Evidence Report: Impact of Climate Change

JULY 2023

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1. Introduction

The earth is heating up as a result of human activity. At the time of writing, the average global surface temperature is 1.1 degrees Celsius higher than it was in the pre-industrial period (1850 to 1900), and this average masks significant regional variations, with some areas significantly hotter than this.[1] Irrespective of any actions taken to slow climate change (such as curbs on the use of fossil fuels), the best estimate for all climate models is that this average temperature will rise to 1.5 degrees Celsius in the decade 2030-2040. After that, the path of climate change will depend on measures taken (from now) to decrease greenhouse gas emissions: the "intermediate" projection of the Intergovernmental Panel on Climate Change (IPCC) is for an average temperature rise to 2.7 degrees over pre-industrial levels by the end of the century, although the rise could be much lower if the world is able to achieve zero emissions of greenhouse gases by 2050.[2]

These climatic conditions have not existed on earth for around 125,000 years.[3] They have no precedent in recorded human history. As a result, it is likely that they will have profound impacts on most aspects of human life on the planet.

This document outlines the key impacts that climate change is likely to have on f areas of humanitarian response: water and sanitation; health; nutrition; and food security and livelihoods. It first considers the consequences of climate change for extreme weather events, then addresses the specific impact of both extreme weather events and longer-term climate change on each of the four areas outlined above.

The document is based on a short literature review conducted in late 2022.

2. The consequences of climate change for extreme weather events

We are already seeing the impact of climate change on extreme weather events, such as floods, cyclones, extreme heat and cold, wildfires and droughts, and can expect these impacts to intensify. Climate change will cause "increases in the frequency of concurrent heatwaves and droughts on the global scale (high confidence); fire weather in some regions of all inhabited continents (medium confidence); and compound flooding in some locations (medium confidence)."[4,5] The IPCC suggests that as temperatures shift from 1 degree above the pre-industrial average to 1.5 degrees above the pre-industrial average, the risk and impact of extreme weather events globally will move from being "moderate" to "high."[6] The next two decades form a transition zone from the world we know to a world with more frequent and more intense extreme weather.

These changes are projected to happen everywhere, with their strongest impacts in Africa and Asia, and to a lesser extend in North America and Europe.[7]

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[1] Masson-Delmotte et al., 2021.

[2] Masson-Delmotte et al., 2021.

[3] Masson-Delmotte et al., 2021.

[4] Masson-Delmotte et al., 2021, p. 9.

[5] This report cites the IPCC reports throughout, using their analysis of confidence level. The IPCC uses the following levels of confidence: very low, low, medium, high and very high. This is a statement "based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively." (Mastrandea et al. 2010, p 1)

[6] Pörtner, Roberts, Tignor, et al., 2022.

[7] Masson-Delmotte et al., 2021.

2.1. Impacts of climate change on heatwaves

Climate change will significantly increase the likelihood of heatwaves in many places.

It is important to recognize that there are differences between "'extreme heat" and "heatwaves." Definitions of extreme heat focus exclusively on temperature—for example, as a period of "marked unusual hot weather (max, min and daily average) over a region persisting at least two consecutive days during the hot period of the year based on local climatological conditions, with thermal conditions recorded above given thresholds."[8] Some definitions of heatwave broaden this to include both heat and humidity, as this combination can have a particularly marked effect on human and natural systems.[9] When providing International Medical Corps country programs with experimental heatwave forecasts from G-SRAT, the climate adaptive programming initiative has used the definition given by Lange et al. (2020) that uses both a relative indicator based on temperature and an absolute indicator based on temperature and relative humidity, related to their respective threshold values.

Climate change has already more than quadrupled the possibility of an extreme heat event.[10,11] According to the IPCC, "Record temperatures in 2020 resulted in a new high of 3.1 billion more person-days of heatwave exposure among people older than 65 years and 626 million more person-days affecting children younger than 1 year, compared with the annual average for the 1986–2005 baseline."[12,13] Climate change is projected to increase the intensity, frequency and duration of extreme hot days and heatwaves[14] in all areas: at 1.5 degrees, the likelihood of what would previously have been a "one in 50-year" extreme heat event increases 8.6 times on average.[15]

In terms of geographical distribution, predictions suggest that extreme heat and heatwaves will become hotter and/or more frequent and/or of longer duration in most areas where International Medical Corps works. Semi-arid regions, including in Africa and Asia, will see "the highest increase in the temperature of the hottest days, at about 1.5 to 2 times the rate of global warming (high confidence)."[16] In Asia, more intense heatwaves of longer durations and occurring at a higher frequency are projected over India[17] and Pakistan.[18] In Africa, "mortality-related heat stress levels and deadly temperatures are very likely to become more frequent in the future…for a 2°C global warming…In particular the equatorial regions where heat is combined with higher humidity levels, but also North Africa, the Sahel and Southern Africa…are among the regions with the largest increases of heat stress."[19] Urban areas are likely to be particularly badly affected.

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[8] Lee et al., 2019, p. 7.

[9] Lee et al, 2019, p.7. Note also that WHO defines heatwaves as "sustained periods of uncharacteristically high temperatures that increase morbidity and mortality" (Lee et al., 2019, p. 2).

[10] Masson-Delmotte et al., 2021.

[11] The current likelihood of a one in 50-year event occurring is 4.8x that of it occurring in the pre-industrial period, and the intensity of that event will be an average 1.2 degrees hotter.

[12] In fact, the IPCC finds that with "every additional 0.5°C of global warming causes clearly discernible increases in the intensity and frequency of hot extremes, including heatwaves (very likely)" (Seneviratne et al., 2021, p. 1534.

[13] Romanello et al., 2021.

[14] Lee et al., 2019; Masson-Delmotte et al., 2021; Romanello et al., 2021.

[15] Masson-Delmotte et al., 2021.

[16] Seneviratne et al., 2021, p. 1518.

[17] Mishra et al., 2017; Murari et al., 2015.

[18] Nasim et al., 2018.

[19] Ranasinghe et al., 2021, p. 1793.

2.2. Impacts of climate change on flooding

Flooding is extremely hard to predict, but it is likely that river flooding, rainfall based flooding and coastal flooding will increase.

It is important to differentiate between three types of flooding.

- **Fluvial (river) floods:** when precipitation or snow melt make a body of water overflow, flooding the areas around the body of water.
- **Pluvial floods:** when precipitation is so intense that areas independent of a body of water (often urban areas) are flooded.
- **Coastal floods:** when seawater floods areas along the coast, generally as a result of high winds and tides.

In certain cases, these different forms of flooding can combine (e.g., as in estuarial floods, where coastal and river flooding combine).

Because climate change is predicted to modify precipitation patterns, intensifying both dry and wet weather, it can influence all three types of floods.[20] We are already seeing increases in the intensity of flooding in a number of areas associated with climate change[21]—including recent flooding in Pakistan in 2022[22]—and it is expected that flooding will increase.[23] Although the specifics of where flooding occurs and will occur are complex, and thus hard to forecast, there is overall "high confidence that the magnitude and frequency of floods are projected to increase in many regions."[24] Increases in rainfall intensity and duration will probably increase fluvial[25] and pluvial[26] flooding at a global level. In Africa, where most "regions will undergo an increase in heavy precipitation that can lead to pluvial floods (high confidence)," with west and central Africa mentioned as being particularly at risk.[27] There is "medium confidence that extreme precipitation, mean precipitation and river floods will increase across most Asian regions."[28] Climate change will also make flooding more probable in coastal cities as a result of the combination of more frequent extreme sea flooding events (due to sea level rise and storm surge) and extreme rainfall/river flow events.[29]

2.3. Impacts of climate change on droughts

The impact of climate change on drought differs greatly depending on location. Globally, the likelihood of agricultural drought will increase despite increased rainfall.

As with floods, the literature distinguishes several different types of droughts. Meteorological droughts are periods of persistent low precipitation compared to normal levels for the area. These can lead to a reduction in surface or sub-surface water supply, known as hydrological drought. Agricultural drought occurs when low soil moisture (generally related to lack of precipitation), potentially combined with high evapotranspiration, means that there is not

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[20] Although note that "The link between rainfall and flooding is complex. While observed increases in extreme precipitation have increased the frequency and magnitude of pluvial floods and river floods in some regions, floods could decrease in some regions due to other factors" (Caretta et al., 2022, p. 577).

[21] Caretta et al., 2022.

[22] Otto et al., 2022

[23] Seneviratne et al., 2021.

[24] Caretta et al., 2022, p. 608.

[25] Caretta et al., 2022; Seneviratne et al., 2021.

[26] Seneviratne et al., 2021.

[27] Ranasinghe et al., 2021, p. 1795.

[28] Ranasinghe et al., 2021, p. 1795.

[29] Masson-Delmotte et al., 2021.

enough water to enable crops (sometimes specific named crops) to grow. While rainfall has increased in many parts of the world, the periodicity of rainfall is also changing as a result of climate change, and around 700 million people are "experiencing longer dry spells than shorter dry spells since the 1950s (medium confidence)."[30] Changes in precipitation coupled with increases in temperature and resulting higher levels of evaporation and transpiration have already contributed to increases in agricultural droughts in some regions.[31]

Looking to the next two decades, with regards to meteorological droughts, there will be "changes in intensity and frequency…with more regions showing increases than decreases."[32] Agricultural droughts will affect larger areas than hydrological droughts,[33] as soil moisture is determined not just by precipitation but also by evaporation and by the degree to which precipitation is absorbed—an element that can be affected where more intense precipitation occurs over drier ground and so runs off, rather than being absorbed. Extreme agricultural droughts are projected to be at least twice as likely globally at 1.5°C and affect large areas of northern South America, the Mediterranean, western China and high latitudes in North America and Eurasia.[34] However, they may *decrease* in some areas, including central North America, the Sahel, parts of the Horn of Africa, the eastern Indian sub-continent and parts of western and eastern Asia. [35] At 2 degrees C of warming, there is medium confidence of "increases in agricultural and ecological drought trends in North, Western and Central Africa as well as both Southern Africa regions."[36] Forecasts regarding drought in Asia, including the Middle East, are much less certain.[37]

2.4. Impact of climate change on wildfires

Climate change has increased the number of wildfires, and this trend will continue.

Climate change is also expected to increase the incidence and coverage of wildfires. This trend has already begun: "nearly 60% of countries had an increase in the number of days people were exposed to very high or extremely high fire danger in 2017–20 compared with 2001–04, and 72% of countries had increased human exposure to wildfires across the same period."[38] Geographically, over 2016-2018, India and China experienced the greatest increases, with an increase of more than 21 million people exposed in India and 17 million exposed in China.[39] Fire weather is expected to increase in North America, Central America, South America, Oceania and across Asia (except Southeast Asia, the Tibetan Plateau and the Arabian Peninsula) as a result of climate change.[40]

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[30] Caretta et al., 2022, p. 4.

[31] Masson-Delmotte et al., 2021.

[32] Masson-Delmotte et al., 2021, p. 15.

[33] Caretta et al., 2022.

[34] Caretta et al., 2022.

[35] Caretta et al., 2022. Note that these areas are given as potentially seeing decreases in extreme drought in the text, p. 608. The figure on p.609 suggests, however, that only *parts* of the horn of Africa will see decreased levels of drought at 1.5 degrees of warming, and that other areas will see increased levels of drought. The same figure suggests that western southern Africa will also see increased levels of drought.

[36] Ranasinghe et al., 2022, p.1794

[37] Ranasinghe et al. 2022

[38] Romanello et al., 2021, p. 1628.

[39] Watts et al., 2019.

[40] Seneviratne et al., 2021.

2.5. Impact of climate change on tropical storms and cyclones

Climate change does not necessarily make storms more frequent, but it does make them more damaging.

The main impact of climate change on cyclones and tropical storms is to increase their intensity and "destructive energy."[41] To date, the "adverse impacts from tropical cyclones, with related losses and damages, have increased due to sea level rise and the increase in heavy precipitation (medium confidence)."[42] The location of tropical storms is also shifting away from the tropics and toward the poles.[43] There are insufficient data to show whether climate change has made tropical storms more frequent.

Climate change is projected to continue to increase the intensity of cyclones, as temperatures rise and the oceans warm. WMO projects that "every 1°C increase in tropical sea-surface temperature will likely result in a 3–5% increase in cyclone wind-speed."[44] As such, the IPCC predicts with high confidence that the *proportion of intense* cyclones and tropical storms (categories 4–5) will increase at the global scale with increased global warming.[45]

The main immediate concerns related to tropical storms and cyclones relate to increased precipitation leading to flooding, and coastal development combined with sea-level rise leading to storm surges in densely inhabited coastal and delta areas. It should be noted that many humanitarian practitioners and populations affected by storms have identified storms as occurring in new areas—but there is not as yet scientific evidence for this.

2.6. The consequences of climate change for forced displacement

There is some disagreement over the degree to which climate change is already leading to forced displacement, but general agreement that it is often at least one important factor that leads people to leave their homes. Most of this displacement appears to be internal, rather than cross-border. Future estimates of the number of people who might be displaced as a result of climate change vary, but can be extremely high.

Though the relationship between climate change and extreme weather is fairly clear, the relationship between climate change and displacement and distress migration is more complex. Climate can influence people's decisions to move in a number of different ways. Acute events such as flooding or cyclones may force people to find shelter elsewhere. Longer-term environmental impacts, such as sea-level rise or increased difficulty in growing crops, may contribute to decisions to move (although studies suggest that, in many cases, climate is just one of many factors that influence this type of decision).[46] But the economic impacts of climate change may also prevent people from moving.[47]

The nature of this movement also differs from one situation to the next, and often depends on pre-existing patterns of movement within the household or community. People might move for a short period of time—perhaps until the flood waters have subsided—or for longer periods. They might move within their own local area, their own country or across an international border. They might move as entire households, or one member of the household might move in order to send remittances home.

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[41] Biermann & Boas, 2010, p. 68.

[42] Pörtner, Roberts, Tignor, et al., 2022, p. 9.

[43] Masson-Delmotte et al., 2021.

[44] IASC, 2021, p. 4; see also WMO, 2020.

[45] Masson-Delmotte et al., 2021.

[46] Peters, 2020; Jayawardhan, 2017; McAdam, 2014.

[47] ICRC, 2020

Perhaps because of this variety in types of displacement, and related difficulties of definition, there is some disagreement over the degree to which climate change is causing forced displacement. Some authorities suggest that climate change alone is causing displacement; others that climate is one of a number of factors that contribute to displacement. The latest IPCC report states unequivocally that "Climate and weather extremes are increasingly driving displacement in all regions (high confidence)."[48] Some researchers point to specific examples of displacement that they say can be clearly attributed to climate change: in recent years, for example, drought has contributed to more than 1 million people being displaced in Somalia[49] and to hundreds of thousands being displaced in Afghanistan.[50] Cyclones and flooding have also directly led to the displacement of very large numbers of people in South Asia.[51] However, others suggest that climate is only one of a number of factors that lead people to move, and that it is difficult to isolate climate from other factors leading to displacement.[52] From this perspective, climate change can be said to contribute to displacement, but cannot be said to cause it.

With respect to forced migration—climate-related displacement across a border—the IPCC AR6 report suggests that "through…involuntary migration from extreme weather and climate events, climate change has generated and perpetuated vulnerability (medium confidence),"[53] while suggesting that in the near term, migration will be driven more by socioeconomic conditions and governance issues than by the climate. But a number of authorities suggest that there is little or no evidence to support the idea that climate change is leading to "climate migrants" or "climate refugees". A recent review of the literature on the topic[54] suggests that "there is no evidence of an upward trend in weather shock- or climate change-related migration."[55] A number of other reports make similar statements,[56] suggesting that there is little or no evidence of climate change leading to people moving across borders. These reports are seemingly motivated (in part at least) by the desire to contradict "the notion regularly presented in the media, global risk polls and some studies that climate change will result in significant new international migration flows."[57] In general, studies considered for this review suggest that, to date at least, people moving to escape extreme weather events have tended to stay in their own countries.[58]

Looking to the future, it is difficult to project how many people will be displaced by climate change. Projections vary enormously[59] for the definitional reasons outlined above, and because future numbers depend on choices that still have to be made by governments and people around the world. Specifically, the number of people displaced by climate will be determined by the success or otherwise of actions taken to prevent further climate change

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[48] Pörtner, Roberts, Tignor, et al., 2022.
[49] UNDRR, 2019.
[50] Amoli and Jones, 2022
[51] Pandey, 2017 in IASC, 2021, p. 21.
[52] Peters, 2020; Warren, 2016; Wilkinson, E. 2016 Jayawardhan, 2017; UNHCR, 2021
[53] [53] Pörtner, Roberts, Tignor, et al., 2022.p.11
[54] Which considered high and medium quality academic journal articles, plus expert studies by climate change and migration research organisations and by development and non-governmental organisations (Selby & Daoust, 2021).
[55] Selby & Daoust, 2021, p.58.
[56] IDMC, 2021; UNHCR 2021
[57] IDMC 2021
[58] Selby & Daoust, 2021;
[59] Selby & Daoust, 2021.

(mitigation), and of actions taken to protect people from the worst effects of climate change (such as flood defenses, changes to agricultural practices, and other adaptation activities).[60]

One figure often quoted is the one proposed in the 2006 “Stern Report,” which estimated that 150–200 million people would be displaced due to climate change by 2050.[61] More recently, the World Bank’s “Groundswell 2” report estimated that by 2050 the world could expect an additional 216 million migrants as a result of climate change, but that 80% of this migration could be prevented if governments put effective climate change mitigation and adaptation measures in place.[62] Most of these projections are for periods beyond 2050. The IPCC says that “migration patterns in the near-term [to 2035] will be driven by socioeconomic conditions and governance more than by climate change (medium confidence),”[63] while “in the mid- to long-term, displacement will increase with intensification of heavy precipitation and associated flooding, tropical cyclones, drought and, increasingly, sea-level rise (high confidence).”[64]

Essentially, we can be almost certain that we will increasingly see very large numbers of people displaced in a variety of ways for reasons related to climate change in specific locations and situations.[65] But it is not possible to say with any certainty how large these numbers will be or whether, in the next decade, these episodes of displacement will show an increasing trend when compared with recent decades.

2.7. The consequences of climate change for conflict

Countries affected by conflict are particularly vulnerable to the effects of climate change. The combination of conflict and climate change magnifies crises and increases suffering, while decreasing the ability of government and civil society to prepare for future disasters.

The relationship between climate change and conflict is also unclear. Some studies suggest a statistically significant link between changes in climate and increased incidence of conflict,[66] and International Medical Corps focus groups participants gave several examples of conflicts that they suggested were clearly related to climatic issues. However, the academic consensus appears to be that climate factors alone are not currently leading directly to conflict where no pre-existing tensions exist. Climate can, however, contribute indirectly to conflict by exacerbating existing social tensions and so making conflict more likely.[67] In the immediate future, the IPCC suggests that conflict is more likely to be driven by socio-economic and governance issues than by climate alone.[68]

In many cases, the greater concern will be around climate change and conflict interacting to increase vulnerabilities and humanitarian need, because conflict makes it more difficult for people to survive the crises of climate change. Conflicts (and particularly internal conflicts) can decrease the resources, attention, access and legitimacy that governments need to successfully engage in programs to develop resilience or prepare for climate-related crises.[69] Conflicts also serve as a disincentive for external donors to invest in programs to reduce the

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[60] Biermann & Boas, 2010; Field et al., 2014; Romanello et al., 2021.
[61] Stern, 2007.
[62] Clement et al., 2021.
[63] Pörtner, Roberts, Tignor, et al., 2022, p. 13.
[64] Pörtner, Roberts, Tignor, et al., 2022, p. 15.
[65] Field et al., 2014.
[66] Hsiang et al., 2013.
[67] Bodhi Global Analysis Ltd, 2021; Field et al., 2014; ICRC, 2020; Peters et al., 2020.
[68] Pörtner, Roberts, Tignor, et al., 2022, p. 15.
[69] Field et al., 2014; ICRC, 2020; Poole et al., 2020.

deadly impacts of climate change,[70] and make communities and households more vulnerable to these impacts by decreasing access to services and making it more difficult to earn a living or build up reserves, even in "good" years.[71]

In short, where countries enduring conflict are also affected by climate change, the two interact to make suffering much worse. These destructive interactions are common in the places where humanitarians work. More than two-thirds of the countries experiencing conflict in 2021[72]—including three of the five largest humanitarian crises[73]—are among the most vulnerable in the world to climate change, according to the ND Gain index of climate vulnerability.[74]

3. Climate change and humanitarian health

Climate change will have significant negative impacts on the health of people living in countries where International Medical Corps operates. The most recent IPCC report states: "Climate change and related extreme events will significantly increase ill health and premature deaths from the near to long-term (very high confidence)."[75] The World Health Organization says that climate change is "the biggest health threat facing humanity"[76] and that 50 years of advances in public health are under threat as a result of climate change.[77]

While the threat is clear, "it remains challenging to accurately estimate the scale and impact of many climate-sensitive health risks."[78] One figure that is regularly quoted is an excess death rate of 250,000 people per year from 2030—which seems low when compared to the very negative pronouncements above. The figure does, indeed, represent a significant underestimate. It is based on a 2014 study that the authors make clear only considers some potential causes of death, has limited ability to model several of these causes and assumes an optimistic emissions scenario.[79] It also considers mortality only, rather than estimating impacts on disease morbidity.

This negative impact on health will occur in a number of ways. In addition to the health impacts of disasters (floods, heatwaves, etc.), changes in temperature and precipitation are expected to make conditions more suitable for transmission of infectious diseases in many areas, extending the range and/or seasonal duration of diseases, including malaria, dengue and cholera.[80] Experts also predict negative impacts related to non-communicable diseases and mental health.

[70] Knox-Clarke, 2018.

[71] Field et al., 2014; ICRC, 2020; UNDRR, 2019; Wagner & Jamie, 2020.

[72] According to the World Bank list of fragile and conflict-affected situations, FY 2022 (World Bank, 2022).

[73] By humanitarian expenditure, the three countries are Yemen, DRC and Somalia (Development Initiatives, 2022).

[74] Of 22 countries, nine are in the bottom 20% for exposure to climate change; 14 are in the bottom 20% of the ND Gain index for vulnerability to the effects of climate change (a combination of exposure, sensitivity to this exposure and ability to adapt) and 19 are in the bottom 20% of the overall ND Gain Index (which combines vulnerability with the ability to leverage investment and use it for adaptation). The ICRC report presents these data slightly differently: "60% of the 20 countries considered to be most vulnerable to climate change, by the ND-Gain Index, are sites of armed conflict" (ICRC, 2020, p. 5).

[75] Pörtner, Roberts, Tignor, et al., 2022, p. 15.

[76] WHO, 2023b.

[77] WHO, 2018.

[78] WHO, 2023b.

[79] WHO, 2014.

[80] Alcayna, 2021; Burson, 2021; Chowdhury et al., 2020; Field et al., 2014; Watts et al., 2019.

It is important to recognize that poor health, in addition to the intrinsic suffering caused, is a major constraint to livelihood generation and a major source of expenditure for poor households.[81]

3.1. The health impacts of extreme weather events

3.1.1. Direct health impacts of extreme weather events

The table below outlines some of the direct health impacts of two types of extreme weather event that are outlined in the literature (note that these are not exhaustive lists).

Table 1: Summary table of the impacts of extreme weather events and populations most vulnerable. Authors' own work.

Type of event	Injury/Mortality	Vulnerable population
(Flash) Flood / Cyclone	Drowning, biting by poisonous insects or snakes, being carried away by high floods or electrocuted.[82] Incidence and mortality tend to be higher in flash floods and storm surges. They tend to happen during the peak of the flood event, but may also occur post flood as people return to salvage goods from their homes.[83]	Women, children, elderly, migrant populations, poor people, people with disabilities.[84] Minorities and ethnic groups might have special needs.[85]
Extreme Heat	Mild skin irritation (heat rash), cramps, swelling, fatigue, heat exhaustion and heat stroke (which occurs at body temperatures above 40°C and can be fatal), aggravation of pre-existing cardio-vascular and respiratory diseases.[86]	Elderly, pregnant women, people with chronic respiratory or circulatory conditions, people living in urban areas, outdoor workers, people on medication that affects their capacity to regulate body temperature.[87]

As Table 1 shows, people who are marginalized in society tend to suffer the worst impacts and higher mortalities. In the case of floods for example, in many countries, women represent the largest share of mortality because they might not have permission to leave the house unaccompanied.[88] In the event of a cyclone, some refugee populations in Cox's Bazar do not have access to cyclone shelters located outside the camp as they are not permitted to leave (personal communication). The 2021 Lancet countdown found that while "the past 30 years have seen statistically significant increases in the number of extreme weather events;

[81] Chowdhury et al., 2020; Kapoor et al., 2021b; Keim, 2008; Levine & Venton, 2019.
[82] Associated Programme on Flood Management (APFM), 2006; WHO & WMO, 2012.
[83] Few et al., 2004.
[84] Associated Programme on Flood Management (APFM), 2006; Few et al., 2004; WHO & WMO, 2012.
[85] WHO & WMO, 2012.
[86] Lee et al., 2019; WHO, 2015.
[87] Costello et al., 2009; Field et al., 2014; IFRC, 2019; Lee et al., 2019; McMichael & WHO, 2003; WHO, 2015.
[88] Parida, 2015; Watts et al., 2019.

only the low HDI group [that is, countries scoring low on the Human Development Index] had a statistically significant increase in the number of people affected by these events."[89]

3.2. Indirect health impacts of extreme weather events

3.2.1. Food and water-borne diseases and extreme weather

The latest report of the IPCC finds that "heavy rainfall events (high confidence) and flooding (medium confidence) are associated with increased water-borne diseases."[90] Extreme water-related events (heavy rainfall and floods) have been associated with a range of water-borne diseases, particularly diarrhea,[91] cholera,[92] hepatitis[93] and typhoid,[94] although the evidence for a causal relationship between these last diseases and flooding is weaker than for diarrhea.[95] Hepatitis A and E virus outbreaks have also been seen to occur after heavy rains and flooding.[96]

With respect to the disease pathway, heavy rainfall and flooding can lead to: pathogens entering the water supply as a result of increased runoff from surrounding areas;[97] damage to water and sanitation infrastructure leading to fecal matter entering the water supply;[98] and changes in behavior, such as an increase in open defecation and use of untreated water for washing and food preparation.[99] In addition, proper food storage and preparation of food depend on facilities for storage and cooking, which might be limited during these events. This increases the risk of foodborne diseases, especially for vulnerable groups such as pregnant and lactating women and children under 5 years of age.[100]

Droughts also impact water-borne diseases, by impacting water quality, quantity, and usage. Drought can increase the concentration of pathogens such as typhoid, cholera and giardiasis in water due to reduced volumes of water and reduced flow rates.[101] It can also lead to "higher probability of microbial contamination of drinking water due to infiltration of organic material along the distribution system when pressure drops [and] higher re-use of wastewaters in agriculture, with consequent contamination of fresh vegetables."[102] By reducing the amount of water available, droughts also influence usage of water. People may be more likely to use untreated water for food preparation or for washing.[103]

In addition to increased levels of pathogens, pollutant concentrations in water tend to increase when conditions are drier. This is of concern for "groundwater sources that are already of low

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[89] All HDI country groups have had a consistent and statistically significant increase in the number of extreme weather events during the past 30 years, with the very high HDI group having the highest increase (appendix 5, pp. 28–32). However, only the low-HDI group has had a statistically significant increase of people affected per disaster event—a situation that might reflect a more rapid growth in the populations living in high-risk areas within low HDI countries or inequities between HDI groups in adaptive capacity and preparedness to respond to worsening climate change hazards. Romanello et al, 2021 P. 11.

[90] Pörtner, Roberts, Adams, et al., 2022, p. 51.

[91] Few et al., 2004; WHO, 2021b; 2021a.

[92] APFM et al., 2015; WHO, 2021b; 2021a.

[93] APFM et al., 2015; Few et al., 2004; WHO, 2021a.

[94] APFM et al., 2015; Few et al., 2004; WHO, 2021a.

[95] Few et al., 2004.

[96] Few et al., 2004.

[97] Cann et al., 2013; Tinker et al., 2010; WHO, 2021a.

[98] APFM et al., 2015; Cann et al., 2013; WHO, 2021b; 2021a.

[99] McMichael & WHO, 2003.

[100] Bush et all, (2022)

[101] Cann et al., 2013; McMichael & WHO, 2003.

[102] Funari et al., 2012, p. 477; see also Lipp et al., 2002.

[103] Funari et al., 2012; McMichael & WHO, 2003.

quality, such as in certain locations in India and Bangladesh, North and Latin America, and Africa, where concentrations of arsenic, iron, manganese and fluorides are often problems."[104]

Heatwaves can also impact the incidence of water-borne diseases by speeding up the growth rate of pathogens in water infrastructure and elsewhere while making some chemical treatments of water less effective (see also the longer-term health impacts of a changing climate, below).[105]

The populations most vulnerable to water-borne diseases in the aftermath of an extreme weather event are children and people with prior health conditions, as well as those living in precarious situations who are most likely to end up using contaminated food and water.[106] Importantly, diarrheal diseases already have greater incidence in developing countries.[107]

This impact of extreme weather on food and water-borne diseases is projected to increase in the near future, as extreme weather events increase. For example, in Pakistan, because of extreme weather events, "the proportion of diarrheal deaths due to climate change could rise from 11.7% to approximately 17% by 2050" and "is projected to lead to an additional 5,639 diarrheal-related deaths in children by the year 2030."[108]

3.2.2. Vector-borne diseases and extreme weather

Extreme weather events, such as heavy rainfall and flooding, can lead to standing water that stagnates,[109] while droughts can reduce water flow—also leading to stagnation of surface water—and incite water storing, both of which can create breeding sites for the mosquito vector.[110] People may also be vulnerable to infection where they have lost shelter or are living in temporary shelters.[111]

Increased incidence of malaria has been reported after flooding and cyclones,[112] as has increased incidence of Rift Valley fever.[113] Droughts, on the other hand, can lead to increase in malaria-related mortality the following year. Because drought can reduce the transmission of malaria at the time of the event, there might be "a reduction in herd immunity in the human population...[such that] in the subsequent year the size of the vulnerable population is increased."[114] People who have been poorly nourished as a result of crop failure may also be more susceptible to malaria.[115] However, evidence for these indirect links is mixed and should not be overemphasized.[116]

Schistosomiasis can also infect larger numbers of people after flooding, where floods wash the snail vector from stagnant water (such as rice paddies) into other water features.[117] Similarly, leptospirosis, a zoonotic disease spread by rats, has been associated with flooding in a number of countries.[118]

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104 WHO, 2017, p. 10 ; see also Caretta et al., 2022.
105 WHO, 2021a.
106 Few et al., 2004; Martin & Zermoglio, 2017.
107 Martin & Zermoglio, 2017.
108 Kapoor et al., 2021b, p. 24; see also WHO, 2016.
109 Importantly, the mosquito transmitting dengue fever breeds in man-made containers, and thus while water stagnation can lead to more breeding, this is especially the case in urbanised spaces (Few et al., 2004).
110 WHO & WMO, 2012.
111 Few et al., 2004.
112 Few et al., 2004; Kapoor et al., 2021a.
113 Martin & Zermoglio, 2017.
114 McMichael & WHO, 2003, p. 82.
115 McMichael & WHO, 2003.
116 Stanke et al., 2013.
117 Few et al., 2004.
118 Few et al., 2004.

3.2.3. Non-communicable diseases and extreme weather

Heatwaves resulting from climate change can aggravate pre-existing cardio-vascular diseases.[119] Cardiovascular disease is the primary cause of death in heatwaves,[120] partially as a result of increased blood viscosity.[121] They can also make respiratory illnesses such as chronic obstructive pulmonary diseases, asthma and respiratory tract infections worse, as heatwave conditions "can inflame the airways resulting in sudden and severe respiratory distress."[122] Higher temperatures in general lead to increased air pollution (see also section 3.3.3 below), which also aggravate respiratory conditions.[123]

People with pre-existing conditions, particularly depression and diabetes (as well as the cardiovascular and respiratory conditions mentioned above), can be at particular risk of negative health impacts in heatwaves as a result of limited mobility and limited awareness of the need to stay hydrated or of the dehydrating effects of some medications.[124] Women and outdoor workers are most vulnerable to the effects of air pollution—the latter because of outdoor exposure, the former due to indoor pollution through the use of fuel for cooking, for example. Indeed, "exposure to household air pollution is estimated to be around 40% higher for women than for men."[125]

Where pre-existing conditions affect mobility, they can also increase the sufferer's vulnerability to other extreme weather events, such as flooding and cyclones.

3.2.4. Maternal and children's health and extreme weather

Pregnant women and children are also particularly vulnerable to heatwaves. Pregnant women's ability to thermoregulate is challenged, increasing their risk of heat-related illness and birth complications—for example, women are more likely to give birth pre-term as a result of heat stress.[126]

Children and infants are also at risk of heat-related illness or death due to their developing thermoregulation mechanisms. An age group study in Durban, South Africa, reported that children under age 4 had the largest increase in natural deaths for each 1°C increase in apparent temperature above a 20°C threshold.[127]

In addition, young children can be unaware of the need to drink more water, and so risk dehydration. Parents or caregivers of young children may not be aware of the need, or may not have the means to ensure that their children drink enough clean water.[128]

3.2.5. Access to healthcare during extreme weather

Extreme weather events also impact infrastructure, limiting access to primary healthcare, and thus allowing pre-existing conditions to deteriorate as well as worsening injuries incurred during the disaster.[129] In the case of a heatwave, for example, hospital admissions are likely to increase, overstretching the services and reducing overall access to healthcare. This is

[119] Franchini & Mannucci, 2015; IFRC, 2019; Martin & Zermoglio, 2017.
[120] Cissé et al., 2022.
[121] Lee et al., 2019; McMichael & WHO, 2003.
[122] IFRC, 2019, p. 48 ; see also Franchini & Mannucci, 2015.
[123] Kapoor et al., 2021a; Martin & Zermoglio, 2017; Romanello et al., 2021; Watts et al., 2019; WHO & WMO, 2012.
[124] Lee et al., 2019.
[125] Romanello et al., 2021, p. 1641; see also Shupler et al., 2018.
[126] USAID, 2020a.
[127] Lee et al., 2019.
[128] Lee et al., 2019.
[129] Few et al., 2004.

worsened by the strains on other systems, such as electricity and water.[130] Similar dynamics, in the sense of straining healthcare services due to both high admissions and infrastructure damage, are found for floods[131] and for cyclones,[132] especially in densely populated areas.[133]

Following an extreme weather event, reduced access to healthcare can remain a problem for some time, having a longer-term impact. This has been seen in areas such as sexual and reproductive services.[134]

Importantly, this impacts the most vulnerable,[135] who might have already suffered from limited access to healthcare prior to the extreme event.[136]

3.3. The longer-term health impacts of a changing climate

In addition to the health impacts of extreme weather events, climate change harms health by increasing existing disease burdens and other threats to health, particularly for those in areas with the weakest health protection systems.[137] As the world heats further, these health effects are expected to increase.

3.3.1. Food and water-borne diseases

The IPCC's latest report finds that "higher temperatures are associated with increased water-borne diseases (very high confidence)."[138]

Higher temperatures can increase water contamination by pathogens "such as cyanobacterial toxins, which cause a range of health problems, including skin irritations, stomach cramps, vomiting, nausea, diarrhea, fever, sore throat, headache, muscle and joint pain, mouth blisters and liver damage."[139] Higher temperatures also speed up the growth rate of pathogens in aquatic environments.[140] One particularly important example is *V. cholerae*, the pathogen responsible for transmission of cholera, which "is known to show an increased growth rate at increased temperatures, with increasing global temperatures also expected to increase prevalence both geographically and temporally."[141] It is anticipated that rising temperatures will endanger water quality, particularly in relation to cholera in South America and Asia.[142]

As noted above, higher temperatures may also complicate the ability to purify water, by rendering certain chemical treatments less stable or effective.[143]

3.3.2. Vector-borne diseases

The incidence of vector-borne diseases, such as malaria or dengue fever, is also predicted to be affected by changing climate. "[T]emperature, precipitation and humidity have a strong influence on the reproduction, survival and biting rates of the mosquitoes that transmit malaria and dengue

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[130] IFRC, 2019; Lee et al., 2019.
[131] Few et al., 2004; Seneviratne et al., 2021; WaterAid, 2021; WHO & WMO, 2012.
[132] WHO & WMO, 2012.
[133] McMichael & WHO, 2003.
[134] McMichael & WHO, 2003; Pörtner, Roberts, Tignor, et al., 2022.
[135] Women, the elderly, children, people with prior health vulnerabilities/conditions, people with disabilities and ethnic minorities (Costello et al., 2009).
[136] Costello et al., 2009; Lee et al., 2019; WHO, 2021c.
[137] Costello et al., 2009; WHO, 2023a.
[138] Pörtner, Roberts, Adams, et al., 2022, p. 51.
[139] WHO, 2021a, p. 11; see also WHO, 2017.
[140] Funari et al., 2012.
[141] Funari et al., 2012, p. 477; see also Lipp et al., 2002.
[142] Funari et al., 2012; Hunter, 2003.
[143] Caretta et al., 2022.

fever, and temperature affects the life-cycles of the infectious agents themselves."[144] Climate change is predicted to impact both the range and seasonality of vector-borne diseases, increasing human exposure, although some areas may see some reduced incidence.[145]

Dengue fever. Increases in temperature favor the development of "both the mosquito vector and the virus, fueling more intense transmission."[146]

As with most climate predictions, there is significant uncertainty around dengue fever.[147] Though some long-term predictions indicate that "the annual number of people exposed to the mosquito [is] projected to increase by 8–12% when only considering climate change,"[148] the projections are significantly higher when population growth is taken into account.[149] Areas most impacted by the El Niño-Southern Oscillation (ENSO)[150] are predicted to see the highest increases in exposure.[151] In South America, for example, it is suggested that the "mean potential transmission intensity could be expected to increase by a factor of 2 to 5 under conditions with a 2°C rise in temperature."[152]

Climate change is predicted to impact not only places where dengue is already present, but also to affect new regions, such as New Zealand and Australia.[153]

Malaria. The incidence of malaria is forecast to be influenced by the impacts of climate change.[154] Climate variables impact the propagation of the mosquito vector and parasite dynamics.[155] "Rainfall produces mosquito-breeding sites, humidity increases mosquito survival and temperature affects parasite development rates."[156]

Increases in temperatures favor the presence of the mosquito vector, in combination with conducive patterns of rainfall and surface water.[157] For example, in the east African highlands, a study found that "mosquito abundance is amplified with warming, with an over ten-fold increase with every unit increase (0.1°C) in temperature."[158] As temperatures increase, parasite development rates increase as well.[159]

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[144] WHO & WMO, 2012, p. 7.

[145] Field et al., 2014; Martin & Zermoglio, 2017; McMichael & WHO, 2003; WHO, 2015; Zermoglio et al., 2019.

[146] WHO & WMO, 2012, p. 20.

[147] Kapoor et al., 2021a; Martin & Zermoglio, 2017; WHO, 2016.

[148] Ebi & Nealon, 2016, p. 120; see also Monaghan et al., 2018.

[149] With the same estimate, the number of people exposed would increase "by 59–65% when considering climate change and a development pathway associated with population growth that peaks mid-century and then declines; and by 127–134% when considering climate change and a development pathway associated with high population growth" (Ebi & Nealon, 2016, p. 121; see also Monaghan et al., 2018).

[150] "The El Niño-Southern Oscillation (ENSO) is a recurring climate pattern involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean. On periods ranging from about three to seven years, the surface waters across a large swath of the tropical Pacific Ocean warm or cool by anywhere from 1°C to 3°C, compared to normal. This oscillating warming and cooling pattern, referred to as the ENSO cycle, directly affects rainfall distribution in the tropics and can have a strong influence on weather" (National Weather Service, 2023).

[151] McMichael & WHO, 2003.

[152] Martin & Zermoglio, 2017, p. 15.

[153] Costello et al., 2009.

[154] Importantly, incidence of malaria is not only impacted by climatic factors, but this is only one of the determinant factors, as "malaria incidence is influenced by the effectiveness of public health infrastructure, insecticide and drug resistance, human population growth, immunity, travel, land-use change and climate factors" (McMichael & WHO, 2003, p. 82).

[155] WHO & WMO, 2012.

[156] WHO & WMO, 2012, p. 10.

[157] Costello et al., 2009; McMichael & WHO, 2003; WHO & WMO, 2012.

[158] Costello et al., 2009, p. 1702; see also Pascual et al., 2006.

[159] Costello et al., 2009; WHO & WMO, 2012.

The effects of climate change can be expected to lead to changes in both the range and seasonality of malaria. With increases in temperatures, the geographical range of malaria is expected to change: some places that were previously suitable for malaria will become too warm and thus unsuitable, while others that were previously too cold will become suitable.[160] Overall, the literature suggests three expected patterns:

- *New areas* of malaria suitability that were previously unsuitable, especially in higher latitudes.[161,162] "The worst-case regional scenario (RCP8.5) of climate change predicted an additional 75.9 million people at risk from endemic (10–12 months) exposure to malaria transmission in Eastern and Southern Africa by the year 2080, with the greatest population at risk in Eastern Africa."[163]
- *Extension* of the number of months suitable for malaria transmission. For example, in Southern Africa, "between the 2030s and 2050s, rising temperatures will likely increase the southern range of seasonal suitability (7–9 months) adding approximately 3 to 26 million people at risk from seasonal malaria exposure."[164]
- *Reduction* of the number of months for malaria suitability, especially in dryer and hotter lowland areas.[165]

Note, though, the uncertainty around these forecasts. A number of authorities point to the uncertainties of predicting malaria epidemics nationally and locally.[166]

Rift Valley fever. Climate change is predicted to make Rift Valley fever, which is more deadly for livestock than humans, more prevalent, worsening food poverty in pastoralist settings. Outbreaks so far have coincided with "altered rainfall patterns resulting from large-scale climate dynamics such as ENSO and La Niña events and elevated Indian Ocean temperatures that cause heavy rainfall and flooding."[167] These make up favorable conditions for vector breeding, increasing the incidence of the disease.[168]

Schistosomiasis. Overall, this disease is predicted to increase with higher temperatures, as "cool water and ambient temperatures currently limit suitable habitat."[169] Indeed, in East Africa, "a modelling exercise suggested that rising temperatures alone may increase the risk of schistosomiasis by 20% in coming decades, with the parasite declining in some areas[170] and expanding in others."[171,172] As with malaria, some places are projected to have reduced incidence of schistosomiasis over the next 20 years, as the temperature becomes too high, such that the "risk might decrease by more than 50 percent in parts of north and east Kenya, southern South Sudan and eastern Democratic Republic of Congo."[173]

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[160] Costello et al., 2009; Martin & Zermoglio, 2017; USAID, 2019; Watts et al., 2019; Zermoglio et al., 2019.
[161] Especially in East Africa (Zermoglio et al., 2019).
[162] Martin & Zermoglio, 2017; Masson-Delmotte et al., 2021; Romanello et al., 2021; Watts et al., 2019; Zermoglio et al., 2019.
[163] Ryan et al., 2020, p. 1.
[164] Martin & Zermoglio, 2017, p. 6.
[165] Martin & Zermoglio, 2017.
[166] Costello et al., 2009; Reiter et al., 2004.
[167] Martin & Zermoglio, 2017, p. 15.
[168] Field et al., 2014; Martin & Zermoglio, 2017.
[169] Martin & Zermoglio, 2017, p. 17; see also Costello et al., 2009; Few et al., 2004; Watts et al., 2019.
[170] Parasite newly endemic in these areas: Rwanda, Burundi, southwest Kenya and eastern Zambia.
[171] The risk of schistosomiasis could decrease by more than 50 percent in parts of north and east Kenya, southern South Sudan and eastern Democratic Republic of Congo.
[172] Martin & Zermoglio, 2017, p. 18; see also McCreesh et al., 2015.
[173] Martin & Zermoglio, 2017, p. 18; McCreesh et al., 2015.

Other vector borne and zoonotic diseases. Losses of biodiversity and changing climate may also lead to increases in "fascioliasis, alveolar echinococcosis, leishmaniasis, Lyme borreliosis, tick-borne encephalitis and hantavirus infections."[174] It can also lead to ecosystem modifications that could "lead to catastrophic diseases outbreaks" as yet unknown.[175]

Other communicable diseases. Meningococcal meningitis is predicted to be influenced by ENSO events, with hot and dry conditions and low rainfalls favoring its transmission.[176]

3.3.3. Non-communicable diseases

The main non communicable diseases addressed in the literature reviewed for this report were cardiovascular and respiratory, which are forecast to be exacerbated by increased temperatures. Information on this can be found in the section "Non communicable diseases and extreme weather," above, relating specifically to heatwaves. Heatwaves, however, are only the most extreme form of heating, and the disease burden related to these conditions can be expected to increase as part of the general increase in average temperatures, as well as situations of extreme heat.

An additional driver of mortality and disease morbidity related to climate change is air pollution. Air pollution currently accounts for an estimated 6.7 million deaths annually,[177] making it a leading cause of death (ahead of malaria, HIV, tuberculosis, drugs and alcohol).[178] Deaths result from a variety of conditions, including ischemic heart disease, stroke, lung cancer, chronic obstructive pulmonary disease, pneumonia, type 2 diabetes and neonatal disorders. Indeed, 43% of chronic pulmonary disorders are a result of air pollution.[179] People in low- and middle-income countries, and particularly vulnerable populations such as the elderly, children and people living in densely populated (urban) areas, are most at risk.[180] A number of authorities highlight the particular risks to people living in informal settlements.[181] Despite this vulnerability profile, NGOs and other actors have tended not to focus on the threat that atmospheric pollution poses to health.[182]

Climate change is related to air pollution in two ways. First, many of the activities that drive climate change (such as burning fossil fuels) also contribute significantly to air pollution. Second, climate change—and the effects of climate change—directly contributes to air pollution in a number of ways. For example, increased heat speeds up the chemical reactions that create ozone in the lower atmosphere.[183] Such ground-level ozone is associated with many health problems, including diminished lung function, increasing numbers of health events caused by asthma and increases in premature deaths.[184] Droughts and related desertification increase the amount of dust in the air, and forest fires increase particulates.[185] Overall, increased heat aggravates the negative health impacts of air pollution.[186])

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[174] Costello et al., 2009, p. 1703 ; see also Brownstein et al., 2005; Cardenas et al., 2008; Clement et al., 2009; Costello et al., 2009, p. 1703; Gray et al., 2009; Mas-Coma et al., 2008; Watts et al., 2019.

[175] Costello et al., 2009, p. 1703 ; see also Aguirre & Tabor, 2008; Costello et al., 2009, p. 1703.

[176] Martin & Zermoglio, 2017; McMichael & WHO, 2003; Oluwole, 2015; WHO & WMO, 2012.

[177] WHO 2023c

[178] Fuller et al. 2022

[179] WHO 2023c

[180] Clean Air Fund, 2022; 2022; Murray et al., 2020

[181] Zimmermann et al., 2017; Wekesa et al., 2011; West et al., 2020

[182] Zimmermann et al., 2017

[183] Ozone in the lower atmosphere is created by the interaction of ultraviolet light and hydrocarbons or nitrous oxides.

[184] Centers for Disease Control (ND)

[185] Delfino et al., 2009; Jones, Matthew W. et al., 2020

[186] Willers et al., 2016

3.4. Climate change and mental health

The most recent IPCC report concluded with very high confidence that "climate change is expected to have adverse impacts on well-being and to further threaten mental health."[187]

3.4.1. Extreme weather events and mental health

Extreme weather events, such as wildfires, floods and storms, are associated with increased diagnoses of post-traumatic stress disorder (PTSD), depression, anxiety, extreme psychological stress and distress, substance use and suicidality. [188]

Extreme weather events have been associated with depression,[189] in particular drought and floods.[190] Extremes in heat have been associated with an increase in psychiatric emergencies and violent behaviors toward self and others.[191] Flooding has been claimed to lead to increased rates of suicide, although the empirical evidence for this is sometimes rebutted.[192] There appears also to be increased suicide risk for people who are experiencing repetitive or severe hazards.[193]

These effects have been observed in people of all ages, as well as in healthcare professionals working in disaster relief and epidemic response[194] which then affects the capacity of emergency health services to respond. In addition, people who are displaced are particularly likely to feel distress, as displacement disrupts access to support and social ties. Children and adolescents are also particularly likely to feel distress.[195]

Secondary stressors predicting worse outcomes in the aftermath of extreme weather events include experiences of evacuation,[196] damage to property and possessions, financial loss, threat or harm to self or loved ones, lesser social support, inadequate medical care and inadequate welfare support (such as unsafe or unclean accommodation, or inadequate food, water or electricity).[197]

3.4.2. Increased temperatures and mental health

There is evidence from a range of countries [198] suggesting that high, extreme and variable temperatures worsen a range of mental health and well-being outcomes, including:

- increased rates of suicide;
- increased rates of hospital, emergency department attendance and admissions for mental disorders; and
- general population mental health and psychosocial well-being impacts.

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[187] Masson-Delmotte et al., 2021, p. 63.
[188] Bryant et al., 2014; Wagner et al., 2009; ISTSS ND; Bourque & Cunsolo Willox, 2014; Carroll et al., 2009; Corvalan et al., 2022; WHO, 2006.: Associated Programme on Flood Management (APFM), 2006; Atwoli et al., 2022; Few et al., 2004.
[189] Corvalan et al., 2022; Hayes & Poland, 2018; Mayer, 2018.
[190] Atwoli et al., 2022; Crimmins et al., 2016; Few et al., 2004.
[191] Burke et al., 2018; Carleton, 2017; Franchini & Mannucci, 2015; Hayward & Ayeb-Karlsson, 2021; Mullins & White, 2019; Obradovich et al., 2018; Romanello et al., 2021.
[192] Cosgrave, 2014; Few et al., 2004; McMichael & WHO, 2003.
[193] Berry et al., 2010; Corvalan et al., 2022; Norris et al., 2002.
[194] Weems et al, 2007; Atwoli et al., 2022; Khanal et al., 2020; Lamoure & Juillard, 2020.
[195] Atwoli et al., 2022; Corvalan et al., 2022; Kapoor et al., 2021a; Meyer et al., 2017; Vins et al., 2015; WHO, 2006.
[196] Munro et al., 2017
[197] Lawrance et al., 2022
[198] Including a number of European countries, USA, East Asia, Mexico, Brazil, Australia, Kazakhstan and Russia: Preti et al., 2000; Ruuhela et al., 2009; Helama et al., 2013; Santurtun et al., 2018; Tsai et al., 2012; Hu et al., 2020; Chung et al., 2019; Kalkstein et al., 2019; Kim et al., 2016 , A, Miotto et al, 2000

The relationships between mental health and weather variables are complex and dependent on context and mediating factors (for example, humidity, season and local baseline temperatures).[199]

Temperature may modulate symptoms of mental disorders or worsen general mental health and well-being through a range of biological or cognitive and societal pathways. These include physiological changes, such as “heat stress” and alterations to blood flow and central nervous-system function, which can lead to cognitive and emotional changes,[200] and societal changes, such as reduced economic outputs[201] and increased conflict and violence. [202] During heatwaves in Spain, high numbers of women are reporting an increase in intimate partner violence,[203] a finding that has been echoed in Kenya.[204] One meta-analysis of climate and conflict found that warmer temperatures or extreme rainfall can be causally associated with changes in interpersonal violence and civil war.[205]

Higher or extreme temperatures can also disturb sleep[206] and reduce its quality, which is known to increase mental health risk.

3.4.2.1. Increased temperatures and suicide

Increased temperatures are also associated with increased suicide rates. One systematic review found strong evidence for a relationship between temperature and suicide frequency in 15 out of 17 studies.[207] Meta-analyses suggest that there is an approximate 1% increase in suicide incidence for each 1 degree C temperature increase above a local ambient temperature threshold.[208] A separate meta-analysis associated a 2.2% increase in overall mortality related to either suicide or mental disorders[209] during periods when temperatures increased above local ambient temperature.[210]

However, the nature of the relationship between temperature and suicide risk is not completely clear. A global study found mixed evidence on the relationship between suicide risk and heatwaves or increases in temperature, and suggested that humidity was a stronger driver of this risk than heat itself.[211]

Other pieces of research suggest that the increased risk of suicide has less to do with actual temperatures and more to do with the effects of temperature and heat on livelihoods and living conditions. For example, studies of agricultural areas in India and Australia indicate that drought and heat can have negative impacts on farming; in those areas where those events occur, there are higher suicide rates.[212]

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[199] Middleton et al., 2021; Ding et al., 2016, Cunsolo, et al., 2021
[200] Lo~hmus et al., 2018
[201] Burke et al., 2015
[202] Tiihonen et al., 2017
[203] Sanz-Barbero, et al., 2018
[204] AAllen, et al., 2021
[205] Hsiang et al., 2013, although the link between climate and armed conflict is disputed by academics; see section 2.7
[206] Buguet et al., 2007
[207] Thompson et al., 2018
[208] Gao et al., 2019
[209] Mortality in these cases could be a result, inter alia, of accidents, overdose and physical conditions aggravated by mental health conditions
[210] Liu et al., 2021
[211] Florido Ngu., 2021
[212] Perceval et al., 2019

3.4.2.2. Increased temperatures and people with existing mental health conditions

People with pre-existing mental health conditions appear to be particularly vulnerable to the negative effects of heat. Evidence from hospital admissions data around the world shows higher heat-related mortality rates and increased hospital attendance and admission for people living with mental disorders during heatwaves.[213]

The data also suggests an increased risk of mental health-related emergency department attendance for people living with bipolar disorder, schizophrenia, dementia, self-harm, and alcohol and substance use when temperatures increase.[214]

However, the relationship between mortality, admissions and worsened mental health symptoms is complicated. It could be due in part to side effects of psychotropic medication, which can impair the body's ability to regulate temperature, placing individuals taking such medication at increased risk of more severe heat-related symptoms or death at high temperatures, particularly for the elderly. [215] This effect is shared with a number of other medicines.[216] The mechanisms by which psychotropic medications impair heat regulation are not well understood.[217]

The increase in mortality and hospital admissions among people living with mental health conditions may also be due, in part, to healthcare staff and first responders being unaware of the impacts of heat on this group and therefore not watching out for signs of heat stress or sufficiently communicating risks. Studies researching the impact of increased temperatures on mental health and psychosocial well-being in high-income countries in the northern hemisphere have reported that increased temperatures (sometimes above a locally contingent threshold) are associated with higher psychological distress,[218] reduced positive emotion,[219] increased negative emotion, increased fatigue, reduced well-being,[220] "depressive" language in social media posts[221] and higher self-reported mental health difficulties. This research has used correlational studies between weather data and either small-scale or nationwide survey data or analysis of social media posts. The mental health metrics are heterogeneous.

It should be noted that the research narrative in this area is overly biased to the experience and perception of populations living in high-income countries. Much more research is needed by and into the experiences of people living in low- and middle-income countries.

3.4.3. Air pollution and mental health

Air pollution poses a number of risks to mental health and well-being. Maternal exposure to air pollution can damage foetal development, while exposure to air pollution during childhood and adolescence has been associated with the development of mental health problems as young people transition into adulthood. This may be a result of air pollution impairing the normal development of the central nervous system.[222]

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[213] Liu et al., 2021
[214] Trang et al., 2016 and Basu et al., 2017
[215] Stollberger et al, 2009
[216] Ebi et al, 2021
[217] Bouchama et al., 2007; Lohmus, 2018
[218] Ding et al., 2016
[219] Hoffmann et al., 2016
[220] Noelke et al., 2016
[221] Baylis et al., 2018
[222] Reuben et al., 2021

Studies have also linked air pollution to increased incidences of depression, anxiety and suicide risks, neurodevelopmental disorders, dementia, bipolar disorder and psychosis.[223]

3.4.4. Longer-term consequences of climate change on mental health

Longer-term consequences of climate change and ecological degradation, such as prolonged or mega-droughts, desertification and deforestation, affect populations over wider areas and for longer periods. [224]

The literature discusses the importance of distress coming from the loss of an important place due to climate change (from sea-level rise or a disaster, for example).[225] It also considers anxiety arising from fear of the scale of the crisis, and inaction toward the crisis (labelled as "eco-anxiety"). This creates feelings of hopelessness and despair,[226] with young people particularly at risk.[227]

4. Climate change and malnutrition

Malnutrition is currently "considered as the single most important risk factor to global health, accounting for an estimated 15% of total disease burden in [disability-adjusted life years],"[228] with nearly half of all deaths among children under 5 years old attributed to malnutrition.[229] Nutrition and climate change are inextricably linked. "Climate change is projected to increase malnutrition through reduced nutritional quality, access to balanced food and inequality (high confidence)."[230]

Populations vulnerable to the negative effects of climate change are also those most vulnerable to malnutrition: women, and children under 5, particularly those living in fragile and conflict-affected states.[231] Climate change will increase the occurrence of short-term shocks and long-term stressors, which will have an impact across the whole life cycle and therefore has potential to worsen the intergenerational cycle of malnutrition (malnutrition during childhood can have an effect on generations to come because malnourished girls might have a sub optimal nutrition status during pregnancy, leading to low birthweight babies, who in their turn experience malnutrition during childhood).

The IPCC predicts that under RCP 8.5—the most pessimistic scenario, leading to a temperature increase of about 4.3˚C by 2100—"climate change will increase loss of years of full health by 10% in 2050…because of undernutrition and micronutrient deficiencies (medium evidence, high agreement)."[232]

The dynamics between climate change, health and nutrition are diverse and complex.[233] The key risk factors for undernutrition and environment change are related to the availability of sufficient nutritious and safe food; economic and physical access to sufficient nutritious and safe food; food safety and quality; maternal and childcare feeding practices; and diarrheal

[223] Environmental pollution is associated with increased risk of psychiatric disorders in the US and Denmark, Atif Khan et al, 2019
[224] Asugeni et al., 2015
[225] Campbell-Lendrum et al., 2003, p. 145; Franchini & Mannucci, 2015.
[226] Campbell-Lendrum et al., 2003, p. 145; Franchini & Mannucci, 2015.
[227] Campbell-Lendrum et al., 2003, p. 145; Franchini & Mannucci, 2015.
[228] Campbell-Lendrum et al., 2003, p. 145; Franchini & Mannucci, 2015.
[229] Victora CG, et all, 2008
[230] Pörtner, Roberts, Adams, et al., 2022, p. 60.
[231] Bush et all, 2022
[232] Bezner Kerr et al., 2022, p. 717.
[233] UNSCN 2017

diseases. As such, the climate change impacts of malnutrition are closely related to those associated with health, as described above, and food security and water, sanitation and hygiene (WASH), as described below.

Malnutrition can result both from climate shocks—such as droughts or flooding—and from long-term impacts on health and food security. In Ethiopia and Kenya, two of the world's most drought-prone countries, studies have found that children under the age of 5 born during a drought were respectively 36% and 50% more likely to be undernourished than those not born during a drought.[234] In terms of the long-term, chronic impacts of climate change, Lloyd, Kovats and Chalabi (2011) projected that climate change will lead to a relative increase in moderate stunting of 1–29% in 2050 compared with a future without climate change. Climate change will have a greater impact on rates of severe stunting, which the same study estimated will increase by 23% (Central and sub-Saharan Africa) to 62% (South Asia) compared to a future without climate change. The relation between short- and long-term malnutrition can take the form of a vicious cycle, where undernutrition weakens the resilience to climatic shocks and the coping strategies of vulnerable populations, reducing their capacity to resist and adapt to the consequences of climate change.

The increased levels of both acute and chronic malnutrition associated with climate change can be expected to have negative results at individual and societal levels. Increased malnutrition results in higher levels of nutrition-related morbidity and mortality, as well as an increased risk of developing non-communicable diseases later in life, a decreased IQ and poor school performance. This in turn can influence national economic performance.

4.1. Infant and young-child feeding and caring practices

Climate challenges may result in increased labor migration and female workloads. This may have knock-on effects on women's availability to adequately feed and care for their children—for example, they may have to travel further to collect scarce water and fuel.[235] The ability of women's caregiving capacity is strongly influenced by agriculture workload,[236] and climate change could increase this workload.

Disruptions caused by extreme weather events may have considerable negative impacts on care and on infant and young-child feeding (IYCF) practices due to increased maternal stress, lack of time or appropriate mother-child spaces, disruption to the promotion and support of infant feeding and decreased access to clean water, sanitation and hygiene. A mother's ability to breastfeed may be compromised by dehydration, with any climate-related impacts on maternal diet influencing breastmilk quality. Disruption from climate-forced migration has also been shown to negatively impact breastfeeding practices, with an increase in the use of breastmilk substitutes negatively impacting infant nutrition and health outcomes.[237] Conversely, breastfeeding provides an opportunity to protect the planet from the impacts of climate change. Compared to infant formula, breastfeeding uses few water or land resources, and produces no carbon emissions and minimal or zero waste.

[234] Tirado, M.C.., et al. (2013).

[235] Levine, N.E. (1988).

[236] Jones AD. 2012.

[237] Hirani, S.A.A.,et al (2020).

Climate-related impacts on food security, and thus dietary diversity, have implications for the ability of caregivers to provide appropriately diverse foods for infants, for children and for themselves, which could lead to increased level of both acute and chronic malnutrition, including micronutrient deficiencies.

4.2. Obesity

There is limited but emerging evidence that climate change will adversely affect the risk of overweight and obesity and, as a consequence, diet-related non-communicable diseases (DR-NCDs). Though severe food insecurity and hunger are associated with lower prevalence of obesity, mild to moderate food insecurity is paradoxically associated with higher obesity prevalence, particularly in contexts where high-energy, commercially processed foods are available at low cost.

Increasing temperatures are associated with less physical activity in many parts of the world, particularly among urban populations, while price instability of fresh foods can reinforce dependency on highly processed foods, especially in the context of aggressive marketing. Furthermore, in humanitarian settings, food assistance provided during an emergency response, such as to climate-induced natural disasters, can weaken long-term food and nutrition security[238]—for example, low-quality, imported foods may persist in the local diet long after the humanitarian response has concluded.[239]

5. Climate change and humanitarian WASH

In many places, the impacts of climate change are forecast to influence both the quantity and quality of water available for domestic use.

5.1. Water quantity

Roughly half of the world's population are assessed as currently subject to severe water scarcity for at least some part of the year due to climatic and non-climatic factors, and this is projected to be exacerbated at higher levels of warming.[240] It is not, however, possible to quantify this impact with any accuracy, due to high levels of uncertainty around forecasts of future precipitation.[241] It is important to note, also, that though climate change is likely to contribute to water scarcity, "human factors [increased use of water] are projected to be the dominant driver of future water scarcity on a global scale."[242]

Higher temperatures will intensify the water cycle, increasing exchanges of water between land and atmosphere.[243] A key element of this change will be in the nature of precipitation. Climate models vary significantly on how precipitation will change in different parts of the globe, and there is a high level of uncertainty around them. The areas where there is the highest consensus is that there will be overall increased precipitation in the central and eastern Sahel and south-central Asia, parts of Greenland and Antarctica, and the far northern regions of North America and Asia, and decreased overall precipitation in South America, southern Africa and the Mediterranean region. Importantly, there will also be greater variability and volatility in precipitation regimes, with many regions seeing both

[238] Castillo-Castrejon, M., et al. (2021). 6
[239] Campbell, J.R. (2015).
[240] Caretta et a. 2022
[241] Caretta et al., 2022.
[242] Caretta et al.,2022 p.560
[243] Caretta et al., 2022.

longer dry spells and heavier rain or snowfall when precipitation does occur.[244] One implication of this is that higher rainfall will not necessarily result in increased availability of surface water, as a combination of dry land and heavy precipitation lead to increased runoff.

Higher temperatures will also change rates of evapotranspiration, although the extent and location of these changes is also uncertain.[245] In general, evapotranspiration is likely to increase globally, particularly in mid and high latitudes,[246] potentially contributing to a reduction in the amount of surface water available.[247]

The melting of glaciers can also be expected to impact seasonal water supply.[248] This could potentially increase water availability in the short term (although in some places "peak water" has already been reached) while decreasing it in the longer term. This is an important consideration given that "more than one-sixth of the world population currently depends on water supplied by glacier melt."[249]

There is a lack of consensus between models on the degree to which changes in the water cycle will affect groundwater recharge. However, "an emerging body of studies have projected amplification of episodic recharge in the tropics and semiarid regions due to extreme precipitation under global warming (medium confidence)."[250] Increased recharge will, however, not necessarily be sufficient to prevent depletion of groundwater reserves if they continue to be exploited as they are currently—this is particularly true in semi-arid areas.[251]

At the same time, higher temperatures can be expected to lead to increased demands for water for consumption and hygiene.[252]

In summary, projections of water availability are uncertain, and there is also great variability between regions.[253] Until recently, there has been a general consensus that wet regions and seasons will generally become wetter, while dry regions and seasons become drier.[254] More recent research suggests that this is not the case in all regions (the Sahel, for example, is projected to see increases in precipitation).[255] What can be said with confidence is that an increasingly wet world will not mean increased water availability for everyone. This is partly because of regional variation, partly because more water will be lost through runoff and evaporation, and largely because of reasons beyond climate change, related to the economic and political systems around access to and use of water. Many urban areas—and particularly the poor within those areas—are likely to become increasingly water-insecure: "even under a scenario where urban water gets the highest priority, more than 440.5 million people in cities globally are projected to face a water deficit by 2050."[256] However, this is as much a result of competition for water between cities and agricultural areas, poor infrastructure and population growth as it is of climate change.[257]

[244] Caretta et al., 2022.
[245] Caretta et al., 2022.
[246] Caretta et al., 2022.
[247] USAID, 2020b.
[248] Caretta et al., 2022; WHO, 2017.
[249] Biermann & Boas, 2010, p. 69.
[250] Caretta et al., 2022, p. 611.
[251] Caretta et al., 2022.
[252] USAID, 2020b.
[253] WHO, 2017.
[254] WHO, 2017.
[255] Caretta et al., 2022.
[256] Flörke et al., 2018; Mitlin et al., 2019.
[257] Caretta et al., 2022.

5.2. Water quality

The threats to health from pathogens and other water-borne contaminants are addressed in the health section above. To briefly recap, WASH programs can expect to face more frequent, larger and more intense weather-related disasters. These are likely to result in:

- higher demand for water;
- higher likelihood of water becoming contaminated by pathogens from runoff, overflow or damage to sanitation infrastructure;
- higher likelihood of dangerous chemicals, or chemicals in dangerous concentrations, entering water supplies;
- higher levels of pathogen activity in stored water;
- damage to WASH infrastructure;
- changes in behavior among disaster-affected populations, potentially including open defecation and use of unsafe water sources; and
- challenges to the treatment of water.

At the same time, longer-term climate effects will also affect the quality of water that people receive. As noted above, higher temperatures (and, in some cases, lower flow rates) will favor the growth of pathogens (such as cholera) in aquatic environments.

Warmer temperatures might also increase drinking-water treatment challenges, as "warmer, less oxygenated water may also result in higher levels of certain metals, phosphorus and phytoplankton,"[258] which will need additional treatment.

Glacier melting and permafrost degradation can also impact "water quality through increases in legacy contaminants (medium evidence, high agreement)."[259]

Sea-level rise can be expected to also cause inundation of low-lying latrines and septic systems,[260] contributing to the effects on water-borne diseases seen above. It can also increase the salinity of groundwater.[261]

Finally, the literature review suggested that water quality may be impacted over time by increased pesticide pollution in the water due to "the adverse impacts of climate stress on agricultural production, [which] could incentivize farmers to increase pesticide use"[262] as well as "increased frequency and intensity of heavy rainfall, [which] could reduce pesticide effectiveness and increase pesticide contamination."[263]

6. Climate change and food security

Climate change is already impacting the food security of many people on the planet. The IPCC chapter on food states that "climate-related extremes have affected the productivity of all agricultural and fishery sectors, with negative consequences for food security and livelihoods (high confidence)."[264] In the future, "climate change will increasingly add pressure on food production systems, undermining food security (high confidence)."[265] The IPCC

[258] WHO, 2017, p. 11; see also WHO, 2021a.
[259] Caretta et al., 2022, p. 582; see also Hock et al., 2019.
[260] USAID, 2020b.
[261] Masson-Delmotte et al., 2021. WHO 2017
[262] USAID, 2017, p. 12.
[263] USAID, 2017, p. 12.
[264] Bezner Kerr et al., 2022, p. 717.
[265] Pörtner, Roberts, Adams, et al., 2022, p. 57.

expects with high confidence that—depending on the scenario used—“climate change is projected to put [an additional] 8 million…to 80 million people…at risk of hunger in mid-century, concentrated in sub-Saharan Africa, South Asia and Central America.”[266]

6.1. Food production

As climate change increases the number and intensity of weather-related disasters, it can be expected to have increased impact on the food production of areas affected, adding to already high levels of global food insecurity.[267]

The effects of climate change on food production are not restricted to disasters, however. While global agricultural production has significantly increased in recent decades, “human-induced warming has slowed growth of agricultural productivity over the past 50 years in mid and low latitudes (medium confidence).”[268] In the future, multiple climate factors can be expected to reduce the yields of staple crops, with estimates pointing to “yield losses in the range of 2.5% to 16.0% for every 1°C increase in seasonal temperature.”[269]

These effects will be more severe in areas that are already hotter.[270] In some areas, cultivation will become impossible: “current global crop and livestock areas will increasingly become climatically unsuitable under a high-emission scenario (high confidence),” such that “globally, 10% of the currently suitable area for major crops and livestock is projected to be climatically unsuitable in mid-century and 31–34% by the end of the century.”[271] On the other hand, areas in higher latitudes may see increased crop production as a result of increased temperatures.[272]

In addition to changes in temperature and precipitation, the following factors may adversely affect crop production in certain areas.

- Loss of arable land resulting from salination due to sea-level rise, and from deforestation and other factors that lead to the loss of topsoil.[273]
- Movements of pests and diseases into areas that are not prepared “biologically and institutionally, with potentially higher negative impacts.”[274] These movements can be expected to be most pronounced toward the poles and in higher latitudes.[275] In the same way that climate change extends the seasonality of some vector-borne diseases, it may also extend the seasonality of crop pests and diseases.[276]
- Climate change may also affect the efficacy of pest control. Higher concentrations of atmospheric carbon dioxide can reduce herbicide and pesticide efficiency.[277]
- Temperature changes have already impacted the “timing of key biological events, such as flowering and insect emergence, impacting food quality and harvest stability.”[278] These changes will likely intensify.
- Climate change affects the distribution and properties of pollinators, reducing “the effectiveness of pollinator agents as species are lost from certain areas, or the

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[266] Pörtner, Roberts, Adams, et al., 2022, p. 64.
[267] APFM et al., 2015, p. 17.
[268] Bezner Kerr et al., 2022, p. 717.
[269] Martin & Zermoglio, 2017, p. 11.
[270] Bezner Kerr et al., 2022.
[271] Bezner Kerr et al., 2022, p. 725.
[272] FAO, 2015.
[273] Costello et al., 2009; WHO, 2020; 2021c.
[274] FAO, 2015, p. 3.
[275] Field et al., 2014; Svobodová et al., 2014.
[276] Bezner Kerr et al., 2022; FAO, 2015.
[277] Bezner Kerr et al., 2022.
[278] Bezner Kerr et al., 2022, p. 717.

coordination of pollinator activity and flower receptiveness is disrupted in some regions (high confidence)."[279]

- In many parts of the world, climate change will also "increasingly expose outdoor workers and animals to heat stress, reducing labor capacity, animal health, and dairy and meat production (high confidence)."[280]
- Extreme weather events can also disrupt the logistics of food production (storage and travel).[281]

Climate change impacts not only crops but also livestock: "the effects include direct impacts of heat stress on mortality and productivity, and indirect impacts [that] have been observed on grassland quality, shifts in species distribution and range changes in livestock diseases."[282] Droughts[283] and seasonality changes impact "herd mobility, decreas[e] productivity, increas[e] incidence of vector-borne diseases and parasites, and reduc[e] access to water and feed (high agreement, medium evidence)."[284]

Ocean acidification and warmer oceans have already "adversely affected food production from shellfish aquaculture and fisheries in some oceanic regions (high confidence),"[285] a trend that can be expected to continue. In addition, sea-level rise, flooding and pollution are expected to impact the availability of inland fishing areas.[286]

6.2. Food quality

Climate change also impacts the nutritional value of food produced. "[H]igher carbon dioxide concentrations in the air reduce zinc and iron concentrations in wheat and rice,"[287] possibly causing deficiencies in micronutrients that are essential for mounting an effective immune response against infection. There is evidence that increased carbon dioxide may be reducing protein levels in cereals and legumes.[288] Estimates have suggested that projected increases in atmospheric carbon dioxide will decrease growth in the global availability of nutrients by 19.5% for protein, 14.4% for iron and 14.6% for zinc, relative to expected technology and market gains, by 2050. Of this impact, the decrease in nutrients attributable to higher levels of carbon dioxide (rather than to other effects of climate change on production) are modelled as decreased growth of protein of 4·1%, iron of 2·8%, and zinc of 2·5%. [289]

In addition, rising sea levels cause salinization—the increase of salt in ground water that translates to more salt in crops produced on those lands. Unintentional higher intake of salt could cause high blood pressure—which can be especially concerning during pregnancy, since the risk of low birth weight is increased through hypertension.[290]

[279] Bezner Kerr et al., 2022, p. 718; see also FAO, 2015.
[280] Bezner Kerr et al., 2022, p. 717; see also USAID, 2020a.
[281] Bezner Kerr et al., 2022; FAO, 2015.
[282] Bezner Kerr et al., 2022, p. 717.
[283] One study found that in "the Sahel region of Burkina Faso show that, on average, 12% of surveyed individuals lose all their livestock income in drought years. Another 38% of those surveyed lose 75% and 50% lose 25–50%" (del Rio & Simpson, 2014).
[284] Bezner Kerr et al., 2022, p. 746; see also Dixon et al., 2020; López-i-Gelats et al., 2015; Vidal-González & Nahhass, 2018.
[285] Pörtner, Roberts, Tignor, et al., 2022, p. 9.
[286] Costello et al., 2009.
[287] Martin & Zermoglio, 2017, p. 11; see also Bezner Kerr et al., 2022; FAO, 2015; A. J. McMichael & WHO, 2003; Nelson & Williams, 2014; USAID, 2020a; WHO, 2021b.
[288] Myers, S.S., et al. (2017).
[289] Beach, R.H., et al. (2019).
[290] Human health and global environment change, HarvardX, August 2013.

A further—if indirect—threat to the quality of food consumed relates to consumer behavior. Faced with higher prices, consumers may opt to buy nutrient-poor but calorie-rich foods and/or endure hunger, with consequences ranging from undernutrition and micronutrient deficiencies to excess weight and obesity.[291]

6.3. Access to food

The direct impacts on food production, particularly in low latitudes where the climate is hotter and drier and where crops are already close to the upper limits of temperature that they can tolerate,[292] can be expected to have extremely negative impacts on many populations of concern to International Medical Corps, including small scale farmers, fishing populations and transhumant pastoralists. Women and indigenous people are particularly vulnerable.[293] In sub-Saharan Africa, rain-fed agriculture is the principal source of livelihood for more than 70% of the population,[294] making the continent particularly at risk.[295]

It is important to note that the impact on these populations will be not only on food grown for consumption, but on decreased income through the sale of crops, fish or livestock and, in areas where alternative non-farm livelihoods are not available, an overall decrease in economic activity and employment opportunities.[296]

Again, women are most vulnerable in many cases, where they are faced with "social norms or time constraints [that]…prevent women from seizing off-farm opportunities, which influences women's level of vulnerability, incomes and ability to adjust their agricultural production."[297]

The impact of climate change on food prices is harder to predict. Climate change has been associated with rises in global food prices[298] and some studies point to a future trend of increased global food prices resulting from climate change.[299] However, raised temperatures in higher latitudes could increase productivity in some of the world's main cereal growing areas,[300] increasing supply and lowering, or at least stabilizing, global prices. Similarly, where weather conditions negatively impact fisheries in lower latitudes, there might be a geographical distribution of fish production to higher latitudes. Chueng et al. have modelled[301] fish production with "an average 30% to 70% increase in high-latitude regions and a drop of up to 40% in the tropics."[302]

To the degree that global prices increase, those in poor countries are likely to be disproportionately affected.[303] It is also important to remember that changes in global prices—even decreases in global prices—will not necessarily compensate for local losses in production for small-scale farmers or others dependent on the food they grow for their food security.

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[291] Hertel TW, et al 2010).
[292] Caretta et al., 2022; Shrestha & Nepal, 2016; Sujakhu et al., 2016.
[293] Bezner Kerr et al., 2022; FAO, 2015; Pörtner, Roberts, Tignor, et al., 2022.
[294] Hellmuth et al., 2007.
[295] Esikuri, 2005; Svobodová et al., 2014.
[296] Pörtner, Roberts, Tignor, et al., 2022.
[297] FAO, 2015, p. 28 ; see also Botreau & Cohen, 2020; FAO, 2015, p. 28; Kapoor et al., 2021a; Romanello et al., 2021.
[298] Pörtner, Roberts, Tignor, et al., 2022.
[299] Bezner Kerr et al., 2022; de Lima et al., 2021.
[300] FAO, 2015.
[301] Taking into account predicted changes in environmental conditions, habitat types and phytoplankton primary production.
[302] FAO, 2015, p. 17; see also Cheung et al., 2010.
[303] Campbell-Lendrum et al., 2003; Romanello et al., 2021; Watts et al., 2019; WHO, 2015.

Even if global food prices do not steadily increase, it is likely that there will be an increase in global price spikes as a result of "increased, potentially concurrent climate extremes [that] will periodically increase simultaneous losses in major food-producing regions (medium confidence)."[304] These "bad year" price spikes are likely to be felt most by poor and marginalized people: the urban poor,[305] small-scale producers[306] and other marginalized groups.[307]

7. Conclusion

In this literature review we have attempted to summarize a variety of high-quality documents outlining the effects of climate change on the potential occurrence and severity of "natural" disasters, and on underlying factors that drive vulnerability: health, nutrition, water security and food security.

Despite the resources now being committed to understanding the impacts of climate change, there is still very significant uncertainty related to some climate effects (such as precipitation), to the geographical impacts of effects, and to the social, economic and political responses that governments and societies will make in response to climate change, which will be critical in determining the human consequences of a hotter planet.

It is also important to recognize that climate change is not the only threat that marginalized and vulnerable communities face. Although out of scope for any detailed consideration, this report has touched briefly on other threats driving future humanitarian needs, such as overuse of resources, damage to biodiversity and earth systems, conflict, and poor governance. Climate change will interact with all of these elements in ways that cannot be reliably predicted with any specificity, but that will, in many cases, be extremely negative.

Despite these caveats, it is clear that climate change will greatly increase the intensity and frequency of weather-related disasters globally, and that these impacts will be particularly severe in many of the locations where International Medical Corps works. It is also clear that climate change will decrease the food security, health and economic status of many people in these areas, making them even less resilient and more vulnerable to the crises precipitated by climate change.

In short, a future defined by climate change promises massive increases in humanitarian need and new types of humanitarian challenges in the form of heatwaves, fires and systemic catastrophes. These can be expected in the very near future, presenting a strong case that the organization must quickly decide how to address these threats in current and future programming.

[304] Bezner Kerr et al., 2022, p. 717.
[305] Costello et al., 2009; Field et al., 2014; Martin & Zermoglio, 2017.
[306] Bezner Kerr et al., 2022; Cohen et al., 2008; Costello et al., 2009.
[307] Bezner Kerr et al., 2022; Cohen et al., 2008; Costello et al., 2009.

8. Method

This report is based on a number of literature reviews conducted by the ADAPT initiative over the period 2021–2022.

The first of these was conducted for the report “Adapting humanitarian action to climate change.” The full methodology, including search strings, can be found here: https://www.alnap.org/help-library/annex-alnap-lessons-paper-adapting-humanitarian-action-to-climate-change.

Documents for this search were coded with the MaxQDA software.

The second of these was conducted for the report “Climate Change and Humanitarian Action.” Detailed methodology can be found on page 26 of that document here: https://adaptinitiative.org/document/climate-change-and-humanitarian-action-2021/

The documents from this review were added to the coding structure developed for the previous report.

The third of these was conducted for a report produced for an NGO client that focused specifically on the effects of climate change on food security, WASH and shelter with respect to displaced people. This literature review was conducted in several stages. In the first stage, the researchers conducted a review of Google Scholar using the search terms “Forced migration OR refugees AND conflict AND climate OR environment” and the date range 2007–2022. This review returned 3,460,000 results. The researchers considered the top 300 results, looking for documents fulfilling the following criteria: a) the document considers the impacts of climate change/the environment on displaced populations, rather than solely the contribution of climate / environment on decisions to move; and b) the document considers displaced people in a country where there are ongoing humanitarian operations. We also did a similar search in the Forced Migration Review (which yielded 1,164 results) and the Journal of Refugee Studies (which yielded 64 results), with the hit search “climate change.” In total, once the inclusion criteria had been considered, these searches returned 25 results.

In the second stage, the reviewers considered literature that had been identified by a research project “Climate vulnerabilities in refugee camps: Impacts and policy solutions” at the United Nations University. Researchers at the university kindly shared the results of a review that they had undertaken, which consisted of 19 documents.

In the third stage, the reviewers considered a number of documents that appeared particularly relevant from the bibliographies of documents considered in the first and second stages (“snowball” selection), which consisted of 19 documents.

In the fourth stage, the reviewers considered evaluations of humanitarian action relating to IDPs or refugees, to identify challenges and good practices related to weather-related hazards affecting refugee populations. This was done using the ALNAP Help Library, looking at all publications from the last five years for term search “refugee” and “IDP.” This returned 1,173 results. For ease of research, we looked at publications by UNHCR (160 results), DRC (33 results) and NRC (49) results, excluding publications which were neither in English nor French. This led to 18 documents.

In developing the current report, the team began with the question, “What has been the impact to date, and what are the predicted effects, of climate change on: the occurrence of ‘natural’ disasters; and the health/food security/water security status of people of concern to International Medical Corps?” To answer this question, we considered the 6,700 coded segments from previous reviews. Recognizing that the IPCC AR6 WGII report had been produced since the previous reviews were conducted, we considered the full document and coded chapters 4, 5 and 7 (food, water, health).

Recognizing also that the existing codes related to health contained only a limited number of segments, we considered the WHO website (searching for climate change) and the WHO/WMO climahealth.info website for documents that were produced by a UN agency and/or were peer-reviewed, addressed the impacts of climate change or specific consequences of climate change on human health and were relevant to low- and middle-income countries. On the basis of this convenience sample, we then conducted backwards searches of bibliographies to identify further documents that met these criteria. This approach yielded 65 additional documents, which were coded in MaxQDA, producing a further 2,167 coded segments.

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