 2017 and 2018 alone, populations around the world were exposed to heatwaves (for example, in Japan and the United Kingdom), severe flooding (for example, in China, France and India), wildfires (for example, in Greece, Sweden and the USA) and tropical storms (for example, in Japan, the Philippines and the USA).

Climate change can affect human health both directly and indirectly. The direct health impacts include physiological effects of exposure to higher temperatures, increasing incidences of NCDs such as respiratory and cardiovascular disease and injuries and death due to extreme weather events such as droughts, floods, heatwaves, storms and wildfires. Climate change has indirect effects on health due to ecological changes, such as food and water insecurity and the spread of climate-sensitive infectious diseases, and also to societal responses to climate change, such as population displacement and reduced access to health services *(17)*. As indirect effects of climate change may result from long causal pathways, they are particularly difficult to anticipate. The effects may be short- or long-term and direct or indirect, sometimes with life-long consequences for health and well-being. For example, NCDs such as mental illness after extreme weather events, climate-related displacement, immigration and loss of culture can be lifelong.

The capacity of disease vectors to spread infectious diseases is increasing as a result of climatic shifts; for example, the vectorial capacity of the mosquitoes that are primarily responsible for the transmission of dengue fever has risen by approximately 10% since the 1950s: *(14)*. Ecological shifts as a result of climate changes may have further health effects, by affecting water and sanitation and causing food insecurity and malnutrition *(18)*. Malnutrition is anticipated to be one of the greatest threats to health resulting from climate change, and the young and the elderly will be particularly affected. Climate variation and extremes are among the leading causes of severe food crises, and the cumulative effect is undermining all dimensions of food security, including availability, access, use and stability. Rising temperatures, floods and droughts also affect food safety; for example, rising temps can increase the levels of pathogens in food sources (such as ciguatera in fish) and in food, and flooding increases the risk that pathogens will spread from livestock. The effects on nutrition also include impaired nutrient quality of crops, the diversity of food produced and consumed, impacts on water and sanitation, patterns of risks and changes in maternal care, child care and breastfeeding *(19, 20)*.

Broader dimensions are important in determining the health outcomes of climate change and associated events and can limit the ability of health systems to deliver health protection and care, in the short-, medium- and long-term. It is widely recognized that, while everyone will be affected by climate change, the poorest and most vulnerable populations will suffer the greatest health impacts. Although LMICs have contributed the least to GHG emissions, their populations will bear the brunt of climate-related health impacts *(21)*. Inequities also occur within countries, due to economic, environmental and social determinants. Thus, people who are poor and undernourished, already ill, have insecure housing, farm degraded land, work in unsafe conditions, have little education, are deprived of their rights or live in places with poor health systems, limited resources and poor governance cannot influence decisions *(22)*. It will be critical to address such inequities in order to reduce vulnerability, build resilience and prevent greater inequity as a result of climate change *(23, 24)*.

The impacts of climate change on health are strongly influenced by individual and population factors, including age (children and the elderly are often at higher risk) and gender. For example, during droughts, women and children in developing countries are often the worst affected, as a consequence of their respective roles in household decisions, and tasks such as water collection. In contrast, male farmers have been found to be disproportionately likely to commit suicide during droughts *(25)*. Understanding gender differences in vulnerability, roles and capacity is essential to design effective, equitable climate adaptation programmes *(26)* and go towards meeting SDG 5 (gender equality) more broadly.

The impacts of climate variation and change on vulnerable infrastructure can increase health risks; for instance, more extreme storms and flooding can disrupt energy distribution and result in chemical and biological contamination of water supplies and sanitation *(27)*. Health facilities are vulnerable to extreme weather events and to sea level rise in coastal locations and to increasing demand as a result of hazards, the spread of vector- and waterborne infectious diseases, food insecurity and forced migration. Fig. 3 shows some of the direct and indirect links between climate change and health, case studies of the effects of climate change on health and certain factors that mediate health outcomes.

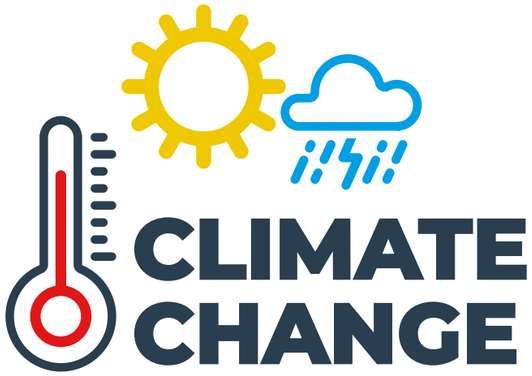


Figure 3

Climate change impacts health both directly and indirectly, but is strongly mediated by environmental, social and public health determinants. From references (14, 28-32).

DIRECT IMPACTS

- Storm
- Drought
- Flood
- heatwave
- Temperature Change
- Wildfires

INDIRECT IMPACTS

- Water Quality
- Air Quality
- Land Use Change
- Ecological change

MEDIATING FACTORS

ENVIRONMENTAL

- Geography
- Baseline weather
- Soil / dust
- Vegetation
- Baseline air / water quality

SOCIAL

- Loss of habitation
- poverty
- Displacement
- Conflict
- Age and gender

RESILIENCY

- Early-warning system
- Socioeconomic status
- Health and nutrition
- Primary health care

HEALTH IMPACTS

Mental Illness
Undernutrition
Injuries
Respiratory Disease
Allergies
Cardiovascular Disease
Infectious Diseases
Poisoning
Water-Borne Diseases
Heat Stroke

Case study: Heatwaves.
The number of vulnerable people exposed to heatwaves increased by 125 million between 2000 and 2016. One of the most extreme heatwaves was the 2003 European heatwave, which was made twice as likely by climate change. Over 70,000 additional deaths occurred over Europe as a result of the heatwave.

Case study: Temperature change.
Exposure to rising temperatures has known associations with rising occurrence of NDCs, such as cardiovascular disease. An 11 year study in Burkina faso has shown that exposure to moderate or extreme heat significantly increases excess daily premature mortality from NCDs; cardiovascular disease accounted for 50% of years of life lost in this study.

Case study: Drought.
Ethiopia has been victim to regular famines since the 1980s, whith droughts being a significant contributing factor. A consequence of this is child undernutrition and wasting. For instance, in areas affected by moderate drought in Ethiopia, child wasting was 34% higher than areas unaffected by drought. However, social mediating factors also play an important role. Firstly, areas affected by severe droughts suffered less from child wasting, as aid programmes were targeted in these areas. Secondly, areas of conflict show clear links with higher levels of undernutrition, as a result of decreased food security.

Case study: Flooding.
Over the last 40 years, more than 90% of natural disasters affecting Pakistan have been triggered by climate change. Flooding has been increasingly affecting Pakistan. For example, in 2010, over 15 million people were affected by flooding, with 6 million people in need of urgent medical care. Attending to these health needs was extremely difficult, as over 200 health care facilities were destroyed by the floods.

Fig. 3 provides clear evidence that climate change is closely associated with human health and that health is negatively affected by rising exposure and vulnerability to climatic stresses (14). Even if all emissions of GHGs were stopped today, the climate would still change, because of cumulative GHG emissions *(33)*.

While broad projections can be made of how climate change will affect human health, the precise impacts in specific places are difficult to predict accurately. Further research is required to provide better information to policy- and decision-makers so that they can design effective policies (34). There are three main sources of uncertainty in projecting the impact of climate change on health. First, the impact will be determined by the extent of climate change resulting from GHG emissions, which in turn are the result of development pathways and policies. The IPCC and the scientific community describe the possibilities as four "representative concentration pathways", which give a plausible range of the extent of climate "forcing" that reflects different GHG emission scenarios *(33)*. These can be used to estimate possible health outcomes. Secondly, while climate modelling has vastly improved, there is still some unavoidable uncertainty over how the climate system responds to GHG emissions and the effects of changes. Thirdly, health outcomes are strongly affected by mediating factors such as societal responses. Resilience will be a vital determinant of the severity of health outcomes, as the greater the resilience of a population, the better it can cope with climate change.

Modelling has been conducted to project potential future health impacts of climate change. Exposure to heat, droughts, floods and heatwaves is projected to increase globally. As many as 3 billion people aged > 65 years (who are particularly vulnerable) may be exposed to heatwaves by 2100, because of a combination of increasing temperatures, ageing and urbanization *(35)*. The warmest and poorest countries of the world will be most severely affected by climate change, particularly in South Asia *(36, 37)*. Overall, the health impacts of climate change could force 100 million people into poverty by 2030, with strong impacts on mortality and morbidity *(38)*. A highly conservative estimate of 250 000 additional deaths each year due to climate change has been projected between 2030 and 2050; of these, 38 000 will result from exposure of the elderly to heat, 48 000 from diarrhoea, 60 000 from malaria and 95 000 from childhood undernutrition. These estimates were calculated within an optimistic scenario in terms of future socioeconomic development and adaptation; furthermore, they cover only four direct effects of climate change on health, while there are many more direct and indirect effects and more complex causal pathways that have not been quantified. Thus, the health of hundreds of millions more people could be affected by climate change *(37)*.

In the short to medium term (to the middle of the 2000s), the health impact of climate change will be determined mainly by the vulnerability of populations and their resilience to the current rate of climate change. In the longer term, the effects will increasingly depend on the extent of climate change, as the health outcomes in scenarios of high and low emissions in the second half of the century differ significantly (Box 2). Ambitious, urgent mitigation and adaptation now could help to meet the goals of the Paris Agreement and secure attainment of the SDGs, to which good health is central.

Box 2

Health impacts under scenarios of warming by 1.5 °C and 2.0 °C

The Paris Agreement commits nations to prevent a rise in global temperatures well below 2 °C above pre-industrial levels and to try to reduce the rise to 1.5 °C. At COP21 in 2015, the IPCC was asked to report on the impacts of warming by 1.5 °C and 2.0 °C. The conclusion of the report, published in October 2018 (14), was that climate change is already affecting human health, with increasing exposure and vulnerability recorded worldwide. Furthermore, warming of even 1.5 °C is not considered "safe". The most disadvantaged, vulnerable, poor populations are expected to be disproportionately affected by warming to 1.5 °C, with rising food and water insecurity, higher food prices, loss of income and livelihood opportunities, negative health effects and population displacement (including forced migration). Thus, climate change is considered to be a "poverty multiplier", which could force 100 million people into extreme poverty.

With warming by 1.5 °C, 350 million more people could be exposed to deadly heat stress by 2050 , with higher numbers exposed if warming is by 2.0 °C. The risks for SIDS are expected to be severe, with particular concern regarding storm surges, coastal flooding and sea level rise. Shifting weather patterns are also changing the geographical range, seasonality and intensity of transmission of climate-sensitive diseases, as greater warming will increase the range of certain vectors and diseases (including malaria, dengue, West Nile and Lyme disease) to previously unexposed areas with Europe and North America. Warming by 2.0 °C is also expected to exacerbate air pollution and the associated deaths from ozone as compared with warming by 1.5 °C. Food security is widely considered to be a major health risk of climate change and is expected to be worse at 2 °C than at 1.5 °C; it is projected that 540–590 million people will be undernourished at warming by 2 °C and 530–550 million people at warming by less than 1.5 °C. Children will be particularly badly affected, with more undernutrition and consequent stunting. Reducing warming to 1.5 °C would markedly decrease the likelihood of drought and water stress, especially in the Mediterranean and southern Africa.

If climate change is not mitigated, global income inequality could increase grossly. As the health impacts of climate change are unevenly distributed, existing inequities will be exacerbated, more at 2.0 °C than at 1.5 °C warming. Maintaining the temperature rise to 1.5 °C could therefore prevent some of the worst health effects of climate change and improve the effectiveness of adaptation, which will become increasingly restricted at warming by 2.0 °C or more. Additionally, at a temperature rise of no more than 1.5 °C, sustainable development would be substantially easier to achieve (including meeting the SDGs), as would eradication of poverty, reduction of inequalities and prevention of health effects. The health threats at 1.5 °C warming are, however, still significant, and targets to prevent the harmful effects of climate change on human health and welfare might not be met in this scenario. These findings should provide a strong incentive for countries to commit themselves to more ambitious mitigation and adaptation targets to minimize the health impacts of climate change. The IPCC report indicates that maintaining warming below 1.5 °C could be achieved in tandem with poverty alleviation, improving energy security and health benefits, which, furthermore, could be greater than the costs of mitigation costs *(14)*.

3. GAINING MASSIVE HEALTH BENEFITS FROM TACKLING CLIMATE CHANGE

3.1 Health gains of climate change mitigation across key sectors

Meeting the targets of the Paris climate agreement would be expected to save over one million lives a year from air pollution alone by 2050, according to the most recent assessment. The same analysis shows that the value of the health gains would be approximately twice the cost of the policies. The largest gains would be expected in China and India, which would generate even larger net benefits by pursuing the 1.5 °C target rather than the 2.0 °C target (US$ 0.27–2.31 trillion in China and US$ 3.28–8.4 trillion in India). The health gains of meeting the 2.0 °C target would also significantly offset the costs in other regions, such as the European Union (7–84%) and the USA (10–41%) *(39)*.

Reducing carbon emissions therefore contributes directly to the fundamental purpose of the UNFCCC: to prevent the adverse effects of climate change, including on human health and welfare. The Paris Agreement goals of limiting global warming to 1.5 °C above pre-industrial levels, with an absolute ceiling well below 2.0 °C, are essential to protect health in the medium to long term. A reduction in GHG emissions by as much as 50–90% is needed to keep global temperature from rising by more than 2.0 °C, and this can be achieved with measures that are directly advantageous to the countries that are mitigating climate change once the co-benefits are accounted for (Box 3).

Box 3

Tools for estimating the health benefits of meeting commitments under the Paris Agreement

Under the Paris Agreement, many Parties have committed to a substantial reduction in GHG emissions by 2030. The WHO "Carbon reduction benefits on health" tool, gives initial quantification of the possible health benefits of expected reductions in air pollutant emissions by country (40), for the WHO European Region. The annual number of preventable premature deaths could amount to 138 000 throughout Region, of which 47% would be averted in the Russian Federation (65 900 deaths) and 33% (45 350 deaths) in the 28 countries in the European Union. In economic terms, the benefit of reduced emissions would be equivalent to savings of US$ 244–564 billion, or 1–2% of the GDP of the Region (at purchasing power parity). The saved costs of treating illness (US$ 34.3 billion) would amount to 6–14% of the total economic benefit.

There are important policy opportunities to advance climate and health goals together. In September 2018, world leaders at the United Nations General Assembly committed themselves to tackle NCDs and agreed that policy, legislation and regulatory measures were required in all nations to decrease morbidity and mortality from these diseases. Reducing air pollution was recognized as integral to meeting the goals *(41)*. The commitment of Member States at the General Assembly should accelerate action in reducing NCDs, including those due to air pollution, and encourage national strategic action plans for the prevention and control of NCDs.

While improvements in local air quality offer a means for improving human health and climate mitigation, other health benefits are to be gained from mitigating climate change. Table 1 summarizes some of the opportunities and actions.

Table 1 **Health gains of selected climate change mitigation activities**

Mitigation activity	Certainty of major effect on short-lived climate pollutants	Aggregate level of potential health benefit	Main health benefits Direct benefits Indirect benefits Ancillary benefits for health	Potential level of reduction in CO_2
TRANSPORT				
Support for active (and rapid mass) transport	High	High	Improved air quality Less crop damage and extreme weather Increased physical activity Reduced noise Fewer road traffic injuries	High
Support for active (and rapid mass) transport	High	High	Improved air quality Less crop damage and extreme weather Increased physical activity Reduced noise Fewer road traffic injuries	None
Ultra-low-sulfur diesel with diesel particle filters	Medium–high	Medium	Improved air quality Less crop damage and extreme weather	None
Higher standards for vehicle emissions and efficiency	High	Medium–high	Improved air quality Less crop damage and extreme weather	High
AGRICULTURE				
Alternate wet and dry rice irrigation	Medium–high	Low–medium	Less crop damage and extreme weather Reduced vector-borne disease	Low
Improved manure management	Low–Medium	Low–Medium	Reduced zoonotic disease Improved indoor air quality	Low
Reduced open burning of agricultural fields	Medium	Low–medium	Improved air quality Less crop damage and extreme weather	Low
Promotion of healthy diets low in red meat and processed meats and rich in plant-based foods	High	High	Less crop damage and extreme weather Reduced obesity and diet-related non-communicable diseases	Medium–high
Reduced food waste	Medium–high	Low–medium	Less crop damage and extreme weather Reduced food insecurity/ undernutrition	Medium-high
HOUSEHOLD AIR POLLUTION AND BUILDING DESIGN				
Low-emission stoves and/or reducing solid fuel use	Medium-high	High	Improved air quality Less crop damage and extreme weather Less violence and risk of injury during fuel collection Fewer burns	Medium
Better lighting to replace kerosene lamps	Medium	Medium	Improved air quality Less crop damage and extreme weather Fewer burns	Low-medium
Passive design principles	Low-medium	Medium	Thermal regulation Improved indoor air quality	Medium
ENERGY SUPPLY, ELECTRICITY				
Switch from fossil fuels to renewable energy for large-scale power production	Low	High (coal, oil) Low–medium (gas)	Improved air quality Less crop damage and extreme weather Fewer occupational injuries	High (coal, oil) Medium–high (gas)

Replacement with or supplementation of small-scale diesel generators with renewable energy	Low-medium	Low-medium	Improved air quality Less crop damage and extreme weather Reduced noise	Low-medium
Control of fugitive emissions from fossil fuel industry	High	Low	Improved air quality Less crop damage and extreme weather	Low-medium
INDUSTRY				
Improved brick kilns	Low-medium	Medium	Improved air quality Less crop damage and extreme weather	Low-medium
Improved coke ovens	Low-medium	Medium	Improved air quality Less crop damage and extreme weather	Low-medium
Control of fugitive emissions from fossil fuel industry	High	Low	Improved air quality Less crop damage and extreme weather	Low-medium
WASTE MANAGEMENT				
Landfill gas recovery	Medium	Low	Improved air quality Less crop damage and extreme weather	Low-medium
Improved wastewater treatment (including sanitation)	Medium	Medium-high	Improved air quality Less crop damage and extreme weather Reduced infectious disease risk	Low-medium

Source: reference *(42)*

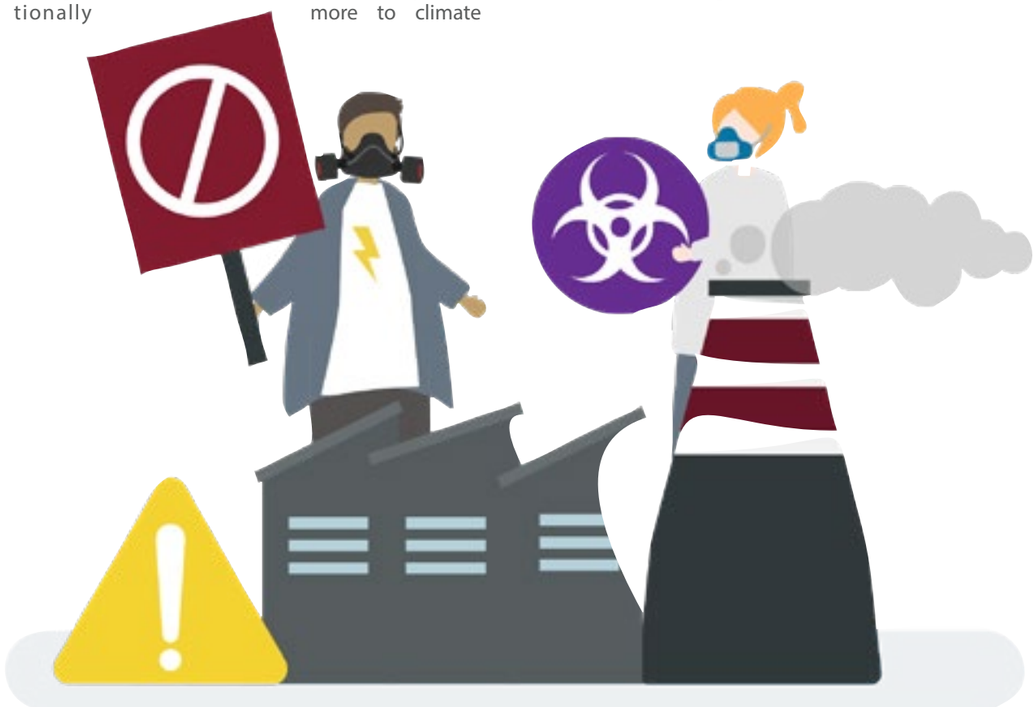
The many ways in which climate mitigation and health goals intersect and the strong influences of social, cultural, economic and environmental determinants call for intersectoral policies that go well beyond the direct control of the health sector. Governments have a range of policy priorities, and health may not always be fully accounted for in decision-making. A "health-in-all-policies" approach is therefore required, in which the health implications of decisions in all public policies are accounted for, synergies are promoted and negative health outcomes avoided, in a transparent and accountable process *(43)*. This is described for the major greenhouse gas emitting sectors, below.

3.2 Energy

Most of the energy used around the world continues to be from fossil fuels. To protect health and the climate, there is a need for a health energy transition to ensure access to affordable, reliable, sustainable and modern energy, with zero emissions of GHGs and health-damaging air pollutants. The cost of renewable energy generation is falling quickly, and investment in and deployment of these source are growing rapidly; however, they still comprise only 25% of global electricity production *(44)*. In order to meet the goal of maintaining the global temperature rise to less than 2.0 °C above pre-industrial levels, renewable energy must account for a least 65% of the global primary energy supply by 2050 *(45)*.

The most important choices for energy policies are therefore based on the fastest means of scaling up renewable energy while maximizing the health benefits. The case for rapidly phasing out some forms of fossil fuels is clear. Coal is a particularly polluting form of energy and contributes to premature mortality worldwide. Coal emits 40% more CO_2 than natural gas and thus contributes proportionally more to climate change *(46)*. Policies should therefore be designed to phase out coal use as quickly as possible while ensuring a just transition for populations and economies that depend heavily on its production.

The Powering Past Coal Alliance of over 20 countries is committed to phasing out coal-fired power generation by 2030, in view of the contribution of coal to climate change and premature deaths worldwide *(47)*. To keep global temperatures from rising above 1.5 °C or even 2.0 °C, coal must be phased out by 2030 in the countries of the Organization for Economic Co-operation and Development and the European Union, by 2040 in China and by no later than 2050 in the rest of the world. Current plans for coal use are, however, inconsistent with the targets of the Paris Agreement, with plans for 1082 new coal plants globally *(48)*. If these are built, the world will be locked onto a carbon-intensive pathway, still heavily reliant on coal, for the next 40 years, with severe implications for human health *(48)*. The positive implications for China of meeting its commitments under the Paris Agreement are outlined in Box 4.



Box 4

Health gains associated with meeting climate commitments in China

Air pollution is a particularly acute problem in Asia, with an estimated 2.2 million premature deaths annually, accounting for approximately a third of the global total (49). Responding to the ever-growing demand for energy in South East Asia, however, countries rely increasingly on coal. This trend is expected to continue, with more than half the energy supply in Asia projected to be from coal by 2035–2040 (50). In Viet Nam alone, the planned increase in coal-fired power plant installations between now and 2030 would increase emissions from coal by 10 times, with an associated rise in the health burden (51, 52).

There are known, quantifiable benefits to less carbon-intensive pathways. For example, if China were to meet its NDC commitments, the health benefits of mitigation would offset 18–62% of the cost (53). China has met and exceeded part of its NDC ahead of schedule. It had planned to cut its energy intensity by 40–45% of 2005 levels by 2020; however, by 2018, it had reduced its energy intensity by 47%, with a 5.1% decrease in 2017 alone. Clear current and future health and economic benefits are associated with mitigation, due largely to improved air quality.

The collective effect of the NDC commitments of all nations, including China, is insufficient to meet the goal of the Paris Agreement to reduce warming below 2 °C. In China, more drastic reductions in emissions are expected to have further health gains, and the net benefit of commitments to reach the goal would exceed the cost of mitigation by three to nine times. An even greater net benefit can be expected for reductions to reach the 1.5 °C target (14, 39). These projections should provide more than enough incentive to further increase mitigation and reap the full health benefits, in China and throughout the region.

3.3 Households and buildings

Nearly 3 billion people lack access to clean fuels and stoves for cooking, and they use polluting stoves that burn solid fuels such as wood, agricultural waste, animal dung and raw coal for their basic energy needs. The burning of such fuels in inefficient cookstoves causes an estimated 3.8 million deaths per year due to household air pollution ((*54*). This burden falls primarily on LMICs and rural populations. Inefficient burning of solid fuels also contributes to climate change; for example, deforestation can increase when people have to use wood to heat and cook food. About 25% of black carbon emissions globally have been attributed to domestic use of biomass.

Lack of access to electricity has other significant health effects; for example, hospitals cannot provide basic health care services, and children without lighting at home often cannot do homework, with effects on their education, health and well-being *(55)*.

Decentralized renewable energy schemes have been established in many LMICs, including solar energy schemes in a number of sub-Saharan African countries. These provide remote populations with reliable access to clean energy; the wide-ranging benefits include access to education, health care and employment. Installing renewable energy also promotes

low-carbon development in communities that "leapfrog" over the dirty technology used previously in HICs. Low-carbon development not only provides important health benefits but also helps meet mitigation targets, reducing current GHG emissions from dirty and inefficient fuels (such as charcoal and kerosene) and also future GHG emissions, by avoiding installation of fossil fuel power supplies.

Cooking is a universal requirement for household energy, as is space heating. The use of inefficient stoves or open fires for cooking and heating are the primary sources of household air pollution. Replacing polluting, inefficient stoves with cleaner fuels and stoves can significantly reduce mortality and morbidity from household air pollution, including from chronic pulmonary diseases and pneumonia (56). Women and girls are most affected by household indoor air pollution because of the time they spend in and around the home. Therefore, improving access to clean cooking and heating can reduce gender inequity and the associated health outcomes. The transition to cleaner household energy has begun in a number of countries, but it should be accelerated to protect health and the climate.

It is not necessarily straightforward to choose the optimal household energy, and it may sometimes involve trade-offs. For example, while liquefied petroleum gas is a fossil fuel, it emits almost no particulate air pollution and emits less climate pollutants than many other household energy sources. There may therefore be rapid health gains and sustainability if it replaces more polluting fuels and technologies, as opposed to crowding out investment in renewable energy.

For instance, in Ecuador, traditional cook stoves were replaced with gas, with important health gains. The country is now, however, implementing a "liquefied petroleum gas substitution programme" to replace the gas cookers with induction cookers in order to reduce Ecuador's dependence on imported fuels. Currently, 80% of liquefied petroleum gas is imported, and it is heavily subsidized, at an estimated cost of US$ 700 million to the economy annually. The scheme will increase the share of renewable energy in the national energy mix. In time, the induction cookers will be powered by renewable sources, with further health benefits *(57)*.

GHG emissions can also be reduced by sustainable construction. Construction companies, particularly in HICs, are improving the energy efficiency of buildings to reduce fuel poverty from inefficient heating, and some are building zero-emission and even climate-positive buildings. As the construction industry is the largest global consumer of resources, its impact could be significantly reduced while improving the health and well-being of the people living in these buildings *(58)*.

3.4 Transport

The transport sector is another significant contributor to both GHG emissions and local air pollution; it accounts for about 23% of global energy-related GHG emissions *(59)*. More sustainable means of transport include electric vehicles, more public transport and encouraging active transport, such as cycling and walking would reduce GHG emissions, with large health benefits. Transport planning, particularly in urban areas, should be sensitive to both health and climate.

Private vehicles are the main means of transport worldwide, and the vast majority run on petrol or diesel fuel. They emit not only GHGs but also particulate matter, which contributes to poor air quality, and health impacts, particularly in cities. Changing to electric vehicles would have benefits for both the climate and health, and their use is increasing rapidly. Between 2016 and 2017, the global number of electric vehicles increased by 50% *(60)*, to about 3 million; however, they represent a very small proportion of the global vehicle fleet. Hence, drivers should be targeted with incentives to purchase electric vehicles. While replacement of fossil fuel-run cars by electric vehicles would represent an important net gain, electric vehicles still emit significant particulate air pollution from physical wear of tyres and brakes and continue to contribute to traffic congestion and road traffic injuries. Furthermore, they do not have the health benefits of other sustainable transport.

Increasing the use of public transport can significantly reduce GHG emissions and air pollution, by reducing emissions per person. Public transport run on clean fuels or electricity is associated with further health gains, decreasing cardiovascular and respiratory disease, traffic injuries and noise-related stress and associated mental health issues due to high-volume traffic *(61)*. Access to public transport also tends to reduce inequity, by increasing the mobility of women, children, the elderly and the poor, who generally have less access to private vehicles *(61)*. Increasing the availability of public transport is often more beneficial and feasible in cities than in rural communities. Although more than 50% of the global population now lives in cities, sustainable transport plans should also be made for isolated communities, groups and individuals.

Encouraging active transport, particularly for short distances in cities, has the widest range of benefits for health and climate mitigation. It reduces not only air pollution but also sedentary lifestyles and may thus prevent some cancers, type 2 diabetes, heart disease and obesity, which are increasing rapidly in rich and poor countries alike: an estimated 3.2 million people die every year from diseases associated with physical inactivity (61). Urban planning and appropriate infrastructure are essential to promote active transport. This is achievable, as many cities, such as Amsterdam and Copenhagen, have extensive cycle ways, making cycling safe and easy.

Tools and approaches are available to integrate transport policy, particularly in cities, with other policy goals. For example, the aim of the Urban Health Initiative, launched by the Climate and Clean Air Coalition, is to use an integrated approach to building cities in which good health is enabled and encouraged, with a focus on climate change, short-lived climate pollutants and air quality *(62)*. Decision-makers are given access to tools for assessing the full impact of air pollution and existing urban policies, mapping the health impacts of sectoral emissions (from transport, land use, energy and housing) in different scenarios and calculating the health cost and benefits. The approach is being pilot-tested in Accra, Ghana, and Kathmandu, Nepal, and will be extended to cities in other developing countries *(63)*.

3.5 Agriculture and food systems

Agriculture is estimated to contribute approximately 24% of global GHG emissions, and current trends indicate that total emissions from the sector will increase by 50–90% by 2050 *(64)*. Global food production is a major source of soil and water pollution and uses more than 70% of all fresh water and 40% of land. Most emissions are due to deforestation and livestock, soil and nutrient management. Agriculture is also a significant source of methane, a particularly potent GHG with about 20 times the warming potential of CO_2. Approximately 3.4 million tonnes of CO_2 equivalent were emitted by the sector in 2008, representing 44% of all agricultural emissions *(65)*.

More sustainable, regenerative agricultural practices could not only reduce GHG emissions but also sequester carbon and protect and enhance biodiversity, soils, watersheds and broader ecosystem services. It has been estimated that all current annual CO_2 emissions could be sequestered in regenerative organic agriculture, which maximizes carbon fixation and minimizes the loss of that carbon once returned to the soil (66). In such practices, deforestation could be reduced, limiting direct CO_2 emissions and the loss of forests as important carbon sinks.

Health and climate change mitigation can be advanced by both supply-side and demand-side measures. Current agricultural practices of intensification, including in tropical rainforests, and maximizing yields with a high input of energy and fertilizers from fossil fuels contribute significant GHG emissions and rapidly degrade soil quality, undermining sustainable food security. Conversely, farming practices that safeguard biodiversity, encourage carbon sequestration, protect soil nutrition and reduce fossil fuel use *(67)* can simultaneously mitigate climate change, reduce air pollution, increase food and nutrition security and promote ecosystem services such as clean water and protection from vector-borne diseases.

These goals can also be advanced by reducing demand-side emissions, including from food waste, and particularly by changes to the diet (67). In HICs, and increasingly LMICs, diet-related NCDs are more frequent. Low consumption of fruit and vegetables and high consumption of meat, processed foods and sugary drinks are associated with risks for obesity, type 2 diabetes, cardiovascular disease and some cancers. Moderation of red meat consumption by high-income populations could result in some of the largest reductions in climate change and the greatest improvements in health associated with the agricultural sector, as a significant proportion of agricultural emissions come from livestock, especially methane from ruminants.

A synergistic combination of supply and demand measures to increase consumption of diets with more fruit and vegetables, produced sustainably and ideally locally, will be necessary to gain the potential health and environmental benefits *(64)*.

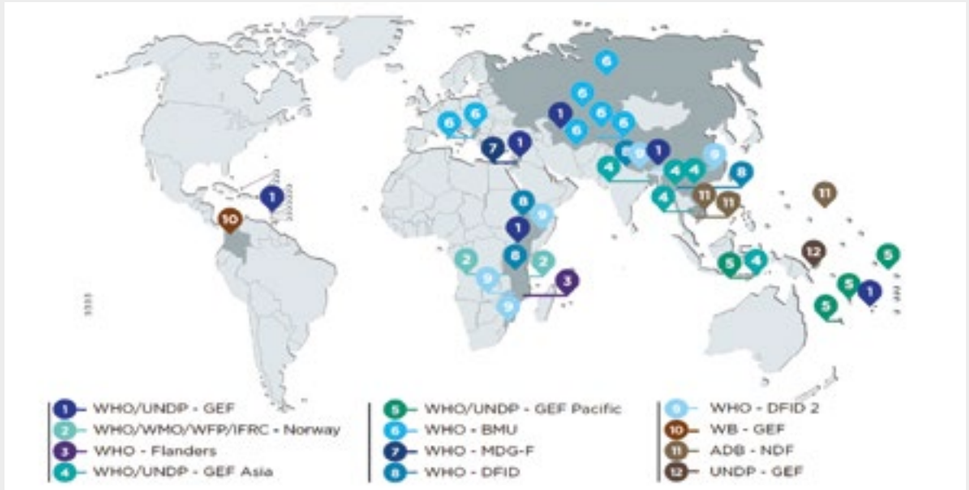
4. ADDRESSING HEALTH RISKS OF CLIMATE CHANGE: BUILDING CLIMATE-RESILIENT HEALTH SYSTEMS

The immediate public health activities necessary to meet the challenge of climate change are to strengthen the prevention of climate-sensitive health risks and to build adaptive capacity to absorb the changing, increasing risks presented by climate change. Globally, health systems are poorly adapted to variations in climate, particularly in LMICs. Climate change adds further pressure on health, which is strongly influenced by effects on other sectors, such as food, water and sanitation. A multisectoral response is therefore required, by building on existing strengths. Thus, the provision of health care and public health and work in sectors such as water and sanitation, food systems and energy provision, should be integrated with the additional functions and capacities required to build climate resilience.

Experience in strengthening the climate resilience of health systems has increased rapidly during the past decade. Fig. 4 summarizes large projects on health adaptation to climate change (≥ US$ 500 000 per country) that have been completed or have been under way since 2008.

Figure 4

Completed, ongoing or approved projects on health adaptation to climate change, 2008 to the present



UNDP, United Nations Development Programme; GEF, Global Environment Fund; WMO, World Meteorological Organization; WFP, World Food Programme; IFRC, International Federation of Red Cross and Red Crescent Societies; BMU, Federal Minister for the Environment, Nature Conservation and Nuclear Safety (Germany); MDG-F, Millennium Development Goals Achievement Fund; DFID, Department for International Development (United Kingdom); WB, World Bank; ADB, Asian Development Bank; NDF, Nordic development Fund

The experience gained in these projects is the basis for a systematic, comprehensive approach in which health systems can anticipate, prevent, prepare for and manage risks associated with climate change. This is summarized in the WHO operational framework for building climate-resilient health systems *(68)*, which starts with the "building blocks" broadly common to all health systems (leadership and governance, health workforce, health information systems, essential medical products and technologies, service delivery) and provides a comprehensive picture of how climate resilience can be added to each (Fig. 5).

Figure 5

WHO operational framework for building climate-resilient health systems based on the six building blocks common to health systems (inner ring), with 10 components to strengthen climate resilience (outer ring)

From reference *(68)*

Complementary approaches are used in some countries. For example, the US Centers for Disease Control and Prevention framework, Building resilience against climate effects, lists five steps for designing strategies and programmes to make population health resilient to climate change: anticipating the impact of climate change and assessing vulnerability; projecting the disease burden; assessing public health interventions; preparing and implementing an adaptation plan for both climate and health; and evaluating impact and improving the quality of activities *(69)*. Other approaches involve transforming public health services, such as monitoring health status, informing and empowering communities, enforcing laws and regulations and conducting research into measures for adaptation to climate change *(70)*.

The successful approaches share some common features: concrete understanding of how adaptation contributes to development goals; investment in building capacity and stakeholder engagement; multisectoral approaches; indicators for effective monitoring and evaluation; an iterative cycle to promote continuous improvement; and avoiding maladaptation *(70, 71)*. Key functions that should be strengthened to increase health resilience to climate change are described below.

4.1 Leadership, governance and capacity-building

In view of the sensitivity of health to climate variation and change, health should be considered in climate change policies and programmes for both adaptation and mitigation. The health sector should therefore be more actively involved in UNFCCC processes for adaptation, notably in national adaptation planning, in which countries identify medium- and long-term requirements for adaptation and devise measures to address them *(72)*. Such involvement would address the longstanding problem in most countries: that health is threatened by climate change, but few have prioritized plans to address it. Of 41 national Adaptation Plans of Action (NAPAs) submitted by least developed countries to the UNFCCC, 95% recognized that health is particularly affected by climate change, but only 11% of their priority projects addressed health.

Guidance and technical support are available for the development of prioritized, time-bound, costed national health adaptation plans, to be implemented in collaboration with other relevant sectors and integrated into an overall multisectoral national plan (20, 73–76). Box 5 contains a description of the WHO/UNFCCC/Fiji Global Initiative on Climate Change and Health in Small-island Developing States.

Box 5

Global leadership and governance: the WHO/UNFCCC/Fiji Global Initiative on Climate Change and Health in SIDS

SIDS are at particular risk of climate-related disasters such as extreme floods, storms, droughts and sea-level rise and of the associated risks of water-, vector- and foodborne diseases, which are exacerbated by environmental and climate variation and change. For instance, between 1976 and 2015, 622 climate-related storms, floods and droughts were recorded in SIDS, causing over 14 000 deaths, affecting 38.5 million people and at least US$ 33.3 billion worth of damage. Climate-related disasters also affect food security in SIDS by damaging food crops and fisheries, which compounds the dietary transition from local, traditional, healthy diets to greater dependence on imported foods with more fat, sugar and salt. These increase the health risks of obesity and diet-related NCDs. The health, livelihoods and development of populations in SIDS depend heavily on ecosystem services, which are fragile and under strain from climate change and other pressures. Although SIDS contribute only 0.03% of global CO_2 emissions from fuel combustion, they bear some of the most severe direct consequences of climate change, with very high risks to their health. Health systems in many SIDS, however, have limited capacity to provide high-quality health services, because of high per capita cost, vulnerability to external shocks and limited financial and human resources *(77)*, all of which are exacerbated by climate change.

Responding to a call by the health ministers of SIDS, WHO, in collaboration with the UNFCCC and the Government of Fiji (as President of COP23), launched a special initiative on climate change and health in SIDS at COP23, in November 2017. The aim of the initiative is to provide political, technical and financial support to health systems in SIDS, provide a better evidence base on the health effects of climate change in SIDS, improve the resilience of health services to climate change and the environmental sustainability of health practices and promote mitigation of climate change in most polluting sectors to maximize potential health benefits, within SIDS and globally *(77)*. The initiative has four interlinked components:

Empowerment: providing support to health leadership in SIDS so that they engage nationally and internationally in mitigating the health effects of climate change.

Evidence: generating the evidence necessary to build a case for investment in improving the resilience of SIDS' health systems and further health benefits of climate mitigation.

Implementation: Preparing for and addressing climate risks and preparing health-promoting policies.

Resources: facilitating access to finance for work on climate change and health.

Ministerial consultations have been organized in the Pacific, Indian Ocean and Caribbean regions among ministers of health, ministers of environment, and operational and technical environment experts from over 40 countries to prepare country-driven regional action plans for implementation of the SIDS initiative, initially for 2019–2023, and a global action plan for endorsement by the World Health Assembly in 2019 *(77)*. Ministers of health of the SIDS are thereby leading in protecting their populations from climate change.

4.2 Using climate services to strengthen health information systems

In strengthening the core function of health information systems for addressing risks associated with climate change, it is important to understand the vulnerability of individuals, groups, communities and health system determined by social, environmental and economic factors *(22)*. There are now well-established methods for assessing health vulnerability and for defining options for adaptation *(78)* in order to set a baseline of vulnerability; build capacity, including for long-term views of today's actions; using adaptive approaches; and ensuring community approaches and expression *(68)*.

A common, more directly operational demand from climate-vulnerable countries and populations is to improve surveillance and response for climate-sensitive health outcomes, and meteorological services are working increasingly with the health sector. For example, the Global Framework for Climate Services of the World Meteorological Organization is improving access to and use of information on climate in climate-vulnerable developing countries, with health as one of the priorities. The aim is to address the current gap between health service and climate service providers. The former often lack access to, understanding of and capacity to interpret and apply information on climate, and climate service providers often do not fully recognize the health impacts of climate change and the role they could play in ensuring more climate-resilient health systems *(79)*. Interoperatibility between health and climate information systems will ensure better understanding of the sensitivity of health to climate factors, so that limited resources can be better targeted geographically and temporally. For example, programmes for disease control could make use of maps of the suitability of climate for transmission of infectious disease in order to time interventions so that they have the greatest effect in the seasonal transmission cycle of an infectious disease. In some cases, early warning systems of climate events could be established, so that health facilities could prepare for extreme weather events such as storms, heatwaves and flooding and more broadly anticipate outbreaks of climate-sensitive diseases. For example, the relations among rainfall, temperature and malaria transmission have been used to establish early warning systems that give up to 4 months' advance notice of potential outbreaks so that preventive and curative interventions can be prepared *(80)*. Such systems not only help to save lives but also improve resilience to the increasing, more variable risks of transmission due to climate change.

4.3 Health service delivery: green, climate-resilient health care facilities

Health care facilities are the operational heart of service delivery, protecting health and treating patients, including during and after weather and climate events (such as heat stroke during heatwaves and injuries during cyclones) and in response to other environmental risks of health (such as asthma due to poor air quality). Health care facilities in poor and rich countries alike must be able to increase the quality, range and population coverage of their services and ensure that they are resilient to changing climate conditions, such as extreme weather events. A large proportion of health care facilities in LMICs lack access to reliable energy supplies. For example, one in four health facilities in sub-Saharan Africa lacks access to electricity, and many more have intermittent, unreliable supplies *(81)*. Along with the provision of water, sanitation, hygiene and other basic environmental services, reliable, modern energy supplies represent "no-regrets" options for improving health now and increasing resilience in the future *(5, 82, 83)*.

At the same time, health care contributes significantly to global GHG emissions, particularly in HICs, where it contributes 3–8% of national emissions. A low-carbon development path for health systems and ultimately a transition to net-zero emissions is essential for health care facilities to meet the goal of the Paris Agreement of maintaining global warming below 2.0 °C or 1.5 °C.

Increasing climate resilience and mitigating carbon emissions in health care facilities can be complementary rather than competing objectives (84). Renewable energy supplies, particularly in remote areas, increase the resilience of health facilities to climate change, including extreme weather events and slower changes, promote adaptation and ensure access to water and electricity. Furthermore, low-carbon health facilities are more cost-effective to run, more productive and improve access to health care, especially in energy-poor settings; broader health benefits result from reduced environmental pollution.

While the "greening" of health facilities differs in HICs and LMICs, any low-carbon health sector should adhere to certain broad principles. These include the use of appropriate low-carbon technology for care; low-carbon building design and construction; investment in renewable energy and energy efficiency; sustainable waste, water and transport management; use of telemedicine; minimizing use of high GHG-emitting anaesthetic gases; procurement policies for low-carbon supply chains; promoting sustainable, healthy diets; and resilient strategies for withstanding extreme weather events *(24)*.

There is growing experience in both HICs and LMICs. For example, the National Health Service in England has reduced its GHG emissions by 18.5% since 2007 (85). It has also invested in new means for promoting sustainable development, through a network of "ambassadors" for sustainable health and care, who demonstrate the benefits of approaches centred on health, well-being and social value. Savings exceeding £ 90 million a year have been made by reducing the costs of energy, water and waste management. Furthermore, health and care treatment costs were decreased by £ 13 million in 2017 by reducing the impact of travel on health *(86)*.

The movement is being integrated into many health systems. For example, in 2017, at the Sixth Ministerial Conference on Environment and Health, the Member States in the WHO European Region committed themselves to prepare national portfolios of actions on environment and health by the end of 2018, including climate change and health. The objective is to make health systems environmentally sustainable and to reduce their environmental impact by increasing the efficient use of energy and resources, sound management of medical products and chemicals throughout their life cycle and reducing pollution by safe management of waste and wastewater, without prejudice to the primary mission of health systems: to promote, restore or maintain health.

The health sectors of other countries are working with Health Care Without Harm to achieve climate-smart health care by reducing GHG emissions, preparing for extreme events, shifting the burden of disease, educating staff and the public about health

and climate change and implementing policies to protect the public against the health impacts of climate (87). The work has been conducted mainly in HICs but increasingly in LMICs: hospitals and health systems in countries such as Brazil, Chile, China, Colombia, Costa Rica, India, Morocco, the Philippines, the Republic of Korea and South Africa are using low-carbon strategies. Overall, more than 180 institutions representing the interests of over 17,000 hospitals and health centers in 26 countries to the principles of climate-smart health care. To date, those that have reported have committed themselves to reduce their emissions by more than 16 million tonnes of CO_2 equivalents, equivalent to the annual emissions from four coal-fired power plants, which is estimated to correspond to US$ 1.7 billion in health costs related to air pollution. Participants also reported that they had saved US$ 381 million through energy efficiency and renewable energy generation.

A number of national institutions and development partners are increasing investment in the provision of renewable energy for health care facilities. For example, the United Nations Development Programme launched its "Solar for health" initiative to support governments in LMICs in installing solar photovoltaic cells in health facilities, to provide reliable electricity and increase access to good-quality health services. The scheme has numerous benefits, notably ensuring reliable, cost-effective electricity, mitigating climate change and advancing achievement of SDGs 3 (good health and well-being), 5 (gender equality), 7 (affordable, clean energy), 13 (climate action) and 17 (partnerships for meeting the goals). The scheme allows for flexible approaches suitable for each health facility and the nature of the care they provide. The scheme has important benefits, including the provision of high-quality health services, climate-resilient health systems, reduced GHG emissions and cheaper energy. It has been estimated that, within 2–3.5 years, health facilities will see a 100% return on their investment in solar photovoltaic cells, which could be reinvested in other health sector priorities (81).

Box 6 describes the "smart hospitals" initiative of the WHO Regional Office for the Americas.

Box 6

Safe and green = "Smart" hospitals

The Caribbean is prone to natural hazards, including climate-related disasters such as hurricanes and impacts such as sea-level rise (88). Furthermore, 67% of health facilities in Member States are in areas at risk of disasters *(89)*; 82% of the hospitals assessed required short-term measures to reduce losses, and 18% required urgent measures to protect the lives of patients and staff (88). This situation has significant consequences for health, as up to 200 000 people would be left without access to health care if a hospital became inoperative after a natural disaster. It is estimated that, over the past 10 years, over 24 million people in the Americas were left without access to health care for months or years because of damage during disasters *(89)*.

Within the "smart hospitals" initiative of the WHO Regional Office for the Americas, countries throughout the Caribbean region have "greened" and strengthened the resilience of their health care facilities, building on the concept of climate-smart health care. The scheme helps health facilities in the Region to improve their resilience to natural disasters, adapt to climate change, decrease their carbon footprint and improve their environmental sustainability. It is based on the premise that safe, "green" health facilities are smart health facilities.

The initiative has already found success. For example, during Hurricane Irma in September 2017, the British Virgin Islands were some of many severely affected Caribbean islands. The Adina Donovan Home for the elderly in the British Virgin Islands was particularly badly damaged, including losing its roof, resulting in water damage and the loss of electricity fixtures. When the facility was rebuilt, the Smart Hospitals Toolkit was used to make the new facility safe and "green", with support from the WHO Regional Office, the Department for International Development in the United Kingdom and the Canadian Government. The new facility has a stronger roof that can withstand hurricane-strength winds, improving the resilience of the facility to extreme weather events and adapting it to climate change. Efficient light and air-conditioning units, solar photovoltaic cells and low-flow taps and toilets were installed to reduce the costs of energy and water and also to reduce the carbon footprint of the facility. It is estimated that the solar photovoltaic cells alone offset 20–30% of the facility's energy use, and the other efficiency measures have also reduced costs significantly *(90)*. The project is just one example of how climate-smart health care can provide numerous short- and long-term health, economic, social and environmental benefits.

4.4 Limits to health system adaptation

The health sector should play a central role in health adaptation to climate change; however, adaptation of the health sector alone will have a limited impact, partly because the environmental determinants of health are complex and are largely outside the direct influence of the health community. For example, human health is ultimately dependent on stable, biodiverse ecosystems and the goods and services that they provide, from the provision of clean water, to adequate, nutritious food, to protection from extreme weather events, to a significant proportion of medical treatments. Many of the threats to human health and well-being could be addressed with nature-based, often low-cost approaches, with numerous common benefits *(91–93)*. For example, increased extreme precipitation in many parts of the world places populations at risk of flooding and the associated health risks. Natural flood management can help to reduce flooding in populated areas. This includes restoring upland river valleys to their natural habitat (as opposed to clearing land for agriculture), absorbing rainwater and helping to slow excess run-off from greater numbers of trees and larger wetland or peatland areas. Trials of natural flood management have been highly successful, and its use is increasing, with the additional benefit of climate mitigation, by restoring wetland, peatland and forests, all of which absorb CO_2 and act as carbon sinks. Similarly, there is a growing body of evidence that preserving access to green spaces, particularly in urban areas, can have health benefits, from increased physical activity to better mental health and reduction of the "urban heat island" effect during heatwaves *(94, 95)*. The health sector cannot directly implement such policies but can assess and advocate for such interventions as part of a holistic approach to sustainable development.

In view of the widespread, systemic nature of the effects of climate change, even the most aggressive, well-planned, well-implemented adaptation measures will not in themselves obviate all the damage to health due to climate change. Health adaptation is limited, particularly under scenarios of a temperature rise above 2 °C *(17)*. For example, the human body has a physiological limit to the temperature it can bear; sustained exposure to a "wet-bulb" temperature > 35 °C will raise the core body temperature to a fatal level *(96)*. Already, approximately 30% of the world's population is exposed to catastrophic heat events every year (which are particularly dangerous for vulnerable populations such as the elderly), yet the number of such events is predicted to increase by as much as 74% this century if emissions remain high *(97, 98)*.

Early, strong mitigation of climate change, including alignment of health sector development with the goals of the Paris Agreement, should be a high priority. Mitigation is fundamental to protecting human health, ensuring the success of health adaptation programmes and avoiding health effects when adaptation is limited. Box 7 outlines the residual impacts of climate change that cannot be avoided by adaptation and mitigation.

Box 7

Loss and damage

"Loss and damage" are the residual impacts of climate change that cannot be prevented or avoided by adaptation and mitigation. Losses are generally associated with slow-onset events, including sea-level rise, Arctic ice melt, desertification, salination, ocean acidification, biodiversity loss, glacial retreat, changing ocean circulation and more frequent extreme weather events (including floods, droughts, heat waves, storms and storm surges) *(99, 100)*. In the context of health, loss and damage are not economic; while health impacts do not have a direct fiscal value per se, loss and damage have important implications for human health and place greater burdens on health systems. Failure to capture these non-economic elements of loss and damage means that the poorest populations (with fewer tangible assets) risk losing more as a result of climate change, thus exacerbating inequity both within and between countries. The importance of loss and damage has long been recognized within the COP process, with the Warsaw International Mechanism established in 2013 (COP19) to address the loss and damage issue. The Paris Agreement also distinguishes loss and damage from adaptation, providing a means to account for them effectively *(3)*.

5. MOBILIZING THE HEALTH COMMUNITY FOR CLIMATE ACTION

Effectively tackling climate change and maximizing benefits for health require broad public support, and both the health community and civil society can play a role. Opinion polls around the world show that the health profession is among the most trusted in society, viewed as having no direct vested interest in policy decisions related to climate change other than their commitment to protect and improve human health and well-being. Health professionals are in direct contact with patients and directly witness and respond to the health effects of environmental and air pollution and climate change. In the same way that the health profession raised public awareness about the health effects of smoking, they could engage the broader health community, civil society and the public in addressing climate change.

During the past decade, climate change has moved from being considered a relatively minor, siloed issue to the centre of public health work. For instance, the number of scientific papers on health and climate change tripled during the past 10 years, and the number of nongovernmental organizations and United Nations initiatives is increasing *(13)*. The WHO Director-General has identified "the health impacts of climate and environmental change" as a priority for the World Health Assembly and WHO's work. Recognizing the importance of building a broad health coalition, WHO has convened partners to form an open civil society working group to advance action on climate change and health. Its aim is to engage and consult with relevant national, regional and global constituencies and to advise the Organization on mobilizing civil society to strengthen national and international commitments to addressing climate change, with an increased focus on health.

Important actions that health professionals, institutions, organizations and the health sector have taken to address these challenges include improving education on health and climate change, political engagement and fossil fuel divestment. Health professionals are increasingly interacting with politicians and policy-makers to ensure adoption of policies to improve the health of their constituents and mitigate climate change (see Annex 1). For example, the Canadian Association of Physicians for the Environment and the Pembina Institute led an effective campaign that resulted in commitments to phase out use of coal by 2030, first in Alberta and then across Canada (101). After this campaign, at COP 23 in Bonn, Germany, in 2017, the governments of Canada and the United Kingdom launched the Powering Past Coal Alliance, in which over 20 countries have committed themselves to phasing out coal *(47)*.

5.1. Bringing health NGOs together to support the Paris Agreement

The Global Climate and Health Alliance brings together health and development organizations around the world that are working to minimize the health impacts of climate change and maximize the benefits to health of mitigating climate change, through leadership, research, policy, advocacy and engagement. Their activities include coordinating summit meetings on climate and health at major climate change events. The annual Global Climate and Health Summits at UNFCCC COPs, held since 2011, attract 200–400 policy-makers, negotiators, local health professionals, nongovernmental organizations and journalists and have proven to be valuable opportunities to strengthen collaboration with local and regional actors to form an international movement for health and sustainable development by engagement to address climate change. The summits have helped to raise global awareness of the health implications of climate change and to ensure a focus on health in the UNFCCC process. Before the meeting of the UNFCCC in Paris, the Alliance gathered declarations from 1700 health systems and 13 million health professionals in support of a strong Paris Agreement.

Box 8 describes a call to action made recently by health organizations.

Box 8

Call to action on climate change and health

A call to action was announced by leading health organizations in September 2018. The groups represented over five million doctors, nurses and public health professionals and 17 000 hospitals in 120 HICs and LMICs. The call to action had two main objectives: "climate action for health" to reduce GHG emissions, improve the health of populations around the world and ensure a path to sustainable development, and, secondly, "health action for climate", in recognition of the contribution of the health sector to climate change and its role in meeting the ambitions of the Paris Agreement and the SDGs (102), providing a framework for a range of campaigns for meeting specific aims.

Ten priorities were identified in the call to action:

1. Meet and strengthen the commitments under the Paris Agreement.
2. Transition from the use of coal, oil and natural gas to clean, safe, renewable energy.
3. Transition to zero-carbon transport systems and emphasize active transport.
4. Build local, healthy, sustainable food and agricultural systems.
5. Invest in policies to support a just transition for workers and communities adversely effected by a move to a low-carbon economy.
6. Ensure that gender equality is central to climate action.
7. Strengthen the voice of the health sector in the call for climate action.
8. Incorporate climate solutions into all health care and public health systems.
9. Build communities resilient to climate change.
10. Invest in climate and health.

The International Federation of Medical Students' Associations, which brings together medical students around the world, has campaigned on climate change and health for over a decade. The Federation serves as a link among civil society and youth constituencies, forming a "health cluster" of nongovernmental organizations that work closely with WHO, which helps to ensure that health issues are recognized and addressed in discussions on climate change and sustainable development. Formal education on the links between health and climate change is being established only slowly, and the Federation has a key role in capacity-building, training students and advocating for the inclusion of climate change in the curricula of medicine faculties around the world. A training manual on health and climate change is available. Work is under way to ensure that an element of the climate–health nexus is included in the curriculum of every medical school by 2020 and that climate–health is integrated into all aspects of medical education by 2025 *(103, 104)*.

5.2. Advocacy campaigns

The health community is increasingly linking health, air pollution and climate change in its advocacy and outreach work. Notably, the BreatheLife Campaign was launched by WHO, the United Nations Environment Programme and the Climate and Clean Air Coalition at Habitat III in October 2016, with the explicit aim of raising awareness about the effects of air pollution on health. The Campaign demonstrates the severity of the health effect and explains that reducing emissions of short-lived climate pollutants could not only mitigate climate change but also save millions of lives by improving air quality. BreatheLife promotes solutions in a wide range of sectors, so that governments can meet the WHO air quality guidelines. More than 50 cities, regions and national governments, representing 153 million citizens, have officially joined the BreatheLife network, with commitments to improve air quality *(63)*.

Health professionals, organizations and institutions are also increasingly demonstrating their commitment to climate action through their own investments. For example, an increasing number are joining the global movement to divest (i.e. remove financial investments from) companies the core business of which involves fossil fuels. The strategy has addressed mainly the 200 largest publicly listed coal, oil and gas companies. Health professionals previously led divestment from the tobacco industry; they are now making the case that profiting from the fossil fuel industry is a direct violation of their responsibility to protect and promote human health *(105)*. Organizations that are committed to divestment from fossil fuels are the World Medical Association and its national member associations, including the British Medical Association, the Canadian Medical Association and the American Medical Association, as well as medical colleges such the Royal Australasian College of Physicians and the Royal College of General Practitioners in the United Kingdom *(106–111)*. Other organizations of health professionals that are committed include the Society for the Psychological Study of Social Issues, the New Zealand Nurses Organisation and several hospitals and health services *(112)*. The Medical Assurance Society in New Zealand announced last year that neither of their savings plans would include investment in fossil fuels *(113)*. Almost 1000 organizations and institutions in various sectors are committed to fossil fuel divestment, for an approximate value of US$ 7 trillion *(112)*.

6. ENSURING ECONOMIC SUPPORT FOR HEALTH AND CLIMATE ACTION

Addressing climate change and health requires financial, institutional and human resources. Most of the financial costs, particularly of mitigation (for example, using cleaner energy technologies), are, however, borne locally and in the short term, while the benefits of reduced climate change and its impacts are dispersed globally, over decades or centuries. Failure to invest in climate change mitigation and adaptation is therefore "the greatest market failure that the world has seen" *(114)*. Better understanding of the health benefits of climate mitigation and adaptation can reverse this failure, encouraging investment in sustainable choices. Local accrual of health gains in the near term can generate political will for cleaner investments.

6.1 Health economics and climate change

Health can contribute significantly to the three economic drivers necessary to address climate change: (i) resource efficiency, including carbon pricing and reform of subsidies; (ii) investment in low-carbon, resilient infrastructure with existing technologies; and (iii) innovation in low-carbon technology *(115)*.

Exposure to air pollution causes as many as one in eight deaths worldwide, resulting in US$ 5.11 trillion in welfare losses globally, nearly doubling the losses in 1990 *(116)*. In the 15 countries that emit the most GHGs, the health impacts of air pollution are estimated to cost more than 4% of their GDP *(115)*.

It is increasingly recognized that both the costs to health of climate change and the benefits for health of action against climate change are substantial and should therefore be included in cost–benefit analyses and the design of economic policy instruments *(117)*. Full accounting for the value of health and other social gains that result from mitigation and adaptation demonstrates in many cases that it is in countries' best interests to invest in cleaner technologies and sustainable development *(118)*.

Governments can obtain more realistic estimates of the overall effects of climate change mitigation by accounting for the numbers of lives saved and improvements in health with better air quality. The extent to which the health benefits of mitigation would compensate for the cost of achieving the targets of the Paris Agreement has been estimated for various scenarios. In all scenarios, the health benefits of meeting climate goals substantially outweighed the costs of action. The benefits were particularly large in China and India, where they compensated the costs of mitigation entirely *(39)*.

Evidence on health impacts therefore contributes to the evidence that low-carbon, climate-resilient development results in more sustainable, equitable economies *(115)*. For example, it is estimated that creating more sustainable, healthy cities would reduce the capital required for urban infrastructure over the next 15 years by US$ 15 trillion. Furthermore, the low-carbon investment necessary to meet the targets of the Paris Agreement is estimated to be US$ 270 billion a year for the next 15 years, while continuing along a high-carbon pathway would cost an estimated US$ 90 trillion per year in infrastructure investment and maintenance.

6.2 Fiscal tools

While there are clear economic benefits to tackling climate change, a perception that those benefits will be generated only in the long-term might slow action. Additionally, although the gains of climate mitigation accrue to society as a whole (e.g. better health through reduced air pollution) and partly to the public sector (e.g. less demand for national health systems), most of the necessary investment will come from the private sector, which responds to fiscal incentives or regulation. The current economic system usually does not oblige polluting sectors to pay proportionally for the damage they cause to the environment, while low-carbon sectors are not appropriately rewarded. Therefore, fiscal incentives are required, as well as cost–benefit analysis to demonstrate the economic gains of investing in climate mitigation and adaptation to further encourage sectors to reduce their GHG emissions, and improve health. Two means of achieving this are carbon pricing and energy subsidy reform.

Photo: James Dowson/UN

6.2.1 Carbon pricing

Carbon pricing mechanisms are designed to capture the true cost of carbon, including external costs, which are often omitted. Health is the largest external cost, as the costs on health of both climate change and the polluting energy sources that cause climate change are borne by the public and not by the emitters.

Work at the International Monetary Fund has shown that, globally, the un-costed damage to health caused by air-polluting fuels accounts for approximately half of the negative externalities of fossil fuel use. Inclusion of health gains in estimates of the optimal, locally beneficial carbon price for each country should incentivize cleaner investment that would reduce deaths due to air pollution by 50%, reduce CO_2 emissions by approximately 20% and result in over US$ 3 trillion/year in revenues, which could be reinvested in socially beneficial objectives *(119, 120)*. Investment of the revenues in health has important social benefits and generally strong public support. For example, Chile introduced a number of such taxes and used the revenues to reduce the environmental and health impacts of burning fossil fuels *(121)*.

It has been estimated that, in order to meet the goals of the Paris Agreement, carbon would have to be priced at US$ 40–80/tonne of CO_2 equivalent by 2020 and US$ 50–100/tonne of CO_2 equivalent by 2030 *(122)*. Health should therefore be an important component of the economic and political rationale for carbon pricing and a major beneficiary of its implementation.

Presently, 24 carbon tax systems operate globally, all of which are national schemes *(123)*. An important consideration in applying carbon taxation is making such schemes non-regressive, in order to ensure that low-income groups are not disproportionately affected by their implementation, thus exacerbating existing inequity. It is also important to establish mechanisms to ensure that companies do not leave areas with a carbon price to establish themselves in countries that do not have such schemes ("pollution havens"). This is also an important consideration with regard to air pollution policies, as companies might relocate to areas with less stringent air quality regulations and hence continue to expose populations to air pollution.

Carbon can also be priced through emissions trading schemes, which reduce GHG emissions by capping the total. Sectors can reduce their GHG emissions to a desired level and either sell their extra GHG allowances or purchase additional allowances to enable them to emit more than their allocation, while keeping within the total emissions cap. This creates a market for GHG emission allowances, thus establishing a price for carbon based on supply and demand.

Currently, 24 regional, national and subnational emissions trading schemes have been established globally, representing 9.9% of global GHG emissions in 36 countries *(123)*. The largest scheme is that established in the European Union, which covers approximately 45% of its GHG emissions, with the aim of reducing emissions in this area by 43% as compared with 2005 levels by 2030 *(124)*. Since the 2008 economic recession, however, the price of allocated permits fell to a level that was no longer an incentive to reduce emissions (125). If such lessons are learnt, the expanding coverage of emissions trading schemes globally is positive. Importantly, China plans to introduce an emissions trading system in 2019.

6.2.2 Subsidy reform

The burning of fossil fuels has severe consequences for human health, due to both climate-related risks and air pollution. Yet, fossil fuels are still heavily subsidized, which artificially lowers their cost and promotes overconsumption *(13)*. If only direct financial subsidies are considered (i.e. omitting the much higher estimates of the un-costed externalities of health and other environmental costs of fossil fuel use), global fossil fuel subsidies comprise US$ 600 billion annually, while subsidies for clean energy represent only US$ 100 billion annually (115). Furthermore, these subsidies divert funding that could be used for the public benefit, such as health spending. Some fossil fuel subsidies may benefit health. For example, lowering the prices of clean-burning liquid petroleum gas for household use can reduce consumption of highly polluting solid fuels and therefore exposure to indoor air pollution. There is still scope for reform, however, as most of the benefits accrue to richer rather than poorer populations, and care must be taken to ensure that they facilitate rather than slow the long transition to renewable fuels. As currently implemented, fossil fuel subsidies hinder sustainable development, by using up government budgets and resources that could be better used elsewhere; reducing industrial competition, especially for low-carbon businesses by discouraging investment in renewable energy and energy efficiency; increasing the risk of "stranded assets" if fossil fuels are regulated by encouraging exploration for and production of unusable fossil fuels; putting energy security at risk; exposing the public to air pollution; and negating carbon price signals *(126)*.

Reform of fossil fuel subsidies is recognized as an integral part of achieving the SDGs and meeting the goals of the Paris Agreement. Although such reforms are often opposed by both energy providers and consumers, well-designed, carefully planned policies, with full risk assessments can be successful, particularly when the savings are reinvested in visible, socially beneficial goals such as health and education (127). By 2014, nearly 30 countries had successfully reformed their policies on fossil fuel subsidies (126). For such reforms to have the greatest benefit for health and ensure public support, the resources saved by reducing perverse incentives should be directed to health programmes, such as increasing the resilience of the health sector to climate change and reducing air pollution.

6.3 Scaling-up financial investment in health adaptation to climate change

Investment in health adaptation must be increased, particularly in the LMICs that are most vulnerable to climate impacts. Parties to the UNFCCC are committed to mobilizing US$ 100 billion a year for adaptation and to promoting low-carbon development in LMICs by 2020. Current estimates suggest that public funding from developed countries in 2020 will be US$ 67 billion, although the US$ 100 billion target could be met when all sources of funding are accounted for *(128, 129)*. Funding to LMICs must be significantly increased to avoid the worst health impacts of climate change and to maximize the benefits to health of action on climate change. Better understanding of the full extent of financing required for both adaptation and mitigation will be essential, with estimates of the costs of action and inaction in order to find cost–effective solutions. Such costs may be complex, uncertain and non-linear. For example, the cost associated with the increasing severity of droughts in China under the scenario of 2 °C global warming is expected to be 10 times greater than that for a 1.5 °C rise *(130)*.

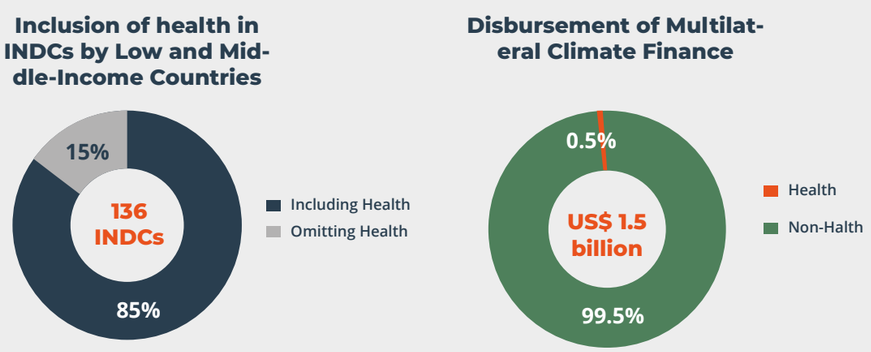
The effects on health differ spatially and temporally; therefore, tailored cost–benefit analysis is required. Tools are available *(131)* that governments can use to estimate the cost of climate-related health adaptation in a cost–benefit analysis framework. These provide mechanisms to assess the cost in damage to health of inaction and the cost of actions to minimize or prevent climate-related health effects. They also summarize indicators of the economic performance of different adaptation measures within and outside the health sector, so that the economic costs and benefits of adaptation can be evaluated.

The evidence on the health impacts of climate change and the benefits of "no-regrets" adaptation measures for climate-resilient health systems is at least as strong for health as for other climate-sensitive sectors, such as agriculture and coastal zone management. Investment in adaptation in health-determining sectors such as water, sanitation and disaster risk reduction will be important to protect health.

Financial support for health adaptation to climate change in LMICs remains, however, alarmingly low. A survey of the main multilateral funds that support climate adaptation indicated that only about US$ 9 million (0.5%) of over US$ 1.5 billion of dispersed funding has been allocated to projects that specifically address health (Fig. 6), despite strong demands for support from the health ministers of the most vulnerable countries *(132, 133)*. The principal constraint appears to be that no health agencies are accredited to these funds.

Figure 4

Numbers of low- and middle-income countries that (a) included health in their intended nationally determined contributions to the Paris Agreement and (b) disbursement of funds for projects by the Global Environmental Facility, the Adaptation Fund, the Pilot Programme for Climate and Resilience, the MDG Achievement Fund and the Green Climate Fund



7. TRACKING PROGRESS AND IMPACT ON HEALTH

Continued, effective progress in protecting health from climate change requires coordination among the many stakeholders acting at various levels. Their priorities, decisions and assessment of progress must, however, be based on reliable, relevant data.

In 2015, three major international agreements with implications for climate change and health were signed: the 2030 Sustainable Development Agenda, the Paris Agreement and the Sendai Framework for Disaster Risk Reduction. Although the three agreements have different objectives, each includes monitoring of targets relevant to health and climate change. The SDGs provide an overarching aspiration for all sectors to work towards a secure, healthy, sustainable future for everyone in all areas of the world. SDG 13 tracks progress in taking urgent action on climate change. This includes the mobilization of funds to accelerate adaptation and mitigation efforts, particularly in developing countries most vulnerable to climate change. The SDGs also provide a framework for monitoring advances in health and determinants of health for building resilience to climate change, including SDG 3 (Good health and well-being), SDG 6 (Clean water and sanitation), SDG 7 (Affordable and clean energy) and SDG 11 (Sustainable cities and communities).

National reporting to the UNFCCC on implementation of the Paris Agreement and NDCs commitments are further opportunities for countries to link climate change with health. Countries can identify potential impacts on health and also report on health adaptation and mitigation measures and the potential benefits for health of mitigation within their work on global climate change while protecting their populations. A review of intended NDCs indicated that 65% of low-income countries but less than 10% of HICs mentioned health adaptation. Health considerations with respect to mitigation were mentioned far less frequently, with references in less than 20% of intended NDCs from low-income countries and only 5% of those of HICs.

The global community, recognizing the connections among sustainability, climate change, disaster preparedness and health, is calling for coordinated approaches to monitoring to complement global mechanisms such as the SDGs, the operational mechanisms of the UNFCCC, the Sendai Framework and other relevant frameworks, including the WHO International Health Regulations (2005) (134). The advantages of building on synergy among global monitoring initiatives include more efficient data collection and reporting at national and regional levels, better data quality and consistency because of more focused work and resources and more opportunity and facility for national monitoring processes to align with a set of global indicators.

In addition to these global frameworks, national, regional and global monitoring of indicators of health and climate change is needed, aligned with international mechanisms but providing a more focused evaluation of health vulnerability related to climate change, impacts, adaptive capacity, resource constraints to developing effective interventions and evaluation of progress in achieving climate-resilient health systems to protect and promote the health of their populations, including the most vulnerable.

The Lancet Countdown on Health and Climate Change is an annual global monitoring report on health and climate indicators in five domains: impacts of climate change, exposure and vulnerability; planning of adaptation and resilience for health; mitigation and health benefits; finance and economics; and public and political engagement. Contributions are made to the report by academia and international institutions in contact with policy-makers, stakeholders and the wider public. The first report was published in 2017, and others will be published every year until 2030. By reporting annually on its indicators, the Countdown not only provides regular updates on global progress in health and climate change but, over time, will provide trends in each of the indicators. For instance, the reports show that the number of additional people exposed to heatwaves since 2000 increased markedly between 2017 and 2018, from 125 million to 157 million in 1 year. Collation of these data and annual updates in all sectors are vital to understanding the challenges of health and climate change. The multisectoral approach of The Lancet Countdown emphasizes the importance of involving all sectors, as health risks and benefits are ubiquitous. The Countdown has numerous areas of synergy with other global monitoring platforms, such as the SDGs and the main United Nations initiative for monitoring progress in health and climate change: the WHO UNFCCC Health and Climate Change Country Profile Project (Box 9, and Annex 2).

Box 9

WHO UNFCCC Health and Climate Change Country Profile Project

The WHO UNFCCC Health and Climate Change Country Profile Project forms the foundation of WHO's monitoring of national progress on health and climate change. Country profiles are prepared in collaboration with ministries of health and other partners such as ministries of the environment and national meteorological services. The aims of the project are to increase awareness of the links between health and climate change, promote strengthening of national evidence for decision-making and measure progress in building climate-resilient health systems. The country profiles also support ministers of health and other health stakeholders in raising awareness and advocating for health in national and global climate change processes, such as national planning and national reporting to the UNFCCC. Almost 50 country profiles have been published (135), which are revised regularly. Participation will be increased, with a target of 100 countries by the end of 2021. As the Project regularly updates the profiles and works with a growing number of ministries of health and other relevant bodies, it is ideally placed to monitor progress and engage with governments on health and climate issues. It would therefore be an appropriate formal framework for monitoring and evaluating progress in health and climate change within the UNFCCC process.

The WHO UNFCCC climate and health country profiles summarize evidence on climate hazards and potential health impacts and provide indicators of the response of the health sector to climate change with regard to leadership, governance, multisectoral collaboration, adaptation and mitigation, financing and engagement in global climate change processes. Data for the indicators are collected in the WHO Health and Climate Change Country Survey. In 2015, findings revealed that 75% (30 out of 40) of the participating countries had a national health and climate strategy or plan, indicating recognition of the importance of health adaptation. Only a handful of these were developed as the health component of their National Adaptation Plan (NAP) within the UNFCCC process, indicating an opportunity for further promotion and incorporation of health considerations in climate action. About two thirds of the countries had conducted a national assessment of the impacts of climate change and vulnerability to and adaptation for health, and less than half had implemented activities to increase the resilience of their health infrastructure to climate change. The findings of the 2018 survey will be published in 2019, with data from an increased number of country respondents and an extended set of indicators.

8. CONCLUSIONS

The drivers of climate change, principally fossil fuel combustion, result in a large burden of disease and make a major contribution to the seven million annual deaths due to outdoor and indoor air pollution.

Emissions that pollute the air and GHG emissions that cause climate change are often emitted by the same sectors: energy, households, transport and agriculture. Short-lived climate pollutants such as black carbon, methane and ozone are important drivers of both climate change and ill health.

Meeting the commitments of the Paris Agreement for mitigation would save millions of lives by the middle of the century.

More stringent mitigation policies would reduce air pollution further and thus offer better health benefits. Additional opportunities for synergy between health and reduced climate change can be found in the energy, food, transport and other sectors, particularly for stemming the rising burden of NCDs.

Economic valuation of health gains would tip the balance decisively in favour of more aggressive climate mitigation.

The most recent evidence indicates that the gains for health to be derived from scenarios that meet the Paris goal for reduced climate warming would more than cover the financial cost of mitigation at global level and would cover it several times over in countries such as China and India.

Climate change already has negative effects on health and is undermining the "right to health" cited in the Paris Agreement.

Climate change undermines the social and environmental determinants of health, including peoples' access to clean air, safe drinking-water, sufficient food and secure shelter. It already affects health, particularly in the poorest, most vulnerable communities, including SIDS and least developed countries, thus extending health inequity.

A wide range of proven strategies and interventions is available to protect health from climate change, but little support has been provided by either health or climate financing mechanisms.

The health impacts of climate change could be greatly reduced if there were investment in climate-resilient health systems and health facilities and in health-determining sectors such as water, sanitation, food systems and disaster risk reduction. At present, only 3% of health resources are invested in prevention, and only about 0.5% of multilateral climate finance has been attributed specifically to health projects.

Many of the actions necessary to reduce carbon emissions, improve health and increase resilience are subnational, particularly in cities.

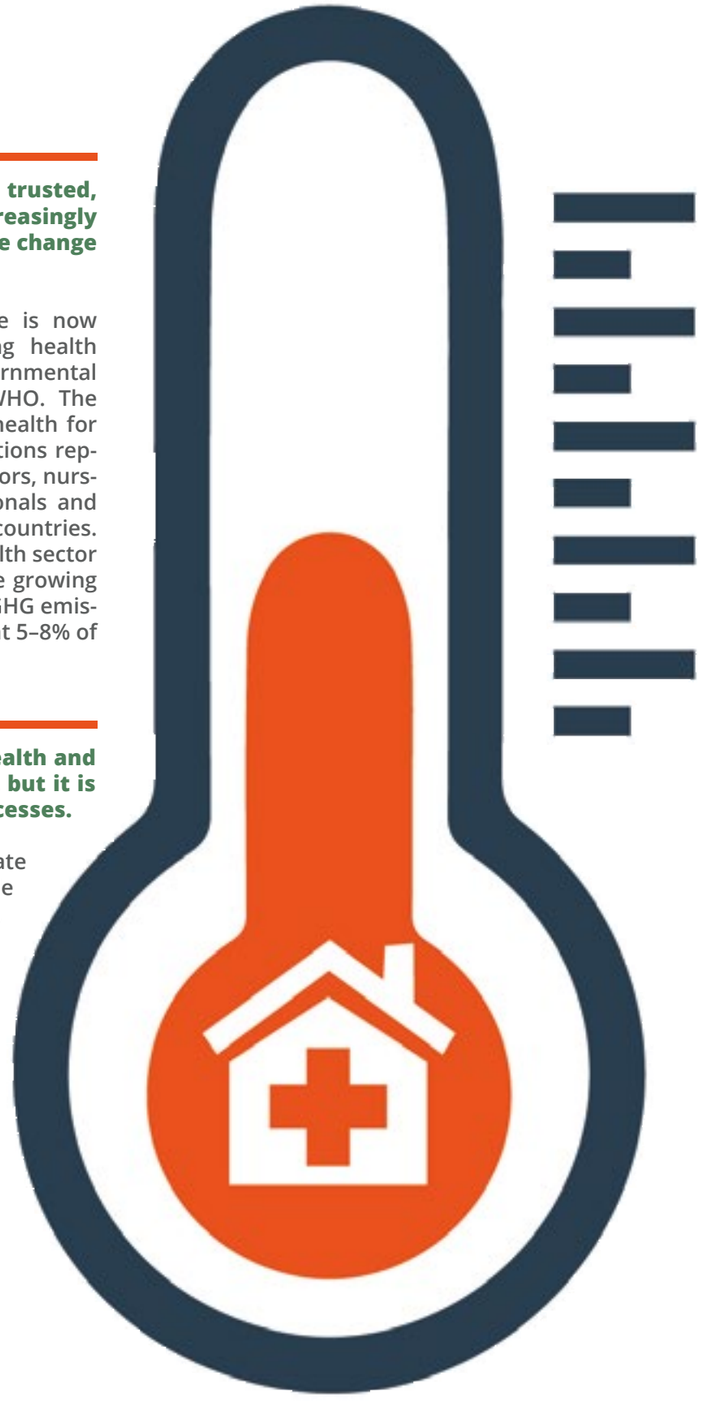
Local authorities are often wholly or partly responsible for services such as energy provision, transport, water, sanitation and health. Cities in particular are important foci for action against climate change and the protection of health.

The health community is trusted, globally connected and increasingly engaged in combating climate change and air pollution.

Action against climate change is now strongly supported by leading health professional bodies, nongovernmental organizations, journals and WHO. The call to action on climate and health for COP24 was issued by organizations representing over five million doctors, nurses and public health professionals and 17 000 hospitals in over 120 countries. Further mobilization of the health sector will be necessary to reduce the growing contribution of health care to GHG emissions, which currently represent 5–8% of the total in HICs.

Monitoring of progress on health and climate change is improving, but it is not well reflected in SDG processes.

The SDG indicators of climate change do not currently include health. The gap is, however, being filled by academic research, WHO and the UNFCCC Secretariat, in partnership with countries. These could form the basis for formal reporting to the UNFCCC and broader outreach to the public and contribute to monitoring of achievement of the SDGs.



9. RECOMMENDATIONS

Parties to the UNFCCC could advance the objectives for climate, health and development by taking up the recommendations listed below.

Identify and promote actions to reduce both carbon emissions and air pollution, with specific commitments to reduce emissions of short-lived climate pollutants in their NDCs.

Targeted action on short-lived climate pollutants would help to save over two million lives each year, and reduce the extent of global warming by 0.5 °C, by the middle of the century. Application within an integrated approach to climate mitigation, air quality management and health promotion would result in more gains and improve the efficiency of public policy.

Include the health implications of mitigation and adaptation measures in the design of economic and fiscal policies, including carbon pricing and the reform of fossil fuel subsidies.

Given the close association between "greener" investment and health outcomes, there is a clear public health case for effective, constructive reform of fossil fuel subsidies and of carbon pricing. In view of the high value that societies place on health, Parties could improve the design of and public support for fiscal measures by including valuation of the health implications and by reinvesting revenues in socially beneficial investments such as health.

Include the commitments to safeguard health in the rulebook for the Paris agreement, and systematically include health in NDCs, national adaptation plans and national communications to the UNFCCC.

The Paris Agreement cites the right to health, and Article 4.1 of the UNFCCC states that all Member States should employ appropriate methods, for example impact assessments, formulated and determined nationally, with a view to minimising adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change.
Compliance with this commitment would include integration of health considerations as a priority and as a measure of overall success in the Paris Agreement and systematic inclusion of health in NDCs, national adaptation plans and national communications to the UNFCCC .

Remove existing barriers to investment in health adaptation to climate change, especially for climate-resilient health systems and "climate-smart" health care facilities.

The current low level of investment in protecting health from risks associated with climate change could be increased by efficient collaboration among the health ministries requesting investment, technical agencies that could support them by formulating investment cases and investment partners, including bilateral and multilateral climate finance mechanisms and development banks. This could be facilitated if agencies with health expertise were accredited to the main multilateral climate funds.

Facilitate and promote the engagement of the health community as trusted, connected and committed advocates for climate action.

Such engagement would involve the growing, increasingly organized health community engaged on this issue, bringing together overlapping campaigns, notably on air pollution, climate-associated risks and NCDs. An effectively mobilized health community could play an instrumental role similar to that which it has played in combating tobacco use.

Mobilize city Mayors and other subnational leaders, as champions of intersectoral action to cut carbon emissions, increase resilience, and promote health.

Local governments, including those of cities, are increasingly promoting health and climate goals through policies for cleaner transport, energy, waste management and urban planning. Strengthening formal mechanisms for the engagement of city and other subnational governments in the UNFCCC process would increase the reach of actions to promote health and protect the climate.

Systematically track progress in health resulting from climate change mitigation and adaption, and report to the UNFCCC, global health governance processes and the monitoring system for the SDGs.

Systematic monitoring of actions and ambitions under the Paris Agreement is essential for continued progress. To ensure relevance and ownership by national decision-makers, monitoring should include direct engagement and formal reporting of the information in the WHO–UNFCCC Health and Climate Change Country Profiles to the UNFCCC.

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Annex 2. WHO UNFCCC Health and Climate Change Country Profile Project

Monitoring Health Impacts of Climate Change and Progress in Building Climate Resilient Health Systems

http://www.who.int/globalchange/resources/countries/en/

List of Published WHO UNFCCC Health and Climate Change Country Profiles

Countries

Algeria
Bangladesh
Bhutan
Botswana
Brazil
Brunei Darussalam
Cambodia
China
Colombia
Egypt
Ethiopia
Fiji
France
Germany
Ghana
Indonesia
Iran
Italy
Jamaica
Jordan
Kenya
Kiribati
Kuwait
Laos
Madagascar
Malaysia
Malawi
Maldives
Mexico
Morocco
Myanmar
Nepal
Nigeria
Oman
Pakistan
Peru
Philippines
South Africa
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COP24 special report: health and climate change
ISBN 978-92-4-151497-2

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Printed in Poland

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