World Health Organization
WHO KOBE CENTRE
Japan

HEAT WAVES, FLOODS AND THE HEALTH IMPACTS OF CLIMATE CHANGE

A Prototype Training Workshop for City Officials

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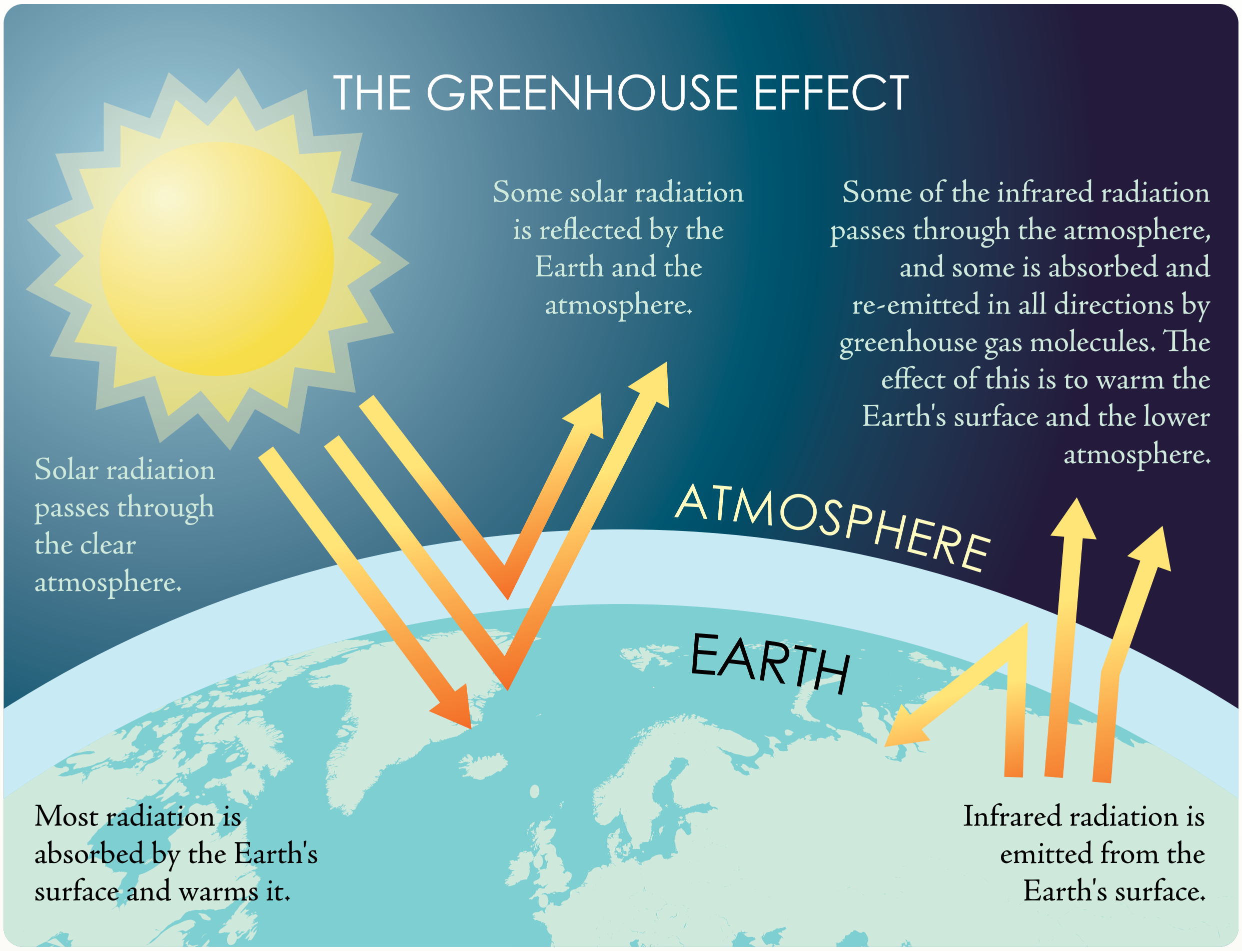
What is the greenhouse effect and why should I be able to explain it to others?



Adapted from: A.J. McMichael, D.H. Campbell-Lendrum, C.F. Corvalan, K.L. Ebi, A.K. Githeko, J.D. Scheraga, and A. Woodward (Editors). **Climate Change and Human Health: Risks and Responses** WHO/WMO/UNEP. 2003.

The greenhouse effect is critical to life on earth; without it, the Earth would be 33°C colder than present and the diurnal temperature range would increase dramatically.

Greenhouse gases include water vapour, carbon dioxide, methane, nitrous oxide, halocarbons, and ozone. These absorb solar radiation and re-emit it. The effect of this is to warm the Earth's surface and lower atmosphere. Human activity has increased many of these greenhouse gases, leading to unusual warming in the past 50 years.

Steps have to be taken at many levels – from individual to global – to cut down on greenhouse gas emissions, and to prepare adaptive measures in response to climate change.

How can I convince decision-makers that human activity contributes to climate change?

Decision-makers must be made aware of the evidence leading to the conclusion of the Intergovernmental Panel on Climate Change (IPCC): most of the warming observed over the past 50 years is attributable to human activities, and this effect is likely to continue over centuries.

Atmospheric concentrations of CO_2 have increased 31% in the last 250 years; methane by 151%; ozone by 35%. Current CO_2 concentrations are higher than they have been for 420 000 years (and possibly for 20 million years).

Greenhouse gases have long lifetimes in the atmosphere. CO_2 takes approximately 100 years to come to equilibrium once it is emitted. Thus, the Earth is committed to several decades of climate change after stabilization of greenhouse gas emissions is achieved, and the sea level will continue to rise for approximately 1000 years.

Models show that:

- Global mean surface temperature is projected to increase by 1.4 °C to 5.8 °C by the end of the century.
- Global precipitation will increase, with an increase in heavy rain events, and increased frequency and intensity of tropical and mid latitude storms. Global climate change may also influence the behaviour of El Niño.
- Warmer temperatures increase soil evapotransporation; so most areas will become drier during the dry season. Warmer air carries more moisture; so many areas will become wetter during the rainy season.
- Global mean sea level is projected to rise 0.09 to 0.88 meters from 1990 to 2100, because of thermal expansion of the oceans and melting of glaciers and ice caps.

GREENHOUSE GASES	HUMAN ACTIVITIES
Carbon dioxide	• Released from fossil fuel burning • Increased by land use change (deforestation)
Methane	• Released from cultivating rice, raising domestic ruminants (cows, sheep) • Released from disposing waste and sewage in landfills • Released from burning biomass • Leaked from gas pipelines

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How does climate change affect health?

The following tables provide a list of direct and indirect effects of climate change on health. These may help you in explaining to decision-makers the need to take steps to control the anthropogenic factors contributing to climate change, as well as to prepare adaptive strategies at the city level.

Direct effects on health

Heat waves	• Increased risk of death and serious illness principally in older age groups, those with pre-existing cardio-respiratory diseases, and the urban poor • Decrease in cold-related mortality (winter deaths) in many temperate countries
Extreme weather events (storms, floods, droughts, cyclones)	• Loss of life • Injury • Psychological distress • Greater frequency of infectious disease
Air pollution	• Change in transportation of airborne pollutants (pollen, fossil fuel pollutants) • Increased concentration of ground-level ozone • Increase in pollutants from forest and rangeland fires, thereby increasing outpatient visits for respiratory disease and eye symptoms

Indirect effects on health

Food production and supply	• Disruptions or local decreases in food supply lead to malnutrition, particularly in places with poor access to markets
Vector-borne infectious disease	• Altered range and seasonality of transmission of many vector-borne diseases (malaria, dengue, leishmaniasis, Lyme disease, tick-borne encephalitis)
Water-borne infectious disease	• Heavy rainfall events can transport microbiological agents into drinking water sources (causing cryptosporidiosis, giardiasis, salmonellosis, amoebiasis, typhoid, and other infections) • Decreasing amounts of water in a river or pond can increase the concentration of bacteria • Surface temperature anomalies in coastal and inland lake waters have been associated with cholera epidemics • Reduction in availability of clean water reduces supplies for personal hygiene, leading to skin infections • Changes in the marine environment may alter risks of bio-toxin poisoning from human consumption of fish and shellfish (ciguatera poisoning in higher altitudes, possibly increased occurrence of algal blooms)
Social and economic disruptions	• Displacement of island and coastal populations • Loss of shelter after extreme weather events • Damage to infrastructure for provision of health services • Increased demand for health services

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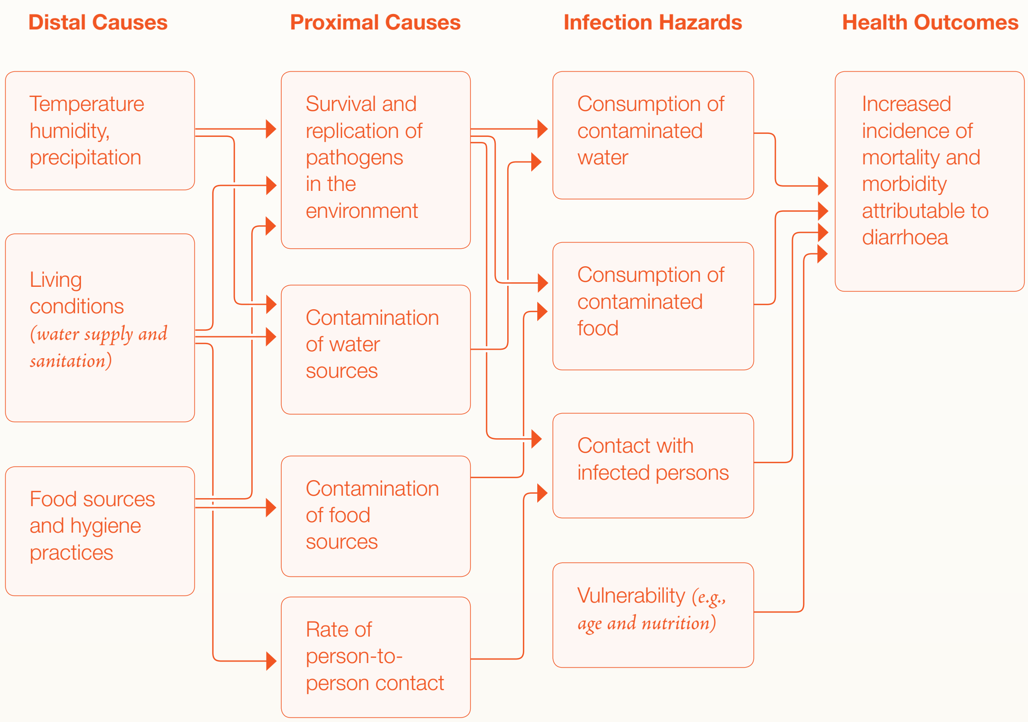
How does climate change interact with other drivers of health?

Climate change does not occur in a vacuum but instead may interact with other drivers of health that optimize or worsen the outcomes for certain groups. Many key factors influence the state of health of a community, including:

- Population growth
- Urbanization
- Public health funding
- Scientific developments
- Environmental conditions
- Number and distribution of populations at risk (the poor, children, elderly, the immuno-compromised, etc.)

However, weather and climate can indeed influence health outcomes.

For example, increasing urbanization in unplanned communities without access to safe water and sanitation, will increase diarrhoeal disease independent of any effect of temperature. However, temperature, humidity, and precipitation can affect the proximal causes of diarrhoeal disease, particularly the survival and replication of pathogens in the environment, and the contamination of water sources. The proximal causes then determine infectious disease hazards.



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How can I monitor the impact of climate change?

Detection and measurement of the health effects of climate change are needed to provide evidence on which to base national and international policies related to adaptation and mitigation measures.

The following principles may guide you in monitoring climate change:

- **Documenting evidence of climate change**, which requires collecting data to demonstrate that the climate has changed in the area being monitored;
- **Attributing changes in health outcomes to climatic change**, which requires separating its influence from other factors; and
- **Appropriately collecting and analysing health and climate data**, as well as data on potential modifiers of the relationship between climate and health, so that there is sufficient confidence that any observed change in health is the result of a climatic effect rather than an alteration in population susceptibility.

The public health community can contribute to monitoring the impacts of climate change in the following areas:

- Determining the climate sensitivity of diseases
- Measuring the public health burden of disease (e.g. Disability Adjusted Life Years)

Areas of study include:

- Direct effects of exposure to high temperatures
- Health impacts of extreme weather events
- Altered food productivity
- Increased frequency of food and waterborne disease
- Geographical change and altered transmission frequency of vector-borne disease (malaria, dengue, filariasis, African trypanosomiasis, leishmaniasis, schistosomiasis, Chagas' disease, tick-borne encephalitis, Lyme disease, Toscana virus)
- Aero-allergens, particularly pollen
- Changes in air pollution
- Rodent-borne diseases, including hantavirus and leptospirosis
- Harmful algal blooms and biotoxins
- Social, economic and demographic dislocations due to effects on economic infrastructure and resource supply

The choice of data to be collected varies with specific diseases, but data should also be gathered on confounding or modifying factors which include:

- Age structure of the population at risk
- Underlying causes of disease, especially cardiovascular and respiratory disease and diarrhoeal illness
- Level of socioeconomic development
- Environmental conditions, e.g. land use, air pollutant concentrations, housing quality
- Quality of health care
- Specific control measures, e.g. vector control programmes

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Vulnerability and adaptation: how are these defined?

The following table provides working definitions to help you operationalize a vulnerability and adaptation plan for your city:

Vulnerability	This is the degree to which individuals and systems are susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes. The vulnerability of human health to climate change is a function of: • Sensitivity, which includes the extent to which health, or the natural or social systems on which health outcomes depend, are sensitive to changes in weather and climate (the exposure–response relationship) and the characteristics of the population, such as the level of development and its demographic structure; • Exposure to the weather or climate-related hazard, including the character, magnitude and rate of climate variation; and • Adaptation measures and actions in place to reduce the burden of a specific adverse health outcome (the adaptation baseline), the effectiveness of which determines in part the exposure–response relationship.
Adaptation	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC). Adaptation includes the strategies, policies and measures undertaken now and in the future to reduce potential adverse health effects.
Adaptive capacity	The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC). This includes what could be implemented now to deal with current climate and climate variability (coping ability), and strategies, policies and measures that can expand future coping ability. It is determined by economic wealth, technology, information and skills, infrastructure, institutions, equity, the current health status and pre-existing disease burdens.
Adaptation strategies, policies and measures	Specific actions or strategies taken in response to climate change. These include: • Rebuilding public health infrastructure – considered by the IPCC as “the most important, cost-effective and urgently needed” adaptation strategy • Public health training programmes • More effective surveillance and emergency response systems • Sustainable prevention and control programmes

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What are the steps in assessing vulnerability and adaptation?

Here are seven steps to guide you in undertaking systematic assessments of the potential human health impacts of climate variability and change. These actions are needed to inform the development of adaptation strategies, policies, and measures to lessen projected adverse impacts. Guidelines need to be developed for country-level assessments to help policy-makers make evidence-based decisions on risk management programmes to increase resilience to current and future climates.

1. Determine the scope of the assessment
2. Describe the current distribution and burden of climate-sensitive diseases; describe the association between climate and disease outcomes
3. Identify and describe current strategies, policies, and measures to reduce the burden of climate-sensitive diseases (adaptation baseline)
4. Review the health implications of the potential impacts of climate variability and change on other sectors
5. Estimate future potential health impacts using scenarios of future climate change
6. Synthesize the results and draft a report
7. Identify additional adaptation measures to reduce potential negative health impacts

Key issues for ensuring that an assessment is informative, timely, and useful include **stakeholder involvement**, an **adequate management structure**, and a **communication strategy**.

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What is the global focus for action in response to the health threats posed by climate change?

Raising awareness

A better understanding of the risks and effects of climate change on health will motivate and facilitate both behavioural change and societal support for actions taken to reduce greenhouse gas emissions.

Improved awareness will help health-sector professionals to provide leadership in supporting rapid and comprehensive strategies for mitigation and adaptation that will both improve health and reduce vulnerability.

Engaging in partnerships

Partnerships at all levels - national, regional and international, requires the public health sector to play a stewardship role in fostering policy coherence across sectors, and to influence policies and actions that can benefit health.

Health representatives need to ensure that health concerns are adequately integrated into national committees, National Adaptation Programmes of Action and regional and international adaptation and mitigation strategies.

Promoting and supporting the generation of scientific evidence

There are some important gaps in our knowledge, in particular about the current and potential future impacts of climate-related risks, the degree of population vulnerability, characteristics of vulnerable groups, the type of surveillance and alert and emergency management systems, the most useful indicators for monitoring and evaluation of the criteria for action, as well as the comparative effectiveness of different adaptation and mitigation policies for health promotion and protection.

Strengthening health systems

Health-system action to protect populations from the impacts of climate change will need to encompass public health interventions within the formal health sector, and actions to improve the environmental and social determinants of health. A common theme must be ensuring equity and giving priority to protecting the health security of vulnerable groups.

There is a particular need to strengthen coordinated preparedness and response in acute emergencies and other crises that may be exacerbated by climate variability and change.

For more information, see **WHA 62.11 Climate change and health**: Report by the Secretariat to the Sixty-second World Health Assembly, 6 March 2009.

Does climate change pose a greater health risk to some populations more than others?

All populations are vulnerable – but some are more vulnerable than others.

- **Populations in small island developing states and other low-lying regions** are in the front line. They are vulnerable to death and injury, and destruction of their public health infrastructure from increasingly severe tropical storms. They are also vulnerable to salinization of water resources and agricultural land.
- **Urban populations**, particularly those of tropical megacities, are exposed to a combination of health risks such as heatwaves, floods, infectious diseases and pollution.
- **Mountainous populations** are at increased risk of water insecurity, floods, landslides and infectious disease.
- The health of **indigenous people in polar regions** may be particularly affected by changes in temperature, food sources and livelihoods.
- Health effects are expected to be more severe for **elderly people and people with infirmities or pre-existing medical conditions.**
- The major diseases that are most sensitive to climate change – diarrhoea, vector-borne diseases like malaria, and infections associated with undernutrition – are most serious in **children living in poverty**. Children have heightened vulnerability to health risks from climate change: both because they suffer disproportionately from climate-sensitive disease and because they will be exposed longer to the accumulating damage that climate change is inflicting on the natural environment.
- **Women in developing countries** are particularly vulnerable to death and illness following natural disasters. In the 1991 cyclone disasters that killed 140 000 people in Bangladesh, death rates among women were almost four times greater than those among men. Natural disasters can also result in increased suffering from domestic violence and post-traumatic stress disorders in women.
- The burden of climate-sensitive diseases is greatest for the **poorest populations**. Individuals without adequate shelter or access to health and other critical services are more vulnerable to a range of risks related to weather and climate, from flooding to infectious diseases.

The risks of climate change call for more equitable access to public health services. The health of the poorest and most disadvantaged people is particularly threatened by climate-sensitive diseases, and by climate change. Greater emphasis will need to be placed on protecting the health of particularly vulnerable groups, in order to ensure that this emerging risk does not further widen the gaps in health outcomes between the most and the least privileged.

Reference: World Health Day 2008: Protecting Health from Climate Change. Geneva: WHO. 2009.

What are climate models and how reliable are they in predicting future climate change?

Climate models are mathematical representations of the climate system, expressed as computer codes and run on powerful computers. Several decades of model development have consistently provided a robust and unambiguous picture of significant climate warming in response to increasing greenhouse gases.

There is considerable confidence that climate models provide credible quantitative estimates of future climate change because:

- The fundamentals of these models are based on established **physical laws**, such as conservation of mass, energy and momentum, along with a wealth of observations.
- Models are able to simulate important aspects of the **current climate**. Models are routinely and extensively assessed by comparing their simulations with observations of the atmosphere, ocean, cryosphere and land surface.
- Models can reproduce features of **past climates** and climate changes. Models have been used to show the global temperature trend over the past century. They have also been used to simulate ancient climates from thousands of years ago.

The models' ability to represent current and past climate features increases our confidence that they represent the essential physical processes important for the simulation of **future** climate change.

Nevertheless, models still show significant errors. For example, models are limited in their representation of clouds, which leads to uncertainties in the magnitude, timing, and regional details, of predicted climate change.

Despite these limitations, global models continue to develop, and their ability to simulate climate changes continues to improve. There are internationally coordinated efforts to collect and disseminate output from model experiments. Climate models are being subjected to more comprehensive tests. As a result, there is an increase in overall confidence in the models' representation of important climate processes such as patterns of precipitation, mean sea level pressure, surface air temperature, extreme hot and cold spells, and frequency and distribution of tropical cyclones.

For more information, see **Climate Change 2007: The Physical Science Basis**. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Randall, D.A., R.A. Wood, S. Bony, et al., 2007: [Solomon, S., D. Qin, M. Manning, et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.