Literature review on "The Impact of Climate Change on Public Health".

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The effect of climate change on Public Health

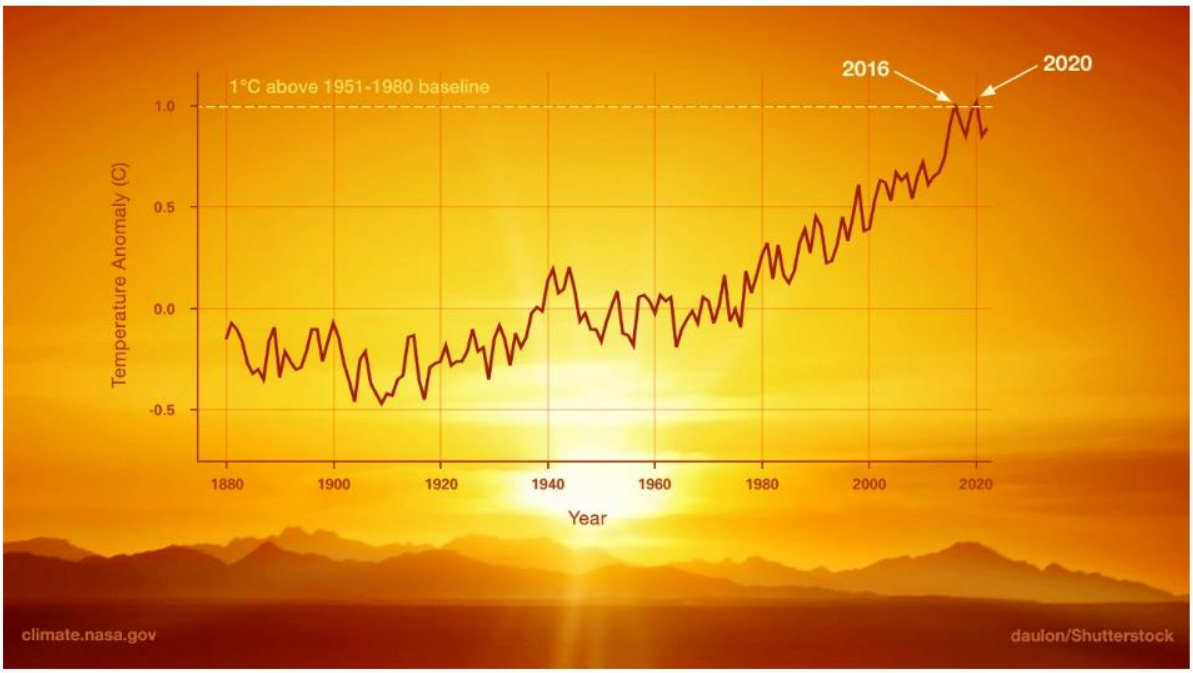
Definitions:

Climate change

Climate change is defined as the human-induced change in the earth's climate, which is due to the increase in the concentration of greenhouse gases in the atmosphere. Human activity, such as the burning of fossil fuels, industrial production and land-use change, has caused an increase in the concentration of gases such as carbon dioxide, methane and nitrogen oxides in the atmosphere. (NASA, 2023)

This change in the composition of the atmosphere has affected the earth's climate, with increased temperatures, changes in rainfall patterns, an increase in the frequency and intensity of storms, rising sea levels, and other phenomena. These changes have significant implications for the economy, health, safety and sustainability of communities across the planet. (European Union, 2019)

In the United Nations Framework Convention on Climate Change (UNFCC), climate change is specifically defined as change in climate that is directly or indirectly caused by human activities, distinguishing the term from climate variability that has natural causes. (National Public Health Organization, 2019)



This chart shows the change in global surface temperature relative to average temperatures 1951-1980, with the year 2020 statistically tied with 2016 for temperatures on record

(Source: NASA Goddard Institute for Space Studies).

Health

The definition of health is constantly evolving. The classic definition of health given by the World Health Organization (WHO) and formulated in its charter in 1946 shortly after the end of the Second World War defines health as "a state of complete physical, mental and social well-being and not merely the absence disease or disability". (WHO, 1946)

This definition bases health primarily on social and then on medical factors and changes the previously existing orientation of the definition of health related only to physical health.

However, the attenuation of human activities, the complexity of lifestyles and the interaction with the environment led the WHO in 1986 to redefine and expand the definition of health by adopting a more socialized perspective.

According to this definition, "Health is the degree to which an individual or a group can, on the one hand, realize their aspirations and satisfy their needs, and on the other hand, change or successfully cope with the environment. Health is therefore seen as a means to daily life and not as the goal of life. It is a positive perception that emphasizes social and personal resources and abilities." (Schramme, 2023)

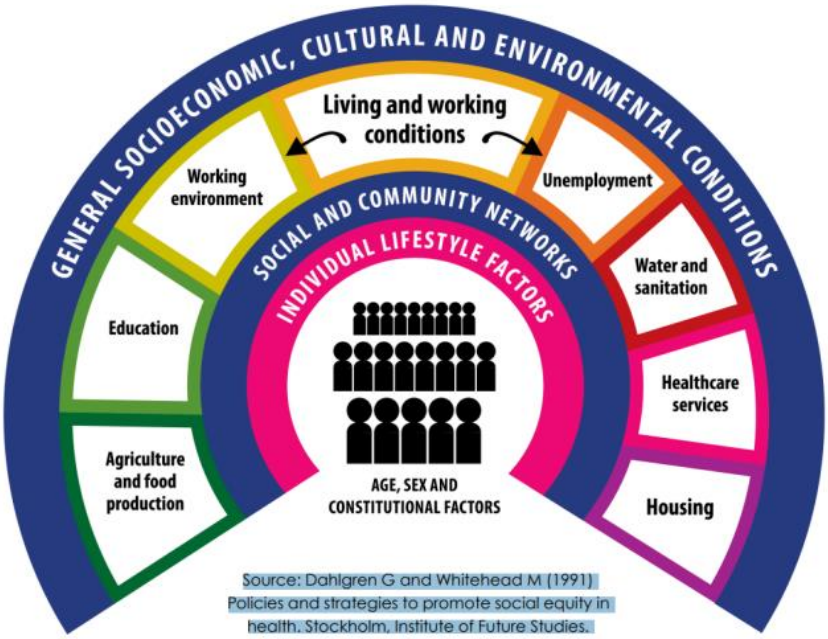
Another definition formulated by Murray, Zentner, and Yakimo in 2009 defines health as "a state of well-being in which the individual is able to use purposeful and adaptive responses and processes physically, mentally, and socially."

Additionally, Pender, Murdaugh, and Parsons in 2006 defined health as "the realization of innate and acquired human potential through goal-directed behavior, the capacity for self-care, and satisfying relationships with other people."

Finally, health was defined by Orem in 2001 as **"a state of the individual characterized by robustness or completeness of developed human structures and physical and mental functioning».** (Melanie McEwen and Mary A. Nies, 2017)

A more detailed version of the determinants of health was advanced in 1991 by Dahlgren and Whitehead, who came to formulate the Ottawa Treaty in 1986, in which the WHO established the Health Promotion Policy, which aims to upgrade the physical and social environment, to strengthen of the wider factors that have a positive effect on human health and the formation of healthy attitudes and behaviors.

This formulation of Dahlgren and Whitehead is captured in the following model:



According to the above scheme, individuals are placed at the center and around them are the various levels of health influences such as individual lifestyle factors, community influences, living and working conditions and general social conditions. (GOV.UK, 2017)

Why a public health approach is critical

Climate change presents risks on a scale that requires strategic, coordinated prevention and response measures. No individual, community, or nation can fully mitigate or adapt to all the health impacts we collectively face as greenhouse gas emissions continue to rise.

This is why climate change requires global public health commitment and surveillance.

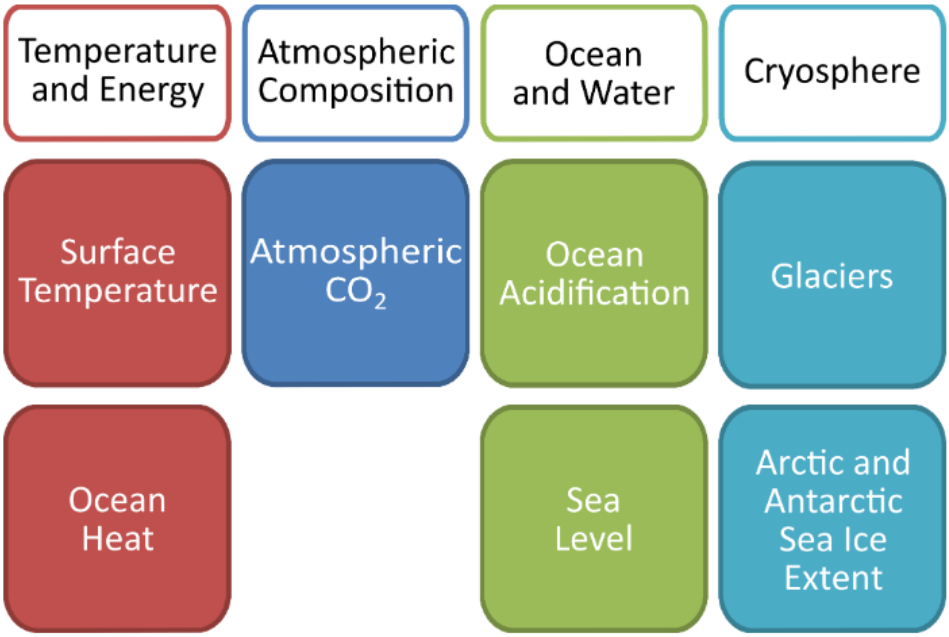
The effect of climate change on the health of populations

Climate change is often referred to **as a "health risk multiplier",** as many of its properties and effects can cause or amplify already existing health risks.

The effects of climate change on public health can be examined through the basic effects that climate change brings and more specifically through:

1. Air pollution
2. Extreme weather events (heatwaves, storms, floods),
3. The forced movement of populations
4. Of vector-borne diseases ,
5. Malnutrition, poor nutrition and food and water security
6. Of the social and economic impacts
7. The pressures on mental health.

Global climate indicators are a set of parameters that describe the changing climate without being limited to the temperature of the planet. Whatever effects the changing climate creates, they harm human health and well-being on the planet. These indicators are reflected in the image below:



(Global Climate Observing System (GCOS), 2021)

According to the WHO, climate change affects health in a myriad of ways, including by leading to deaths and illnesses from increasingly frequent extreme weather events such as heat waves, storms and floods, disruption of food systems, increases in zoonotic and vector-borne diseases from food, water and carriers, as well as mental health problems.

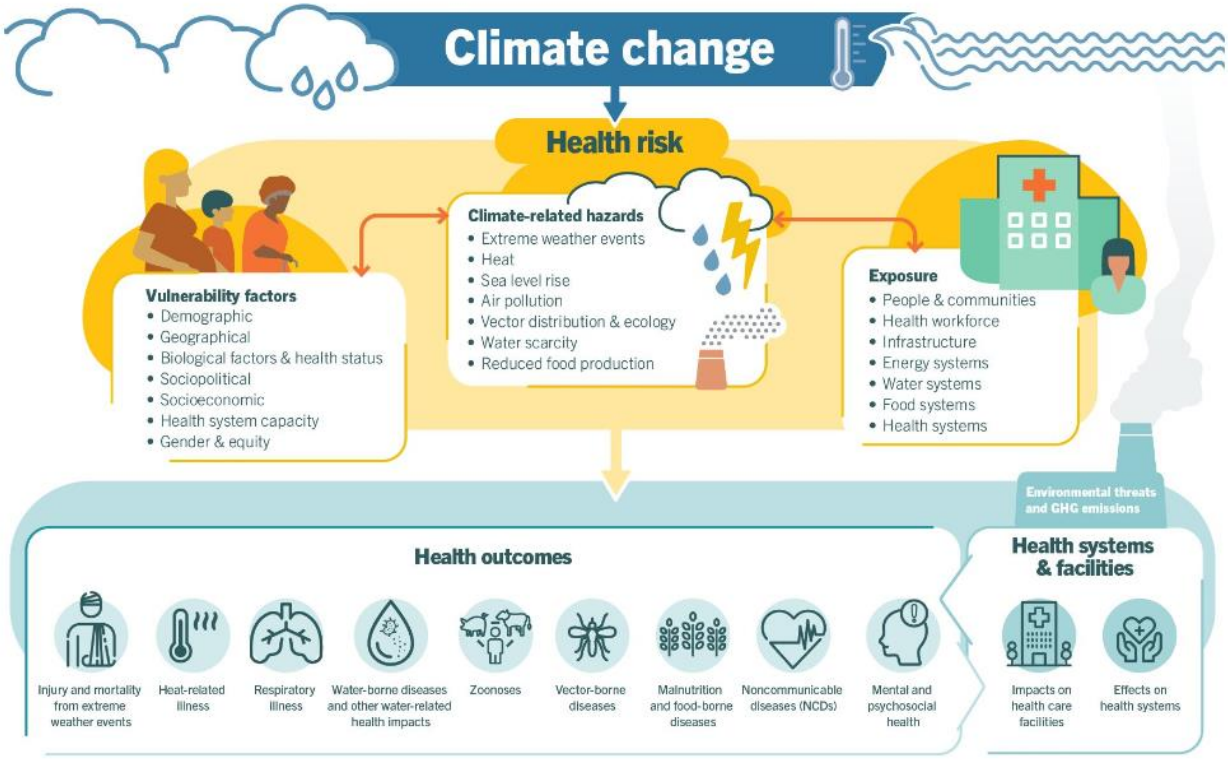
In addition, climate change undermines many of the social determinants of good health, such as livelihoods, equity and access to health care and social support structures.

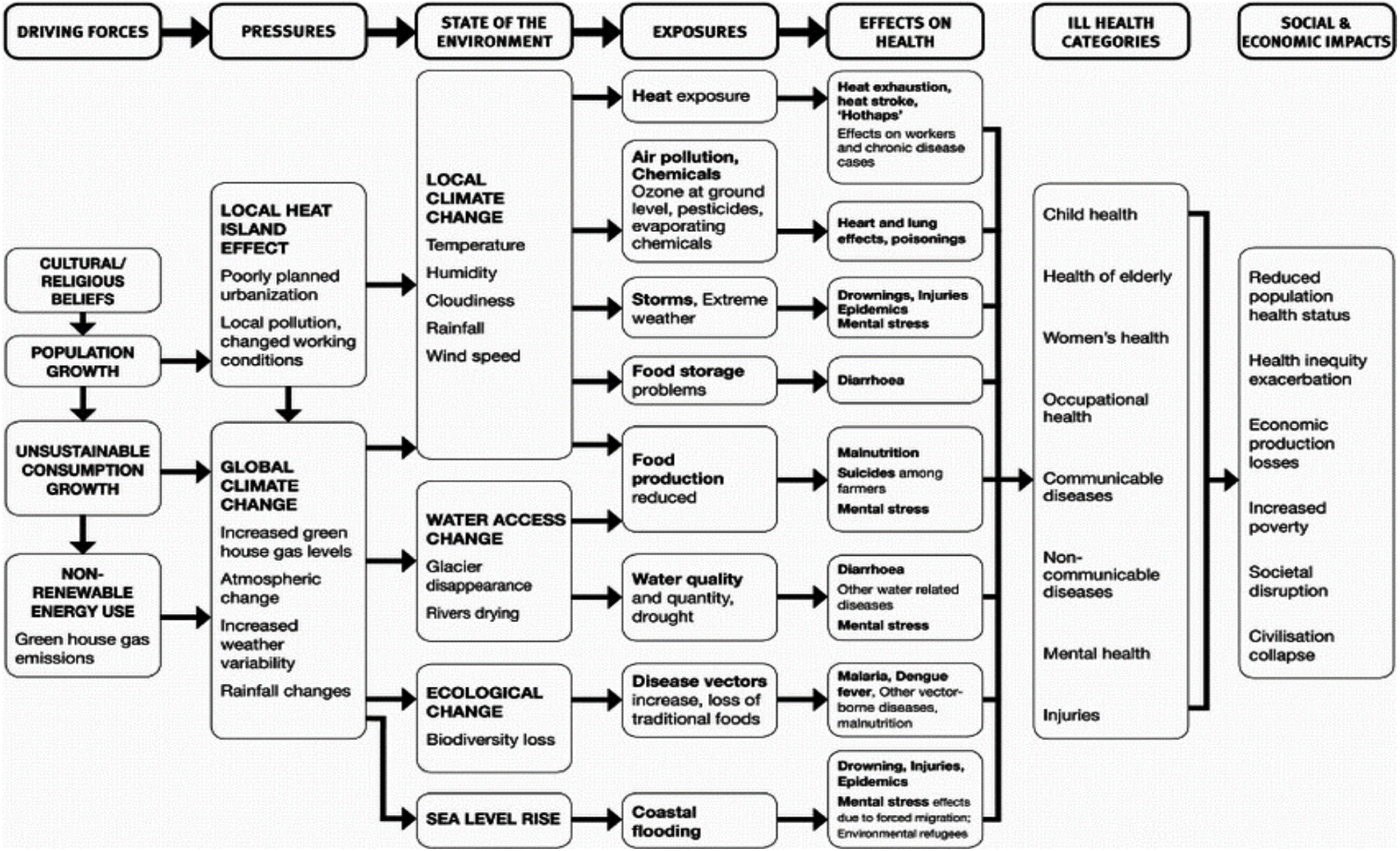
These climate-sensitive health risks are disproportionately felt by the most vulnerable and disadvantaged, including women, children, ethnic minorities, poor communities, migrants or displaced persons, older populations and people with underlying conditions.

The figure below provides an overview of climate-sensitive health risks, exposure pathways and vulnerability factors. Climate change affects health both directly and indirectly, and is strongly mediated by environmental, social and public health determinants.

(WHO, 2023a)

In addition, the DPSEEA framework on climate change and global public health outlines the path from the forces that create the phenomenon of climate change, to its effects on health, the diseases that develop and finally what socio-economic consequences that arise in societies.





(Kjellstrom & McMichael, 2013)

Who is most vulnerable to climate change?

Women, children, ethnic minorities, poor communities, migrants or displaced persons, older populations and people with underlying health conditions are most vulnerable to climate change. (WHO, 2023)

For example, the adverse effects of malaria, diarrhea and malnutrition are found among children today because of the sensitivity of their bodies.

Children are also considered more vulnerable to heat-related illnesses due to their small body mass to surface area ratio.

Finally, children are at greater risk when food supplies are limited and there is food insecurity, which is linked to a range of negative health effects in young children. (Gillian Dunn , 2016)

Older people are at greater risk from storms, floods, heat waves and other extreme events, in part because they tend to move less than younger adults and thus have a harder time avoiding dangerous situations, and also because they are more likely to live alone in some societies. Older people are also more likely to suffer from health problems that limit the body's ability to respond to stressors such as heat and air pollution. (Harper, 2023)

Women and girls are also more likely to be affected by climate change than men for the following 5 reasons:

1. They face an increased risk of violence against women and girls
2. There is an increased risk of child marriage
3. They are more likely to miss classes or drop out of school
4. They face an increased risk of death and injury
5. They are less likely to have food availability and earn a living

This is because women and girls already face inequalities and discrimination based on their gender, which are amplified and multiplied when disasters occur.

Poorer countries and regions are generally more vulnerable to damage caused by climate extremes and climate variability, which does not in the least mean that rich countries are immune. (*Harnessing Nationally Determined Contributions to Tackle Loss and Damage in Least Developed Countries* , 2022)

A systematic review of global trends in tropical cyclones that included 71 cyclone cases showed that they are associated with a consistently increased risk of overall morbidity, mental health, posttraumatic stress disorder (PTSD), and all-cause mortality or hospitalization. The risk of mortality at country level depends mostly on three factors:

1. The intensity of storms,
2. The quality of governance and
3. Poverty levels. (Huang et al., 2023)

Populations without access to good quality health care services and basic public health services are most likely to be adversely affected by climate variability and climate change.

States and especially their island regions must be subject to policies of natural disaster prevention. (Salam et al., 2023)

Population growth is associated with sensitivity to climate change and affects public health

Even if climate change were not to change for the worse, the increasing number of people in already resource-poor locations affected by climate hazards would increase the harmful effects. There are 4 ways climate change and global population growth are affecting public health.

1. Infectious communicable diseases
2. Water and food safety
3. Poor air quality
4. Extreme temperatures

Health risks from climate change

Health risks from extreme weather events

When we burn fossil fuels, such as coal and natural gas, we release carbon dioxide (CO_2). CO_2 builds up in the atmosphere and causes the Earth's temperature to rise, like a blanket traps heat. This extra trapped heat disrupts many of the interconnected systems in our environment.

Climate change affects human health by increasing the frequency and intensity of extreme heat events. Increases in the overall temperature of the atmosphere and oceans associated with climate change are causing changes in wind, moisture, and heat circulation patterns. (Centers for Disease Control and Prevention, 2019)

Extreme temperatures

Mortality generally increases at both high and low temperatures above and below the optimum temperature value.

Higher average temperatures lead to warmer days and more frequent and longer heat waves. These changes lead to an increase in heat-related deaths reaching up to hundreds of thousands of additional deaths each year.

These deaths are not offset by the smaller reduction in cold-related deaths that occur in the winter months. (United States Environmental Protection Agency, 2023)

Globally, just under half a million deaths a year are estimated to be due to extreme heat, according to a 2021 study, although data are missing from many low-income countries. Up to 61,000 people may have died in Europe during widespread heatwaves in the summer of 2021. (Jennifer Rigby and Kate Turton, 2023)

Heat exhaustion, which can include dizziness, headaches, shivering and thirst, can affect anyone.

The most serious version is heatstroke, where the body's core temperature exceeds 40.0 degrees Celsius. It is a medical emergency and can lead to long-term organ damage and even death. Symptoms include rapid breathing, confusion or seizures, and nausea.

Once a person exceeds the body's normal ability to cope with increased heat stress, the risks for collapse of physiological functions, exacerbation of disease and death increase rapidly. This is especially true in elderly people and people with underlying cardiovascular or chronic respiratory diseases. Some people are more vulnerable, including young babies and the elderly, as well as people who need to stay active or are more exposed, such as the homeless.

Most heat deaths occur in people with pre-existing cardiovascular or chronic respiratory conditions. (Mayo clinic , 2023)

Extreme storms and floods

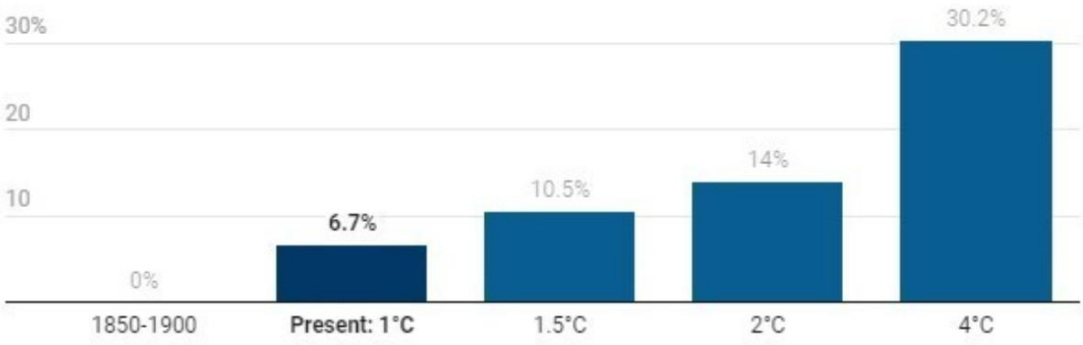
Climate change is resulting in more intense rainfall. This increases the chances of flooding. This is because warming means the air can hold more moisture (for every 1°C of warming, the atmosphere can hold 7% more moisture).

High temperatures expose more and more areas to severe flooding, causing billions in damage.

Although flooding is a natural phenomenon, human-induced climate change is making severe flooding more frequent. Climate change affects hydrology and floods.

In mountainous regions, three effects of climate change in particular create higher flood risks: heavier rainfall, changing patterns of snow and rain, and forest fires.

The chart below shows how wetter and heavier one-day storms that historically occurred about once every 10 years are likely to become as temperatures rise.



(World Economic Forum, 2022)

Floods are the most common natural disaster worldwide, affecting more than two billion people worldwide between 1998 and 2017 and with 44% of global disasters linked to them.

Floods are high-impact events that crush natural infrastructure, human resilience, and social organization. they can cause widespread devastation, resulting in loss of life and damage to personal property and critical public health infrastructure.

People who live in flood plains or non-resilient buildings or do not have warning systems and are not aware of flood risk are more vulnerable to floods.

There are 3 common types of flooding:

Flash floods are caused by rapid and excessive rainfall that rapidly increases water levels and may bypass rivers, streams, canals or roads.

River floods are caused when continuous rain or melting snow causes a river to exceed capacity.

Coastal flooding is caused by storm surges associated with tropical cyclones and tsunamis .

The health effects of flooding are wide-ranging and depend on several factors. (WHO, 2023d)

Immediate health effects from flooding include drowning, injuries, hypothermia and animal and insect bites, allergies. Health risks are also associated with evacuation of patients from health facilities, loss of health workers and loss of health infrastructure, including essential medicines and supplies.

In the medium term, infected wounds, injury complications, poisoning, poor mental health, communicable diseases and starvation are indirect consequences of flooding.

In the long term, chronic disease, disability, poor mental health and poverty-related diseases, including malnutrition, are the likely consequence. (Du et al., 2010)

The World Health Organization in its guidelines on personal protection against floods states that floods can potentially increase the transmission of water- and vector-borne diseases such as typhoid fever, cholera, malaria and yellow fever, among others , it is important to be aware of the risk and protect your water sources.

The most common hazards associated with flooding are contamination of drinking water facilities and standing water, which can be a breeding ground for mosquitoes, carry chemical hazards and cause injuries.

Health protection during a flood by:

- Knowing your community's evacuation route and warning signs and identifying areas prone to flooding or landslides.
- Chlorination or boiling of all water for drinking and food preparation.
- Ensuring an uninterrupted supply of safe drinking water. This is the most important preventive measure to be implemented after flooding in order to reduce the risk of waterborne diseases.
- The promotion of good hygiene practices and safe food preparation techniques
- Not using flood water for washing dishes, brushing teeth, washing food and preparing food.
- Always wash hands with soap and water if there has been contact with flood water.
- Avoiding walking or driving through flooded areas and standing water. Even the smallest amount of water can pose significant risks. During or immediately after a flood occurs, it is not known to anyone whether there are downed power lines or hazardous chemicals in the water.
- Avoiding driving in areas where cars and people can easily be swept away during a flood.
- Throwing away any food that has come into contact with flood water. If the food has been touched by any flood water, it is unsafe to eat and increases the risk of water-borne diseases.
- Safely cleaning the home if it has come into contact with flood waters.
- Disposing of any items that cannot be washed and cleaned with bleach, such as pillows and mattresses.
- Cleaning walls, floors and all surfaces with soap and water, as well as bleach.
- Protection from mosquitoes
- The use of insect repellents , if the house is located in an area with stagnant or stagnant water, following the instructions on the label, regarding its application to clothing or the skin.
- The use of pants and shirts with long sleeves and covering the beds with mosquito nets during sleep. (WHO, 2023e)

Drought

A drought is a prolonged dry period in the natural climate cycle that can occur anywhere in the world. It is a slow-onset disaster characterized by a lack of rainfall, resulting in water scarcity. Drought can have serious impacts on health, agriculture, economies, energy and the environment.

Rising temperatures caused by climate change are making already dry areas drier and wet areas wetter. In arid regions, this means that when temperatures rise, water evaporates more quickly and thus increases the risk of drought or prolongs dry periods. Between 80-90% of all documented disasters from natural hazards during the past 10 years have resulted from floods, droughts, tropical cyclones, heat waves and severe storms. (WHO, 2023c)

Severe drought can affect:

- Water supply: Droughts are defined by a lack of available water. During droughts, communities may have limited access to water for domestic use, including drinking, cooking, cleaning and watering plants, as well as for agriculture, transport and energy production. Droughts can lead to higher water costs, with consequences for poor populations.
- Agriculture: Droughts affect livestock and crops, including corn, soybeans, and wheat. Globally, drought hit several major grain-growing areas simultaneously in 2012, increasing food price volatility. In countries already experiencing food insecurity, cost increases can lead to social unrest, migration and famine.
- Transportation: Droughts can lower river water levels, threatening river trade. Transport barges need at least nine feet of water to operate and to maintain this level. Drought-fueled fires also affect travel, closing roads and railways and grounding planes when the smoke is thick.
- Energy: Droughts can raise concerns about the reliability of electricity generation from plants that require cooling water to maintain safe operations. Hydropower may also be unavailable during droughts. When heat waves coincide with droughts, electricity demands can increase, exacerbating pressure on the grid.
- Public health: Reduced flows in rivers and streams can accumulate pollutants, threatening the quality of water used for drinking and recreation. Also, drought-fueled fires can expose nearby communities to smoke and pollutants, which can exacerbate chronic respiratory diseases. (Center for Climate and Energy Solutions, 2023)

The causes through which climate change and extreme weather events affect human nutrition are complex and include diverse pathways such as regional water scarcity, agricultural salinization , crop destruction due to flooding, food supply disruption, increased pollutant load diseases or pests.

Both acute and chronic nutritional problems are linked to climate change.

Health impacts of drought include deaths, malnutrition (malnutrition, protein-energy malnutrition and/or micronutrient deficiencies), infectious diseases and respiratory diseases. (Kirch et al., 2005)

Drought reduces dietary diversity and reduces overall food consumption and can therefore lead to micronutrient deficiencies . This was demonstrated in Gujarat , India, during a drought in the year 2000, where diets were found to be deficient in energy and several vitamins. In this

population, the severe effects of drought on anthropometric indices may have been avoided by public health measures (Kumar et al., 2005) .

Subtropical regions are already experiencing water shortages. Therefore these areas are directly and even more affected by the reduction of water as a result of climate change. The facts are that a third of the world's population does not have adequate access to water. Based on the models of the evolution of drought phenomena, this percentage will grow until 2025. This directly affects the production, availability and safety of food, as the yields of crops and animals will be directly affected (*Under the Weather* , 2001).

An estimated 55 million people worldwide are affected by droughts each year, and they are the most serious threat to livestock and crops in almost every part of the world. Drought threatens people's livelihoods, increases the risk of disease and death, and fuels mass migration. Water scarcity affects 40% of the world's population and 700 million people are at risk of displacement as a result of drought by 2030. (WHO, 2023c)

Global warming also threatens fisheries in the oceans as they become more acidic by taking in carbon dioxide as the water warms. (Food and Agriculture Organization of the United Nations FAO, 1999)

Malnutrition

We distinguish between the concept of malnutrition, which refers to the case where the individual/population does not have sufficient food, and the concept of nutritional deficiency of micronutrients , where the diet does not contain enough important vitamins and minerals. Malnutrition increases the risk of infectious diseases such as diarrhea, measles, malaria and pneumonia, and chronic malnutrition can impair a young child's physical and mental development. Micronutrient deficiencies can lead to poor health and development, particularly in children and pregnant women. (WHO, 2020) A study in Bangladesh found that drought and food insecurity were associated with an increased risk of mortality from diarrheal disease especially among children. (Aziz et al., 1990)

Food safety

Development of foodborne infections

Climate change and the direct effects of higher concentrations of carbon dioxide in the atmosphere are expected to affect food security and nutrition. Extreme weather events can also disrupt or slow food distribution.

- Warmer air temperatures can increase cases of salmonella and other bacteria-related food poisoning because bacteria grow faster in warm environments. These diseases can cause gastrointestinal distress and, in severe cases, death. Food safety practices can help prevent these diseases, even as the climate changes.
- Climate change will have a variety of impacts that may increase the risk of exposure to chemical contaminants in food. For example, higher sea surface temperatures will lead to higher mercury concentrations in seafood, and an increase in extreme weather events will introduce pollutants into the food chain through stormwater runoff .
- Higher concentrations of carbon dioxide in the air can act as "fertilizer" for some plants, but they reduce the levels of protein and essential minerals in crops such as wheat, rice and potatoes, making these foods less nutritious.
- Extreme events such as floods and droughts create challenges for food distribution if roads and waterways are damaged or become inaccessible. (United States Environmental Protection Agency EPA, 2023)

The main recommendations to minimize the health risk from foodborne infections and poisonings are in the area of kitchen hygiene, which should always be practiced during food preparation.
These include thorough hand washing and the use of fresh cooking utensils after handling raw meat and fish, as well as avoiding cross-contamination, i.e. the direct or indirect transmission of pathogens from one food to another.
The use of gloves can prevent the entry of pathogens through unnoticed skin lesions.
Food safety is also highly dependent on maintaining the cold chain.
In addition, most microbiological pathogens can be safely killed by an adequate heating process.
For example, a core temperature of 70 °C for at least two minutes must be maintained when preparing seafood.
In contrast, food-associated biogenic toxins are largely insensitive to temperature. (Dietrich et al., 2023)

Lack and degradation of water quality

Climate change greatly affects the social and natural environment and is one of the most important threats to public health. Increasing water demand follows population growth, economic growth and changing consumption patterns.

The world population is growing, with a total of 7.4 billion in 2016, and is expected to increase in the coming decades. Approximately 884 million people live without access to clean drinking water in 2019. (Vineis et al., 2011)

Global water demand for all uses, currently around 4,600 km3 per year, will increase by 20% to 30% by 2050, i.e. from 5,500 to 6,000 km3 per year. Global water demand for agriculture will increase by 60% by 2025.

Water security, the ability of a population to secure sustainable access to sufficient quantities of water of acceptable quality, is already at risk for many, and the situation will worsen in the coming decades.

Water scarcity is a major issue in today's world of 7.7 billion people. The pressure on the water system will increase by 2050, when the world's population will reach between 9.4 and 10.2 billion, an increase of 22 to 34%. (United Nations, 2018)

It has been estimated that the average global temperature over the past hundred years has risen by a total of about 0.8 °C due to greenhouse gas emissions, and recent years have been heralded as the warmest in recent history. In addition, it has been argued that sea level will rise in the range of 1 to 3 mm per year as warming melts low-level glaciers (Froelich & Daines, 2020; Yang et al., 2015).

The quality of water and water systems is significantly affected by extreme weather conditions, such as storms and hurricanes, which increase the contamination of drinking water leading to water-borne diseases that affect human health and subsequently human life. (Andrade et al., 2018; Tong & Ebi, 2019)

Poor water quality, especially drinking water, increases the chances of waterborne diseases. About 1.8 million people die every year due to cholera and diarrhea and 3900 children die every day due to poor water and sanitation conditions. (WHO, 2004)

Climate variability affects climate-sensitive diseases such as dengue fever, cholera and malaria. In addition to common waterborne pathogens, Helminths , Giardia lamblia , Entamoeba histolytica , Legionella , Cryptosporidium , H. pylori , E. Coli .

Viruses such as norovirus , hepatitis E virus and rotavirus have been confirmed as emerging pathogens that can spread through water. These pathogens spread through changes in climate, such as changing precipitation and global weather patterns, as well as degradation of its layer.

Various aspects of climate change, including sea-level rise, flooding, extreme rainfall and warming, have been assessed in the past for the transmission and spread of water-borne diseases such as cholera and malaria

Microclimatic parameters, especially rainfall and temperature, play a key role in the spread of waterborne and water-related diseases. (Leddin & Macrae, 2020)

Risk from exposure to UV radiation-

It has already been said that climate change is resulting in an increase in the frequency of hot weather events. These periods of extreme temperatures are likely to significantly affect public

health; however, little has been said about how these events may affect human exposure to solar UV radiation.

Terrestrial solar ultraviolet (UV) radiation, which includes both UV-B (280–315 nm) and UV-A (315–400 nm), has a significant impact on health, as excessive exposure damages the skin and eyes and increases the risk of skin cancer. (Rendell et al., 2020)

Excessive exposure is mentioned as exposure below the safe level has benefits for vitamin D production, bone health, cardiovascular health, reduced risk of certain cancers and other causes of death. In addition, exposure to visible radiation (400-700 nm), plays an important role in the regulation of melatonin for better sleep quality and in the regulation of serotonin for improved mental health related to the duration and quality of life.

Therefore, both very little exposure and excessive exposure to the sun and solar ultraviolet radiation in particular can be harmful to health. (Baczynska et al., 2019)

There is a perception among the public that solar UV radiation and temperature are directly related. However, there are significant differences in the diurnal and annual variation of UV radiation and temperature and are affected by different atmospheric variables (such as ozone, clouds, aerosols and humidity). With climate change, temperatures are undoubtedly expected to rise. (Butler et al., 2016)

A few easy-to-implement sun safety measures could prevent much of the cancer and other deaths and illnesses from UV radiation:

- Limiting time in the midday sun.
- Use shade wisely: seek shade when UV rays are strongest.
- Wear protective clothing, including hats and sunglasses.
- Use a broad-spectrum sunscreen with a sun protection factor of 15+.
- Avoid sun lamps and tanning salons for young people under 18, the WHO recommends that they not use them at all.
- Know the UV index: when the UV index predicts radiation levels of 3 (moderate) or above, sun safety practices should be taken.
- Protect children from the sun. (WHO, 2006)

Allergies- Aeroallergens

Allergic diseases have been reported to be caused by genetic susceptibility and environmental factors such as food, dust mites , pollen, fungi and animal dander. Since these allergenic precursors are important determinants of the incidence and prevalence of allergic diseases, climate change affects the levels and location of these aeroallergens . (Ayres et al., 2009)

Atmospheric conditions created by climate change have been shown to alter the pattern of pollen release and can alter the timing and magnitude of pollen release by flowering plants. Just as pollen is responsible for respiratory allergies in humans, climate change can adversely affect human health in susceptible individuals. (Singh & Kumar, 2022)

Several epidemiological studies have highlighted that global warming, air pollution and climate change lead to an increased incidence of respiratory disorders such as rhinitis and

asthma, especially among vulnerable groups, including children and the elderly. (Pawankar et al., 2020)

The incidence of pollen allergies has continued to increase in recent years due to changing climate conditions. Pollination is the cause of allergic reactions, such as rhinitis (allergic rhinitis) and asthma, which are considered global health concerns. In addition, pollen has also been associated with non-allergic respiratory diseases, for example, chronic obstructive pulmonary disease, stroke and myocardial infarction, and even suicide mortality. (Takaro et al., 2013)

The urban population is constantly exposed to pollutants and reduced biodiversity, which has led to a reduced interaction of plants, animals and microbes. This has led to a reduced immune response in the urban population compared to the rural population, as they are exposed to similar levels of pollution but inhabit a habitat rich in flora and fauna compared to a habitat with reduced biodiversity. (Shima, 2017)

Fires

Fires are increasing worldwide in frequency, severity and duration, increasing the need to understand the health effects of fire exposure. The risk of wildfires increases in extremely dry conditions such as drought, heatwaves and during high winds.

Fire smoke is a mixture of dangerous air pollutants such as PM2.5, NO 2, ozone, aromatic hydrocarbons or lead . In addition to polluting the air with toxic pollutants, wildfires also affect the climate by releasing large amounts of carbon dioxide and other greenhouse gases into the atmosphere.

With climate change leading to warmer temperatures and drier conditions and the increasing urbanization of rural areas, the fire season is starting earlier and ending later. Wildfires are becoming increasingly extreme in terms of acres burned, duration and intensity, and can disrupt transportation, communications, water supply, and electricity and gas services. (WHO, 2023b)

Here are five examples of how wildfires affect people hundreds or even thousands of miles away:

1) Fires can create hazardous air

As recent fires in Quebec have shown, wildfires can have far-reaching effects on air quality, with wind blowing smoke hundreds of miles and causing widespread health risks. Fine particles in wildfire smoke pose the greatest threat to human health: They can cause burning eyes, respiratory illnesses such as bronchitis, and worsening symptoms for people with chronic heart or lung conditions.

2) Fires fuel climate change

In addition to creating poor air quality, wildfires produce greenhouse gases that warm the planet and fuel climate change. Because trees store carbon, they also release it into the air as they burn. In 2021 alone, arctic forest fires across North America, Europe and Asia released 1.76 billion tonnes of carbon dioxide. Ranked as a country, this would put fires in the world's top ten polluters.

After a fire is over, some of this carbon will be recaptured as the forest recovers. But tree loss reduces a forest's ability to sequester and store carbon over many years. Since forests absorb a net 7.6 billion metric tons of carbon dioxide annually—about 1.5 times the annual emissions of the United States—large forest losses can exacerbate the climate crisis.

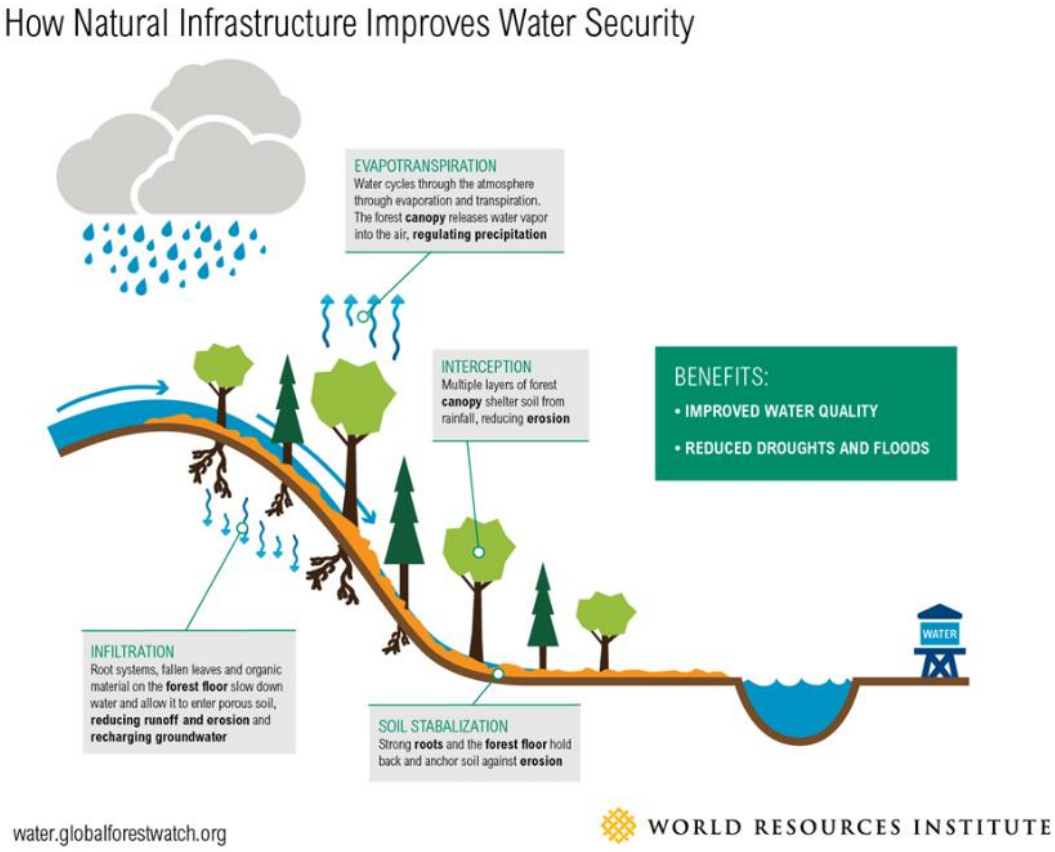
3) Fires threaten water safety

Forests are vital for ensuring water quality and access to fresh water. Forested catchments provide over two-thirds of the world's drinking water, with 33 of the world's 105 largest cities relying on forested areas for their water supply along with many smaller cities and rural areas.

Forests and trees increase infiltration and reduce erosion rates, which prevent sediment and other pollutants from reaching vital water supply rivers and lakes. After a fire there are fewer trees to block storm water runoff and the soil becomes unstable and more prone to erosion. This means that when it rains, more sediment, ash and pollutants end up flowing into lakes, rivers and reservoirs. After the 2018 wildfires in California, for example, post-fire storms caused debris and toxic substances to enter nearby bodies of water, and some utilities had to stop using water from sources too close to the fire.

How forests affect water supplies

Forest watersheds can help recharge groundwater and ensure a steady water supply throughout the year. Trees in a forest store and release water vapor, which can regulate weather and precipitation. Tree canopy and roots can also help slow the flow of runoff, releasing water more gradually. Catastrophic fires cause losses to the forest canopy and affect the soil beneath it, which can disrupt these water-regulating systems and deplete freshwater supplies in areas that rely on forested watersheds.



4) Fires can increase the risk of flooding

Cities are particularly vulnerable to flooding. Urban areas have large amounts of impervious surfaces such as sidewalks and roads, which leads to more runoff when it rains. Healthy forests near cities can act as sponges, increasing soil infiltration, storing excess runoff and slowing water. In other words, they serve as dams that protect downstream cities from flooding.

When heavy rainfall occurs in a forest after a fire, there is no tree canopy to slow down the water and the soil is less able to store water. As a result, flash floods can occur even with relatively small amounts of rainfall.

This is not a short-term issue: It can take years for vegetation to regrow after a wildfire, leaving cities and other communities at risk for just as long.

5) Fires can cause direct and indirect economic losses

Each of these impacts can have negative economic impacts:

Air quality

The health effects of air pollution caused by wildfires can result in significant medical costs. In the United States alone, the health effects of wildfire smoke cost $16 billion annually.

Water quality

If a watershed that a city depends on is affected by fire, the city may have to pay for water treatment in that watershed and/or water shipments from other sources. After a major fire, the cost of producing drinking water can increase by $10 million to $100 million.

Risk of flooding

Floods can damage infrastructure, disrupt supply chains and leave people in need of medical care. As usual, flood-related economic losses could total $1 trillion worldwide by 2050.

Decrease in economic activity

Australia's wildfires may have cost the nation's tourism industry as much as $4.5 billion between 2019-2020. Most recently, the devastating wildfires in Maui , Hawaii resulted in economic losses of approximately $9 million per day, greatly affecting local livelihoods.

Compression of the travel industry

Many small town economies rely on tourism to survive, and constant fire threats can cause long-term business closures, putting jobs and income at risk. (*5 Ways Climate Change Affects Women and Girls* , 2019)

Infectious diseases

Infectious diseases are caused by pathogenic organisms that can potentially harm the human body. Such organisms can be viruses, bacteria, fungi and parasites. Each type of pathogen has climatic conditions in which its growth is facilitated. Changes in weather conditions and especially those related to the increase in average temperature, rainfall and relative humidity, create a suitable environment for the development of pathogenic microorganisms, their ability to survive and spread.

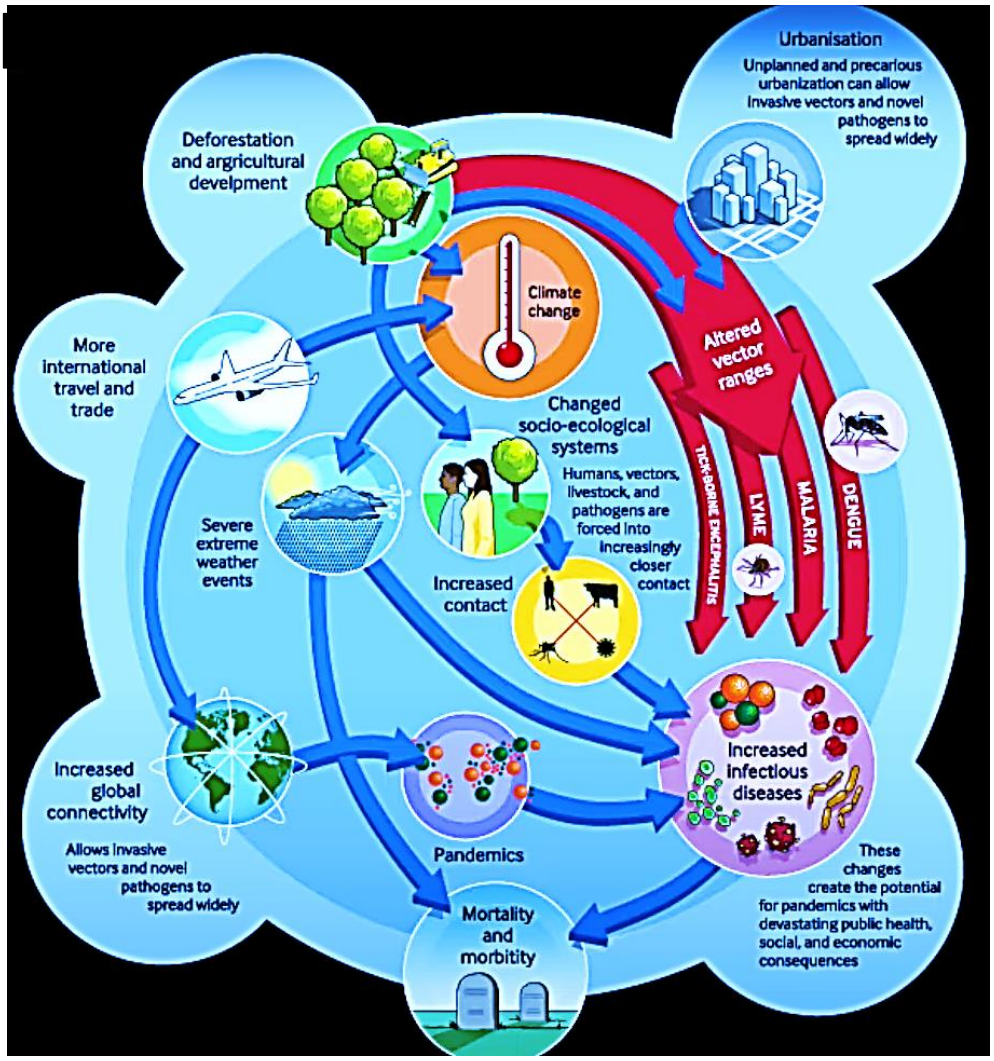
The change in temperature works to support this and for the better survival of some animals and insects that help in the transmission of pathogens such as rodents, mosquitoes, ticks, bed bugs, etc. (National Academies, 2022)

The spread of infectious diseases is also influenced by travel habits. In particular, air travel enables the rapid spread of an infectious disease agent from region to region within a continent or from one continent to another.

The socio-economic status and distribution of human populations are additional factors in the spread of infectious airborne , waterborne and sexually transmitted diseases. Poverty and a lack of basic food or housing goods also affect the transmission of infectious diseases.

Addressing all of the above factors is linked to how effective the health system is, its accessibility and the availability of medical treatments.

are vital for waterborne diseases such as cholera and typhoid fever. On the other hand, vaccinations, antibiotic drugs, regular medical care, accessibility to health services and the affordability of health services from a socio-economic point of view are equally important in the prevention of infectious diseases. (National Academies , 2022)



Mental health

Climate change not only harms physical health, but also takes a toll on mental health.

Psychological responses to climate impacts include:

Environmental stress and sadness

The natural environment is changing and people are worried about what this means for the future.

This concern, which becomes increasingly severe to cause discomfort and dysfunction, is called *ecological anxiety* .

The American Psychological Association and Eco America have defined eco-anxiety (also known as climate anxiety) as a "chronic fear of environmental destruction." This fear may come from directly experiencing extreme weather events and environmental changes (eg, floods, wildfires, hurricanes, drought) or from exposure to information about climate change through news media and other sources.

Witnessing ecological destruction and loss with our own eyes (or through the media) can cause clinically significant anxiety, depression, PTSD stress - PTSD (Post Traumatic Stress Disorder) and adjustment disorders.

Young people report high rates of eco-anxiety due to the fear of inheriting a damaged planet.

Existential anguish over the loss of biodiversity, natural landscapes, and climate stability on which humans depend can manifest as grief reactions.

A psychological phenomenon that has emerged due to climate change has been called solastalgia and is a form of mental distress characterized by a sense of loss, for example experienced after the loss of property or land following fires. It can include emotional pain, a sense of loss of comfort and relaxation that the person previously experienced in their environment. (Edward Bell & Lindsey Jean Schueman, 2023)

Who is most at risk?

- **Youth.** Young people expect to suffer more from the consequences of climate change and therefore tend to fear more about their future.

- **Indigenous peoples.** Nature plays an important role in both the culture and daily life of many indigenous communities.

- **Marginalized communities with the least resources to deal with the crisis.** This includes groups such as displaced people, people with pre-existing mental or physical conditions and people of lower socio-economic status.

- **People who work closely with the land.** Workers such as farmers, fishermen and hunters, as well as climate researchers may experience its changes most acutely.

- **People living in higher risk areas.** Geographically, some areas face greater risk of extreme climate change impacts than others (eg northern communities, coasts).

- **First responders .** Those working on the front lines of weather disasters have unique, first-hand experience with the consequences of the climate crisis. (Mental Health Commission of Canada , 2023)

Increased anxiety, aggression, and violence

time-series studies using real-world heat and violence data provide converging evidence. Cities and areas with warmer temperatures tend to experience more violent crime than cooler areas, even after controlling for a dozen sociocultural factors such as age, race, poverty and honor culture.

In addition to the direct effect of heat, on the human biological constitution that promotes aggression and violence anyway, there are many indirect ways in which rapid climate change (either rapid warming or rapid cooling) increases the risk of violence such as:

- Food insecurity created by increased drought, extreme weather events such as fires and floods that threaten vital crop production and lead to large-scale food shortages. Studies have shown that malnutrition both prenatally and in early childhood is a precursor to antisocial behavior, aggression and violence in adulthood.

- Increasingly frequent extreme weather events destroy infrastructure, homes and jobs and require significant emergency spending to recover. The economic impact is disproportionately felt by disadvantaged and vulnerable populations, resulting in increased rates of poverty and income inequality.

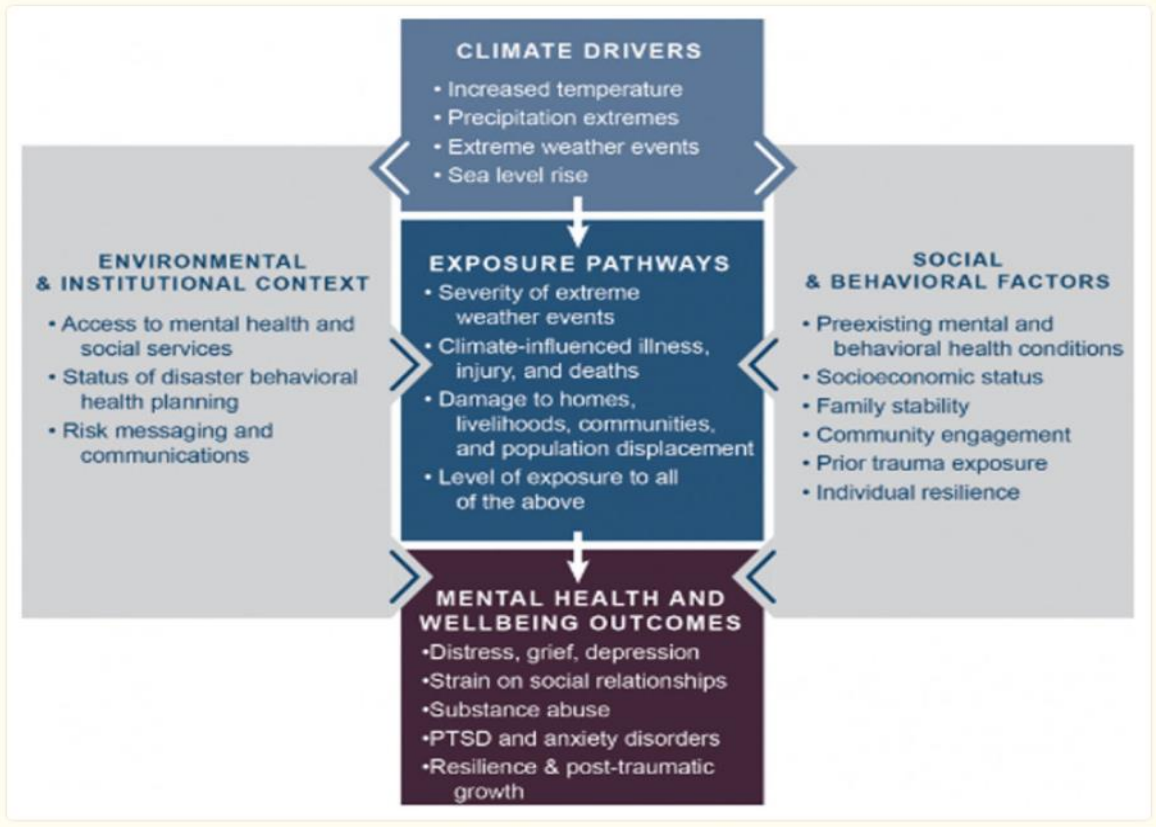
- Uncertainty and frustration about one's survival, seeing others unfairly unaffected and the belief that there are no other viable options for one's survival contribute to crime, increased suicides of farmers and ranchers, and terrorism.

- Among the most significant group-level impacts created by climate change is eco - migration, where entire groups migrate in response to physical, economic, or political instability caused by an ecological disaster. Although eco-migration is not, in itself, a sign of aggression, it can lead to hostility and conflict through a sudden increase in competition for an area's resources, bringing together people with opposing or incompatible worldviews, concerns about the intentions of both the immigrant group as well as the local population and a range of socio-economic issues. (Courtney Plante & Craig A. Anderson, 2017)

The Climate Change and Mental Health and Wellbeing Model was developed by Crimmins et al. identified key pathways by which people are exposed to health threats from climate factors and potential harmful outcomes for mental health and well-being.

The framework identified climate factors, exposure pathways and their impact on mental health and well-being outcomes. Climatic factors include increased temperature. extreme rainfall. extreme weather events; and sea level rise. Exposure pathways include the severity of extreme weather events. disease, injury and death affected by climate; damage to homes, livelihoods, communities and population movements; and the level of exposure to all of the above.

These climate factors and exposure pathways then influence mental health and well-being outcomes that can lead to distress, sadness and depression. strain on social relationships. substance abuse; post-traumatic stress disorder and anxiety disorders. or resilience and post-traumatic growth (potentially positive outcome).



(White et al., 2023)

As a conclusion to this literature review, some recommended public health actions to address climate change are listed. These include:

- Conduct vulnerability assessments and expand monitoring of climate health indicators.
- Improving access to medical care, mental health support and public health resources.
- Targeting preparedness measures to high-risk populations.
- Educating health professionals and communities about climate health risks.
- Developing the capacity of health systems to manage the increase in climate-related diseases.
- Reducing greenhouse gas emissions and co-pollutants from the healthcare sector.
- Adopting sustainable practices that increase the climate resilience of health facilities.
- Declaring climate change a public health emergency and issuing directives to local health services.
- Call for comprehensive policies to immediately limit greenhouse gas emissions.
- Supporting adaptation to climate change and changes to systems that protect public health.

Climate change is no longer a distant threat, but a clear and present risk to public health. Heat waves, wildfires, extreme weather events, new disease vectors, mental distress and environmental degradation are endangering our communities here and now, while exacerbating inequalities. (Edward Bell & Lindsey Jean Schueman, 2023)

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