Effects of Global Warming on Human Health

Subjects: Environmental Sciences
Contributor: HandWiki

The effects of global warming include its effects on human health. The observed and projected increased frequency and severity of climate related impacts will further exacerbate the effects on human health. This article describes some of those effects on individuals and populations.

Keywords: global warming ; health ; climate

1. Impact of Excess Heat on the Human Body

The human body requires evaporative cooling to prevent overheating, even with a low activity level. With excessive ambient heat and humidity, adequate evaporative cooling does not take place. Human thermoregulatory capacity is exceeded. A sustained wet-bulb temperature or Wet-bulb globe temperature exceeding about 35 °C (95 °F) can be fatal.[1][2]

Human response to heat stress can be hyperthermia, heat stroke and other harmful effects. Heat illness can relate to many of the organs and systems including: brain, heart, kidneys, liver, etc.[3]

2. Impact on Disease

2.1. Impact on Infectious Diseases

Warming oceans and a changing climate are resulting in extreme weather patterns which have brought about an increase of infectious diseases—both new and re-emerging.[4] These extreme weather patterns are creating extended rainy seasons in some areas,[5] and extended periods of drought in others,[6] as well as introducing new climates to different regions.[6] These extended seasons are creating climates that are able to sustain vectors for longer periods of time, allowing them to multiply rapidly, and also creating climates that are allowing the introduction and survival of new vectors.

Impact of warmer and wetter climates

Mosquito-borne diseases are probably the greatest threat to humans as they include malaria, elephantiasis, Rift Valley fever, yellow fever, and dengue fever.[7][8] Studies are showing higher prevalence of these diseases in areas that have experienced extreme flooding and drought.[7][8] Flooding creates more standing water for mosquitoes to breed; as well, shown that these vectors are able to feed more and grow faster in warmer climates. As the climate warms over the oceans and coastal regions, warmer temperatures are also creeping up to higher elevations allowing mosquitoes to survive in areas they had never been able to before. As the climate continues to warm there is a risk that malaria will make a return to the developed world.

Ticks are also thriving in the warmer temperatures allowing them to feed and grow at a faster rate.[9] The black legged tick, a carrier of Lyme disease, when not feeding, spends its time burrowed in soil absorbing moisture.[5][10] Ticks die when the climate either becomes too cold or when the climate becomes too dry, causing the ticks to dry out.[5][10] The natural environmental controls that used to keep the tick populations in check are disappearing, and warmer and wetter climates are allowing the ticks to breed and grow at an alarming rate, resulting in an increase in Lyme disease, both in existing areas and in areas where it has not been seen before.[5][9]

Another impact that the warming global temperature has had is on the frequency and severity of heat waves. In addition to dehydration and heat stroke, these heat waves have also resulted in epidemics of chronic kidney disease (CKD). Recent studies have shown that prolonged heat exposure, physical exertion, and dehydration are sufficient factors to developing CKD.[11] These cases are occurring across the world congruently with heat stress nephropathy.

Other diseases on the rise due to extreme weather include hantavirus,[12] schistosomiasis,[8] onchocerciasis (river blindness), and tuberculosis.[4] It also causes the rise in hay fever, as when the weather gets warmer there is a rise in pollen levels in the air.[13]

Projected increases in temperature would make parts of southwest Asia uninhabitable, when temperature combined with high humidity reaches a wet-bulb temperature of 35 °C, the threshold for a fit human to survive in well-ventilated conditions.[14]

Warmer temperatures may also lead an increase in aggression levels. Research has shows links between higher temperatures and increased aggressive and criminal behaviour. Which can be seen by the rise in the rate of criminality during the warmer summer months.[15]

Impact of warmer oceans

The warming oceans are becoming a breeding ground for toxic algae blooms (also known as red tides) and cholera.[16] As the nitrogen and phosphorus levels in the oceans increase, the cholera bacteria that lives within zooplankton emerge from their dormant state.[16] The changing winds and changing ocean currents push the zooplankton toward the coastline, carrying the cholera bacteria, which then contaminate drinking water, causing cholera outbreaks.[16] As flooding increases there is also an increase in cholera epidemics as the flood waters that are carrying the bacteria are infiltrating the drinking water supply.[17] El Nino has also been linked with cholera outbreaks because this weather pattern warms the shoreline waters, causing the cholera bacteria to multiply rapidly.[16][17]

Malaria

Malaria is a mosquito-borne parasitic disease that infects humans and other animals caused by microorganisms in the Plasmodium family. It begins with a bite from an infected female mosquito, which introduces the parasite through its saliva and into the infected host's circulatory system. It then travels through the bloodstream into the liver where it can mature and reproduce.[18] The disease causes symptoms that typically include fever, headache, shaking chills, anemia, and in severe cases can progress to coma or death.

'About 3.2 billion people – nearly half of the world's population – are at risk of malaria. In 2015, there were roughly 214 million malaria cases and an estimated 438,000 malaria deaths.' [19]

Climate is an influential driving force of vector-borne diseases such as malaria. Malaria is especially susceptible to the effects of climate change because mosquitoes lack the mechanisms to regulate their internal temperature. This implies that there is a limited range of climatic conditions within which the pathogen (malaria) and vector (a mosquito) can survive, reproduce and infect hosts.[20] Vector-borne diseases, such as malaria, have distinctive characteristics that determine pathogenicity. These include the survival and reproduction rate of the vector, the level of vector activity (i.e. the biting or feeding rate), and the development and reproduction rate of the pathogen within the vector or host.[20] Changes in climate factors substantially affect reproduction, development, distribution and seasonal transmissions of malaria.

Mosquitoes have a small window for preferential conditions for breeding and maturation. The ultimate breeding and maturing temperature for mosquitoes ranges from 16 to 18 degrees Celsius.[21] If the temperature is decreased by 2 degrees, most of the insects will succumb to death. This is why malaria is unsustainable in places with cool winters. If a climate with an average of approximately 16 degrees Celsius experiences an increase of about two degrees, the mature bugs and the larvae flourish. Female mosquitoes will need more food (human/animal blood) to sustain life and to stimulate production of eggs. This increases the chance of spread of malaria due to more human contact and a higher number of the blood sucking insects surviving and living longer. Mosquitoes are also highly sensitive to changes in precipitation and humidity. Increased precipitation can increase mosquito population indirectly by expanding larval habitat and food supply.[22] These prime temperatures are creating large breeding grounds for the insects and places for the larvae to mature. Increased temperature is causing snow to melt and stagnant pools of water to become more common. Bugs that are already carrying the disease are more likely to multiply and infect other mosquitoes causing a dangerous spread of the deadly disease.

Climate change has a direct impact on people's health in places where malaria was originally not prevalent. Mosquitoes are sensitive to temperature changes and the warming of their environment will boost their rates of production.[23] A fluctuation of two or three degrees is creating exceptional breeding grounds for mosquitoes, for larvae to grow and mature mosquitoes carrying the virus to infect people that have never been exposed before. In communities living in the higher altitudes in Africa and South America, people are at now at a higher risk for developing malaria because of increase in the average temperature of the surroundings. This is a severe problem because people in these communities have never been exposed to this disease, causing an increased risk for complications from malaria such as cerebral malaria (a type of malaria that causes mental disability, paralysis and has a high mortality rate) and death by the disease. Residents of these communities are being hit hard by malaria because they are unfamiliar with it; they do not know the signs and symptoms and have little to no immunity.

The population at risk of malaria in the absence of climate change is projected to double between 1990 and 2080 to 8820 million, however; unmitigated climate change would, by the 2080s, further increase the population at risk of malaria by another 257 to 323 million.[24] Therefore, reducing the effects of climate change in the present would reduce the total by about 3.5%, saving tens of thousands of lives worldwide.

If there is a slight discrepancy in the normal temperature, the perfect conditions for the insects to multiply are created. People that have never been infected before are unknowingly at risk for this deadly disease and do not have the immunity to combat it. An increase in temperature has the potential to cause a widespread epidemic of the disease that has the capacity to wipe out entire populations of people. It is important to track the prevalence, species and number of insects carrying the disease as well as the number of humans infected in countries and places that have never seen malaria before. It is simple for the slightest of fluctuation in temperature to cause a catastrophic epidemic that has the possibility to end the lives of many innocent and unsuspecting people.[21]

Dengue fever

Dengue fever is an infectious disease caused by dengue viruses known to be in the tropical regions.[25] It is transmitted by the mosquito Aedes, or A. aegypti.[26]

The cases of dengue fever have increased dramatically since the 1970s and it continues to become more prevalent.[25] The greater incidence of this disease is believed to be due to a combination of urbanization, population growth, increased international travel, and global warming.[27] The same trends also led to the spread of different serotypes of the disease to new areas, and to the emergence of dengue hemorrhagic fever. There are four different types of viruses in dengue fever. If someone is infected with one type of dengue virus, he or she will have permanent immunity to that type of dengue virus, but will have short term immunity to the other type of dengue fever.[25] Some of the symptoms of dengue fever are fever, headache, muscle and joint pains and skin rash.[28] There is no vaccine for dengue fever right now and there is no true treatment to get rid of it, but there are treatments to assist with some of the work of dengue, such as the use of oral or intravenous fluids for rehydration.[28]

Dengue fever used to be considered a tropical disease, but climate change is causing dengue fever to spread. Dengue fever is transmitted by certain types of mosquitoes, which have been spreading further and further north. This is because some of the climate changes that are occurring are increased heat, precipitation and humidity which create prime breeding grounds for mosquitoes.[29] The hotter and wetter a climate is, the faster the mosquitoes can mature and the faster the disease can develop. Another influence is the changing El Nino effects that are affecting the climate to change in different areas of the world, causing dengue fever to be able to spread.[30]

There are many things that can be done, both on a governmental level and on an individual basis. One improvement would be having a better system of detecting when dengue outbreaks may happen. This can be done by monitoring environments, such as temperatures, rainfall and humidity that would be attractive to these types of mosquitoes and help them to flourish. Another useful plan is to educate the public by letting them know when a dengue outbreak is occurring and what they can do to protect themselves. For example, people should create a living environment that is not attractive to mosquitoes (no standing water), dress in appropriate clothing (light colours, long sleeves), and wear insect repellent.

"Some 1.8 billion (more than 70%) of the population at risk for dengue worldwide live in member states of the WHO South-East Asia Region and Western Pacific Region, which bear nearly 75% of the current global disease burden due to dengue. The Asia Pacific Dengue Strategic Plan for both regions (2008--2015) has been prepared in consultation with member countries and development partners in response to the increasing threat from dengue, which is spreading to new geographical areas and causing high mortality during the early phase of outbreaks. The strategic plan aims to aid countries to reverse the rising trend of dengue by enhancing their preparedness to detect, characterize and contain outbreaks rapidly and to stop the spread to new areas." [31]

Tick borne disease

A high humidity of greater than 85% is the best condition for a tick to start and finish its life cycle.[32] Studies have indicated that temperature and vapor play a significant role in determining the range for tick population. More specifically, maximum temperature has been found to play the most influential variable in sustaining tick populations.[33] Higher temperatures augment both hatching and developmental rates while hindering overall survival. Temperature is so important to overall survival that an average monthly minimum temperature of below -7 °C in the winter can prevent an area from maintaining established populations.[33]

The effect of climate on the tick life cycle is one of the more difficult projections to make in relation to climate and vector-borne disease. Unlike other vectors, tick life cycles span multiple seasons as they mature from larva to nymph to adult.[34] Further, infection and spread of diseases such as Lyme disease happens across the multiple stages adding additional variables to consider. Infection of ticks happen in the larval/nymph stage (after the first blood meal) when they are exposed to borrelia burgdorferi (the spirochete responsible for Lyme disease), but transmission to humans doesn’t occur until the adult stages.

The expansion of tick populations are concurrent with global climatic change. Species distribution models of recent years indicate that the deer tick, known as *I. scapularis,* is pushing its distribution to higher latitudes of the Northeastern United States and Canada, as well as pushing and maintaining populations in the South Central and Northern Midwest regions of the United States.[35] Climate models project further expansion of tick habit north into Canada as progressing Northwest from the Northeastern United States. Additionally, however, tick populations are expected to retreat from the Southeastern coast of the U.S., but this has not yet been observed.[36] It's estimated that coinciding with this expansion, increased average temperatures may double tick populations by 2020 as well as bring an earlier start to the tick exposure season.[35][37]

Tick populations are not only spreading wider, but moving to higher elevations. In Colorado, the Rocky Mountain wood tick known as *D. andersoni* is found along the front range and is want to feed, and consequently infect, human populations with tularemia (*Francisella tularensis*), Rocky Mountain spotted fever (*Rickettsia rickettsii*), and Colorado tick fever (CTF virus). A case study testing climatic interaction affecting tick vector (*D. andersoni*) populations in Larimer County, Colorado indicated that an estimated increase of 1.2–2.0 °C in summer temperatures would increase tick populations moving 100m upwards in elevation, increasing the range and susceptibility of tick-borne illnesses along the front range.

Initial symptoms of tick-borne infections are generally quite similar to that of other viral illnesses. This includes fever, headache, fatigue, and general malaise. This group of diseases can further be difficult to distinguish early on in the disease process due to these general symptoms in addition to most people (reported around 75%) not realizing they have been bitten or exposed to the tick vector.[38] Unique to early Lyme disease is the development of the classic erythema migrans skin rash, also known as the "bull's eye" or "target" rash, which occurs in about 80% of people diagnosed with Lyme disease.[39] This symptom can be an important distinguishing factor helping to make the diagnosis early. If Lyme disease is unrecognized, misdiagnosed, or improperly treated it can lead to much more severe and serious consequences with the spread of the spirochete to joints, heart, and nervous system causing arthritis, carditis, cranial nerve palsies or encephalopathy and cognitive dysfunction.[39]

Regardless of the specific diagnosis (Lyme, Rocky Mountain Spotted Fever, Colorado Tick Fever, Babesiosis etc.) the key to management and prevention of sequelae is early identification of disease and initiation of appropriate antibiotic therapy. With regard to the effects of a warming world and the expansion of tick populations to previously unexposed areas, adaptive keys to prevention will include expansion of health care infrastructure and pharmacologic availability, as well as education of people and providers as to the risks of disease and preventative measures they can take.[40]

In the face of these expanding threats, strong collaboration between government officials and environmental scientists is necessary for advancing preventative and reactive response measures. Without acknowledging the climate changes that make environments more habitable for disease carriers, policy and infrastructure will lag behind vector borne disease spread.[41] The human cost associated with denying climate change science is one that concerns many governments. In the United States, the Centers for Disease Control and Prevention (CDC) is conducting a grant program called Building Resilience Against Climate Effects (BRACE) which details a 5 step process for combating climate effects like tick borne disease spread.[42] As is the case when responding to other vectors and effects of climate change, vulnerable populations including children and the elderly will need to be prioritized by any intervention.[43] Productive policies in the U.S. and the world need to accurately model changes in vector populations as well as the burden of disease, educate the public on ways to mitigate infection, and prepare health systems for the increasing disease load.[44]

2.2. Impact on Mental Health

While the physical health impacts of climate change are well known, the impact on mental health has only begun to be recognized in the last decade.[45] According to 2011 in *American Psychologist* Clayton & Doherty, concluded that global climate change is bound to have substantial negative impacts on mental health and wellbeing, effects which will primarily be felt by vulnerable populations and those with pre-existing serious mental illness.[46] Research done by Berry, Bowen, and Kjellstrom in 2008 found that climate change exposes populations to trauma, which negatively impacts mental health in very serious ways.[47] Both the Clayton study and the Berry study identify three classes of psychological impacts from global climate change: direct, indirect, and psychosocial.[46][47] The Clayton study claims that in order to appreciate these impacts on psychological wellbeing, one must recognize the different cultural narratives associated with climate change, as well as how climate change and global phenomena like increased population, are interrelated. Climate change does not impact everyone equally; those of lower economic and social status are at greater risk and experience more devastating impacts.[46] A 2018 study of CDC data connected temperature rise to increased numbers of suicides.[48] The study revealed that hotter days could increase suicide rates and could cause approximately 26,000 more suicides in the U.S. by 2050.[49]

Direct impacts

Direct impacts on mental health happen when a community experiences extreme weather and changed environment.[46] Direct impacts like landscape changes, impaired place attachment, and psychological trauma are all immediate and localized problems resulting from extreme weather events and environmental changes.[46] Extreme weather events cause negative changes to landscape and agriculture. This leads to communities facing economic aspects, especially for communities that use agriculture as a main source of income. After economic fall, communities face loss of livelihoods and poverty. Many communities will also face isolation, alienation, grief, bereavement, and displacement from these effects.[47][50] Individuals will have an increased rate of anxiety and emotional stress. The rate of effects on mental health increases in already-vulnerable communities.[50] Clayton reinforces that the more powerful the extreme weather event, and the more frequent these weather events are, the more damage is done to the mental health of the community.[46] Some of the extreme weather events responsible for these mental health changes include wildfires,[50] earthquakes, hurricanes, fires, floods,[47] and extreme heat.[51]

Indirect impacts

Indirect impacts on mental health occur via impacts on physical health and community well-being. Physical health and mental health have a reciprocal relationship.[47] If the physical health of an individual is negatively impacted, the decline in mental health will soon follow.[47] These impacts are more gradual and cumulative. They are threats to emotional wellbeing through concern and uncertainty about future risks.[46] They are also large-scale community and social effects, like conflicts related to migration and subsequent shortages or adjustment after a disaster. Extreme weather events play a major role here; their impacts can be indirect, not just direct.[47] This is due to the effect on physical health from extreme weather events. Each extreme weather event affects humans in different ways, but they all lead to the decline of mental health.[47] Heat indirectly causes mental health issues through physical health issues. The World Health Organization presents the fact that high extreme heat is directly related to certain ailments like cardiovascular disease, respiratory disease, and asthma. One piece of their evidence is that in summer 2003, during Europe's big heat wave, there were 70,000 recorded deaths related to the heat.[51] Heat exhaustion also occurs during extreme heat. As climate change continues, heat will continue to rise and these problems will exacerbate. These physical problems lead to mental health problems. As physical health worsens and is less curable, mental stability starts to deteriorate.[47]

As extreme heat makes landscapes dry, nature is more prone to fire. Research shows that rising heat due to climate change has caused an increase in fires around the United States.[52] Burns and smoke inhalation from the increasing number of fires lead to a decline in physical health, which leads to mental health problems. Deaths of family and friends cause individuals to suffer from stress and other conditions. Many suffering from loss of family and friends will internalize their emotions, feel extreme guilt and helplessness, and become paranoid. Others will develop fear of future loss and have an overall displacement of feelings that could last for years.[53] Anderson published research in the American Psychological Association that shows the increase in murders in the United States directly correlates with the temperature increase. For every one-degree Fahrenheit, there will be nine more murders in the country, which leads to an additional 24,000 murders or assaults per year in the United States.[54]

There is also an increased risk in suicide in communities that suffer from extreme weather events. Studies show that suicide rates increase after extreme weather events. This is evidence for the decline in mental health.[55] The increased suicide risk has been demonstrated in *Australia* , where drought has resulted in crop failures and despair to the Australian countryside. After the event, farmers were left with almost nothing. They were forced to sell their belongings, reduce their stock, and borrow large sums of money to plant crops at the start of the next season.[55] These consequences have caused a growing increase in depression, domestic violence, and suicide. More than one hundred farmers in the Australian countryside had committed suicide by 2007.[55] An individual's suicide often leads to mental health problems of loved ones. They face issues like those who have lost loved ones due to fire: grief, sadness, anger, paranoia, and others.[53]

Some impacts pertaining to mental health are even more gradual and cumulative than the others, like social interaction, media, and communication.[46] The social interaction between communities and within communities is greatly affected by migration. Communities choose to migrate, or are forced to migrate, due to stressors on limited resources. This is worsened by extreme weather events caused by climate change.[50] Common mental health conditions associated indirectly from these extreme weather events include acute traumatic stress, post-traumatic stress disorder, depression, complicated grief, anxiety disorders, sleep difficulties, and sexual dysfunction. Drug abuse and alcohol abuse are also common aftereffects, and can lead to both physical and mental issues, addiction and substance reliance being the most common.[50]

The effects of Hurricane Katrina, a past extreme weather event in New Orleans, lead to a variety of mental health problems due to the destruction of resources[55] Many people impacted by Hurricane Katrina were left homeless, disenfranchised, stressed, and suffering physical illness. This strain on the public health system decreased access and availability of medical resources.[55] Some climate change adaptation measures may prevent the need for displacement. However, some communities may be unable to implement adaptation strategies, and this will create added stress, further exacerbating already existing mental health issues.[50] Extreme weather events and population displacement lead to limited availability of medications, one of the primary resources required to meet psychological and physical needs of those affected by such events. Less medication and medical resources means fewer people can get the help they need to recover. Slowed recovery and lack of recovery worsen overall mental health.[50]

Psychological impacts

Psychological impacts are the effects that heat, drought, migrations, and climate-related conflicts have on social life and community life. This includes post-disaster adjustment.[46] Most of these effects are indirect instead of direct, but Clayton and Berry place them in a separate category because they deal with the relationships within a community.[46][47] Many of the results are from how people use and occupy territory.[46] Human migration of large communities causes discord within those communities because the already scarce resources are even more limited during migration.[50] Agriculture and aquaculture are severely impacted by the extreme weather events of climate change, the suitability of territory being the most notable kind of change.[46] During and after migration, the geographical distribution of populations is altered.[46] Children and parents may be separated at these times. The early separation of kids from their parents can cause symptoms of grieving, depression, and detachment in both the young and old.[53] The loss in resources can also lead to inter-community violence and aggression. Two groups may fight over remaining natural resources. A community may choose to migrate to find better resources, and encroach on another community's territory, either accidentally or purposefully.[46] Civil unrest can occur when governments fail to adequately protect communities against the extreme weather events that cause these effects. When this happens, individuals lose confidence and trust in their government. A loss in trust can be the beginning of oncoming mental health problems.[53][56] The disruption of a community when they are forced to relocate results in the deterioration of geographic and social connections. This leads to grief, anxiety, and an overall sense of loss.[57]

3. Climate Change and Permafrost

Permafrost is an important part of our environment and plays an important role in maintaining the stability of many ecosystems around the world.

3.1. Soil Sustainability

Permafrost is integral to soil stability in arctic regions.[58] Melting permafrost causes the surrounding soil to become unstable and settle.[58] Settlement of surface soil associated with melting permafrost leads to significant infrastructure instability and damage to roads, bridges, buildings, homes, pipelines and airstrips in affected areas.[58]

4. Impact on Natural Resources

4.1. Drinking Water

Global Health Corps reports that when interruptions in the regular water supply, "forces rural and impoverished families to resort to drinking the dirty, sediment-and-parasite-laden water that sits in puddles and small pools on the surface of the earth."[59] Many are aware of the presence of contamination, but will drink from these sources nonetheless in order to avoid dying of dehydration. It has been estimated that up to 80% of human illness in the developing world can be attributed to contaminated water. [60]

When there is an adequate amount of drinking water, humans drink from different sources than their livestock. However, when drought occurs and drinking water slowly disappears, catchment areas such as streams and depressions in the ground where water gathers are often shared between people and the livestock they depend on for financial and nutritional support, and this is when humans can fall seriously ill. Although some diseases that are transferred to humans can be prevented by boiling the water, many people, living on just a litre or two of water per day, refuse to boil, as it loses a certain percentage of the water to steam.[61]

The sharing of water between livestock and humans is one of the most common factors in the transmission of non-tuberulosis mycobacteria (NTM). NTM is carried in cattle and pig feces, and if this contaminates the drinking water supply, it can result in pulmonary disease, disseminated disease or localized lesions in humans with both compromised and competent immune systems.[62] During drought, water supplies are even more susceptible to harmful algal blooms and microorganisms.[63] Algal blooms increase water turbidity, suffocating aquatic plants, and can deplete oxygen, killing fish. Some kinds of blue-green algae create neurotoxins, hepatoxins, cytotoxins or endotoxins that can cause serious and sometimes fatal neurological, liver and digestive diseases in humans. Cyanobacteria grow best in warmer temperatures (especially above 25 degrees Celsius), and so areas of the world that are experiencing general warming as a result of climate change are also experiencing harmful algal blooms more frequently and for longer periods of time. During times of intense precipitation (such as during the “wet season” in much of the tropical and sub-tropical world, including Australia and Panama), nutrients that cyanobacteria depend on are carried from groundwater and the earth's surface into bodies of water. As drought begins and these bodies gradually dry up, the nutrients are concentrated, providing the perfect opportunity for algal blooms.[64][65][66]

4.2. Fresh Water

As the climate warms, it changes the nature of global rainfall, evaporation, snow, stream flow and other factors that affect water supply and quality. Freshwater resources are highly sensitive to variations in weather and climate. Climate change is projected to affect water availability. In areas where the amount of water in rivers and streams depends on snow melting, warmer temperatures increase the fraction of precipitation falling as rain rather than as snow, causing the annual spring peak in water runoff to occur earlier in the year. This can lead to an increased likelihood of winter flooding and reduced late summer river flows. Rising sea levels cause saltwater to enter into fresh underground water and freshwater streams. This reduces the amount of freshwater available for drinking and farming. Warmer water temperatures also affect water quality and accelerate water pollution.[67]

5. Impact on Livestock

Climate change is beginning to lead the global population into a food shortage, greatly affecting our livestock supply. Although the change in our climate is causing us to lose food, these sources are also contributing to climate change, essentially, creating a feedback loop. Greenhouse gases, specifically from livestock, are one of the leading sources furthering global warming; these emissions, which drastically effect climatic change, are also beginning to harm our livestock in ways we could never imagine.

5.1. Greenhouse Gas Effects

Our agricultural food system is responsible for a significant amount of the greenhouse-gas emissions that are produced.[68][69]

According to the IPCC, it makes up between, at least, 10-12% of the emissions, and when there are changes in land due to the agriculture, it can even rise as high as 17%. More specifically, emissions from farms, such as nitrous oxide, methane and carbon dioxide, are the main culprits, and can be held accountable for up to half of the greenhouse-gases produced by the overall food industry, or 80% of all emissions just within agriculture.[69]

The types of farm animals, as well as the food they supply can be put into two categories: monogastric and ruminant. Typically, beef and dairy, in other words, ruminant products, rank high in greenhouse-gas emissions; monogastric, or pigs and poultry-related foods, are low. The consumption of the monogastric types, therefore, yield less emissions. This is due to the fact that these types of animals have a higher feed-conversion efficiency, and also do not produce any methane.[69]

As lower-income countries begin, and continue, to develop, the necessity for a consistent meat supply will increase.[69][70] This means the cattle population will be required to grow in order to keep up with the demand, producing the highest possible rate of greenhouse-gas emissions.[69]

There are many strategies that can be used to help soften the effects, and the further production of greenhouse-gas emissions. Some of these strategies include a higher efficiency in livestock farming, which includes management, as well as technology; a more effective process of managing manure; a lower dependence upon fossil-fuels and nonrenewable resources; a variation in the animals' eating and drinking duration, time and location; and a cutback in both the production and consumption of animal-sourced foods.[69][70][71][72]

5.2. Heat Stress

Heat stress on livestock has a devastating effect on not only their growth and reproduction, but their food intake and production of dairy and meat. Cattle require a temperature range of 5-15 degrees Celsius, but upwards to 25 °C, to live comfortably, and once climate change increases the temperature, the chance of these changes occurring increases.[70] Once the high temperatures hit, the livestock struggle to keep up their metabolism, resulting in decreased food intake, lowered activity rate, and a drop in weight. This causes a decline in livestock productivity and can be detrimental to the farmers and consumers. Obviously, the location and species of the livestock varies and therefore the effects of heat vary between them. This is noted in livestock at a higher elevation and in the tropics, of which have a generally increased effect from climate change. Livestock in a higher elevation are very vulnerable to high heat and are not well adapted to those changes.

6. Impact on Plant Based Food

Climate change has many potential impacts on the production of food crops—from food scarcity and nutrient deficiency to possible increased food production because of elevated carbon dioxide (CO
2) levels—all of which directly affect human health. Part of this variability in possible outcomes is from the various climate change models used to project potential impacts; each model takes into account different factors and so come out with a slightly different result.[73] A second problem comes from the fact that projections are made based on historical data which is not necessarily helpful in accurate forecasting as changes are occurring exponentially.[74] As such, there are many different possible impacts—both positive and negative—that may result from climate change affecting global regions in different ways.[74][75]

6.1. Food Scarcity

Food scarcity is a major key for many populations and is one of the prominent concerns with the changing climate. Currently, 1/6 of the global population are without adequate food supply.[76] By 2050, the global population is projected to reach 9 billion requiring global food productions to increase by 50% to meet population demand.[76][77] In short, food scarcity is a growing concern that, according to many researchers, is projected to worsen with climate change because of a number of factors including extreme weather events and an increase in pests and pathogens.

6.2. Extreme Weather

Rising temperatures

As the temperature changes and weather patterns become more extreme, areas which were historically good for farmland will no longer be as amicable.[78][79] The current prediction is for temperature increase and precipitation decrease for major arid and semi-arid regions (Middle East, Africa, *Australia* , Southwest United States, and Southern Europe).[78][80] In addition, crop yields in tropical regions will be negatively affected by the projected moderate increase in temperature (1-2 °C) expected to occur during the first half of the century. During the second half of the century, further warming is projected to decrease crop yields in all regions including *Canada* and Northern United States.[80] Many staple crops are extremely sensitive to heat and when temperatures rise over 36 °C, soybean seedlings are killed and corn pollen loses its vitality.[81] Scientists project that an annual increase of 1 °C will in turn decrease wheat, rice and corn yields by 10%.[80]

There are, however, some positive possible aspects to climate change as well. The projected increase in temperature during the first half of the century (1-3 °C) is expected to benefit crop and pasture yields in the temperate regions.[73] This will lead to higher winter temperatures and more frost-free days in these regions; resulting in a longer growing season, increased thermal resources and accelerated maturation.[74][75] If the climate scenario results in mild and wet weather, some areas and crops will suffer, but many may benefit from this.[73]

Drought and flood

Extreme weather conditions continue to decrease crop yields in the form of droughts and floods. While these weather events are becoming more common, there is still uncertainty and therefore a lack of preparedness as to when and where they will take place.[75][82] In extreme cases, floods destroy crops, disrupting agricultural activities and rendering workers jobless and eliminating food supply. On the opposite end of the spectrum, droughts can also wipe out crops. It is estimated that 35-50% of the world's crops are at risk of drought. Australia has been experiencing severe, recurrent droughts for a number of years, bringing serious despair to its farmers. The country's rates of depression and domestic violence are increasing and as of 2007, more than one hundred farmers had committed suicide as their thirsty crops slipped away. Drought is even more disastrous in the developing world, exacerbating the pre-existing poverty and fostering famine and malnutrition.[73]

Droughts can cause farmers to rely more heavily on irrigation; this has downsides for both the individual farmers and the consumers. The equipment is expensive to install and some farmers may not have the financial ability to purchase it.[78] The water itself must come from somewhere and if the area has been in a drought for any length of time, the rivers may be dry and the water must be transported from further distances. With 70% of “blue water” currently being used for global agriculture, any need over and above this could potentiate a water crisis.[73][76] In Sub-Saharan Africa, water is used to flood rice fields to control the weed population; with the projection of less precipitation for this area, this historical method of weed control will no longer be possible.[83]

With more costs to the farmer, some will no longer find it financially feasible to farm. Agriculture employs the majority of the population in most low-income countries and increased costs can result in worker layoffs or pay cuts.[73] Other farmers will respond by raising their food prices; a cost which is directly passed on to the consumer and impacts the affordability of food. Some farms do not export their goods and their function is to feed a direct family or community; without that food, people will not have enough to eat. This results in decreased production, increased food prices, and potential starvation in parts of the world.[76]

6.3. Financial

Some research suggests that initially climate change will help developing nations because some regions will be experiencing more negative climate change effects which will result in increased demand for food leading to higher prices and increased wages.[73] However, many of the projected climate scenarios suggest a huge financial burden. For example, the heat wave that passed through Europe in 2003 cost 13 billion euros in uninsured agriculture losses. In addition, during El Nino weather conditions, the chance of the Australian farmer's income falling below average increased by 75%, greatly impacting the country's GDP. The agriculture industry in *India* makes up 52% of their employment and the Canadian Prairies supply 51% of Canadian agriculture; any changes in the production of food crops from these areas could have profound effects on the economy.[74][79] This could negatively affect the affordability of food and the subsequent health of the population.

6.4. Pests and Pathogens

Currently, CO_2 levels are 40% higher than they were in pre-industrial times. This diminishes nutritional content for both human and insect consumption. Studies have shown that when CO_2 levels rise, soybean leaves are less nutritious; therefore plant-eating beetles have to eat more to get their required nutrients. In addition, soybeans are less capable of defending themselves against the predatory insects under high CO_2. The CO_2 diminishes the plant's jasmonic acid production, an insect-killing poison that is excreted when the plant senses it's being attacked. Without this protection, beetles are able to eat the soybean leaves freely, resulting in a lower crop yield. This is not a problem unique to soybeans, and many plant species’ defense mechanisms are impaired in a high CO_2 environment.[77]

Currently, pathogens take 10-16% of the global harvest and this level is likely to rise as plants are at an ever-increasing risk of exposure to pests and pathogens.[77] Historically, cold temperatures at night and in the winter months would kill off insects, bacteria and fungi. The warmer, wetter winters are promoting fungal plant diseases like soybean rust to travel northward. Soybean rust is a vicious plant pathogen that can kill off entire fields in a matter of days, devastating farmers and costing billions in agricultural losses. Another example is the Mountain Pine Beetle epidemic in BC, Canada which killed millions of pine trees because the winters were not cold enough to slow or kill the growing beetle larvae. The increasing incidence of flooding and heavy rains also promotes the growth of various other plant pests and diseases.[84] On the opposite end of the spectrum, drought conditions favour different kinds of pests like aphids, whiteflies and locusts.

The competitive balance between plants and pests has been relatively stable for the past century, but with the rapidly shifting climate, there is a change in this balance which often favours the more biologically diverse weeds over the monocrops most farms consist of.[84] Currently, weeds claim about one tenth of global crop yields annually as there are about eight to ten weed species in a field competing with crops. Characteristics of weeds such as their genetic diversity, cross-breeding ability, and fast-growth rates put them at an advantage in changing climates as these characteristics allow them to adapt readily in comparison to most farm's uniform crops, and give them a biological advantage. There is also a shift in the distribution of pests as the altered climate makes areas previously uninhabitable more uninviting.[81] Finally, with the increased CO2 levels, herbicides will lose their efficiency which in turn increases the tolerance of weeds to herbicides.[84]

7. Impact on Nutrition

Another area of concern is the effect of climate change on the nutritional content of food for human consumption. Studies show that increasing atmospheric levels of CO2 have an unfavourable effect on the nutrients in plants. As the carbon concentration in the plant's tissues increase, there is a corresponding decrease in the concentration of elements such as nitrogen, phosphorus, zinc and iodine. Of significant concern is the protein content of plants, which also decreases in relation to elevating carbon content.[74][77][85]

Irakli Loladze explains that the lack of essential nutrients in crops contributes the problem of micronutrient malnutrition in society, commonly known as “hidden hunger”; despite adequate caloric intake, the body still is not nutritionally satisfied and therefore continues to be “hungry”.[86] This problem is aggravated by the rising cost of food, resulting in a global shift towards diets which are less expensive, but high in calories, fats, and animal products. This results in undernutrition and an increase in obesity and diet-related chronic diseases.[76][86]

Countries worldwide are already impacted by deficiencies in micronutrients and are seeing the effects in the health of their populations. Iron deficiency affects more than 3.5 billion people; increasing maternal mortality and hindering cognitive development in children, leading to education losses. Iodine deficiency leads to ailments like goitre, brain damage and cretinism and is a problem in at least 130 different countries.[86] Even though these deficiencies are invisible, they have great potential to impact human health on a global scale.

Small increases in CO2 levels can cause a CO2 fertilization effect where the growth and reproduction abilities of C_3 plants such as soybeans and rice are actually enhanced by 10-20% in laboratory experiments. This does not take into account, however, the additional burden of pests, pathogens, nutrients and water affecting the crop yield.[85][87]

8. Adaptation and Mitigation Strategies

While researchers acknowledge there are possible benefits of global warming, most agree that the negative consequences of climate change will outweigh any potential benefits and instead the shifting climate will result in more benefits to developed countries and more detriments to developing countries; exacerbating the discrepancy between wealthy and impoverished nations.[77][87] By thoughtful and proactive efforts, climate change can be mitigated by addressing these issues with a multidisciplinary approach that works on a global, national and community basis that recognizes the uniqueness of each country's situation.[76][79]

According to a study of East Africa’s smallholder farms, impacts of climate change on agriculture are already being seen there resulting in changes to farming practices such as intercropping, crop, soil, land, water and livestock management systems, and introduction of new technologies and seed varieties by some of the farmers.[82] Some other suggestions such as eliminating supply chain and household food waste, encouraging diverse and vegetable-rich diets, and providing global access to foods (food aid programs) have been suggested as ways to adapt.[73][76][77] Many researchers agree that agricultural innovation is essential to addressing the potential issues of climate change. This includes better management of soil, water-saving technology, matching crops to environments, introducing different crop varieties, crop rotations, appropriate fertilization use, and supporting community-based adaptation strategies.[74][76][79][84][88] On a government and global level, research and investments into agricultural productivity and infrastructure must be done to get a better picture of the issues involved and the best methods to address them. Government policies and programs must provide environmentally sensitive government subsidies, educational campaigns and economic incentives as well as funds, insurance and safety nets for vulnerable populations.[73][76][77][79][88] In addition, providing early warning systems, and accurate weather forecasts to poor or remote areas will allow for better preparation; by using and sharing the available technology, the global issue of climate change can be addressed and mitigated by the global community.[76]

9. Oceans and Human Health

9.1. Overview

Perhaps one of the most recent adverse effects of climate change to be explored is that of ocean acidification. Our oceans cover approximately 71 percent of the Earth's surface and support a diverse range of ecosystems, which are home to over 50 percent of all the species on the planet.[89] Oceans regulate climate and weather as well as providing nutrition for a vast variety of species, humans included.[89] Covering such an extensive part of the planet has allowed the oceans to absorb a large portion of the carbon dioxide (CO2) from the atmosphere.[90] This process is part of the carbon cycle in which the fluxes of carbon dioxide (CO2) in Earth's atmosphere, biosphere and lithosphere are described.[91] Humans have drastically added to the amount of carbon dioxide (CO2) in the atmosphere through the burning of fossil fuels and the process of deforestation. Oceans work as a sink absorbing excess anthropogenic carbon dioxide (CO2). As the oceans absorb anthropogenic carbon dioxide (CO2) it breaks down into carbonic acid, a mild acid, this neutralizes the normally alkaline ocean water. As a result, the pH in the oceans is declining. In the research surrounding global climate change we are only just beginning to realize that our oceans can sequester a finite amount of CO2 before we start seeing impacts on marine life that could lead to devastating losses. Acidification of our oceans has the potential to drastically alter life as we know it - from extreme weather patterns and food scarcity to a loss of millions of species from the planet - all of these consequences hold the potential to directly affect human health.

9.2. Coral

With degradation of protective coral reefs through acidic erosion, bleaching and death, salt water is able to infiltrate fresh ground water supplies that large populations depend on.[92][93] Nowhere is this more evident than atoll islands. These islands possess limited freshwater supplies, namely ground water lenses and rain fall. When the protective coral reefs surrounding them erodes due to higher temperatures and acidic water chemistry, salt water is able to infiltrate the lens and contaminate the drinking water supply.[92] In coastal Bangladesh it has been demonstrated that seasonal hypertension in pregnant women is connected with such phenomenon due to high sodium intake from drinking water.[93] Reef erosion, coupled with sea level rise, tends to flood low-lying areas more frequently during storm surges and weather events. Warming ocean waters generate larger and more devastating weather events that can decimate coastal populations especially without the protection of coral reefs.

9.3. Human Health

The health of our oceans has a direct effect on the health humans. According to Small and Nicholls, they estimated that 1.2 billion people worldwide, lived in the near-coastal region (within 100 km and 100m of the shoreline).[94] This data was collected in 1990 and therefore is a conservative estimate in modern terms. In the U.S. alone 53% of the population lives within 50 miles of the coastal shoreline.[95] Humans rely heavily on oceans for food, employment, recreation, weather patterns and transportation.[96] In the U.S. alone the lands adjacent to the oceans contribute over $1 trillion annually through these various activities not to mention pharmaceutical and medicinal discoveries.[96] In all, the oceans are very important for our survival as a species.

9.4. Food Safety

Our insatiable appetite for seafood of all types has led to overfishing and has already significantly strained marine food stocks to the point of collapse in many cases. With seafood being a major protein source for so much of the population, there are inherent health risks associated with global warming. As mentioned above increased agricultural runoff and warmer water temperature allows for eutrophication of ocean waters. This increased growth of algae and phytoplankton in turn can have dire consequences. These algal blooms can emit toxic substances that can be harmful to humans if consumed. Organisms, such as shellfish, marine crustaceans and even fish, feed on or near these infected blooms, ingest the toxins and can be consumed unknowingly by humans. One of these toxin producing algae is Pseudo-nitzschia fraudulenta. This species produces a substance called domoic acid which is responsible for amnesic shellfish poisoning.[97] The toxicity of this species has been shown to increase with greater CO
2 concentrations associated with ocean acidification.[97] Some of the more common illnesses reported from harmful algal blooms include; Ciguatera fish poisoning, paralytic shellfish poisoning, azaspiracid shellfish poisoning, diarrhetic shellfish poisoning, neurotoxic shellfish poisoning and the above-mentioned amnesic shellfish poisoning.[97]

10. Extreme Weather Events

Infectious disease often accompanies extreme weather events, such as floods, earthquakes and drought. These local epidemics occur due to loss of infrastructure, such as hospitals and sanitation services, but also because of changes in local ecology and environment. For example, malaria outbreaks have been strongly associated with the El Niño cycles of a number of countries (India and Venezuela, for example). El Niño can lead to drastic, though temporary, changes in the environment such as temperature fluctuations and flash floods.[98] Because of global warming there has been a marked trend towards more variable and anomalous weather. This has led to an increase in the number and severity of extreme weather events. This trend towards more variability and fluctuation is perhaps more important, in terms of its impact on human health, than that of a gradual and long-term trend towards higher average temperature.[98]

10.1. Drought

Arguably one of the worst effects that drought has directly on human health is the destruction of food supply. Farmers who depend on weather to water their crops lose tons of crops per year due to drought. Plant growth is severely stunted without adequate water, and plant resistance mechanisms to fungi and insects weaken like human immune systems. The expression of genes is altered by increased temperatures, which can also affect a plant's resistance mechanisms. One example is wheat, which has the ability to express genes that make it resistant to leaf and stem rusts, and to the Hessian fly; its resistance declines with increasing temperatures. A number of other factors associated with lack of water may actually attract pestilent insects, as well- some studies have shown that many insects are attracted to yellow hues, including the yellowing leaves of drought-stressed plants. During times of mild drought is when conditions are most suitable to insect infestation in crops; once the plants become too weakened, they lack the nutrients necessary to keep the insects healthy. This means that even a relatively short, mild drought may cause enormous damage- even though the drought on its own may not be enough to kill a significant portion of the crops, once the plants become weakened, they are at higher risk of becoming infested.[99]

The results of the loss of crop yields affect everyone, but they can be felt most by the poorest people in the world. As supplies of corn, flour and vegetables decline, world food prices are driven up. Malnutrition rates in poor areas of the world skyrocket, and with this, dozens of associated diseases and health problems. Immune function decreases, so mortality rates due to infectious and other diseases climb. For those whose incomes were affected by droughts (namely agriculturalists and pastoralists), and for those who can barely afford the increased food prices, the cost to see a doctor or visit a clinic can simply be out of reach. Without treatment, some of these diseases can hinder one's ability to work, decreasing future opportunities for income and perpetuating the vicious cycle of poverty.[100]

10.2. Floods

Health concerns around the world can be linked to floods. With the increase in temperatures worldwide due to climate change the increase in flooding is unavoidable.[101] Floods have short and long term negative implications to peoples' health and well being. Short term implications include mortalities, injuries and diseases, while long term implications include non-communicable diseases and psychosocial health aspects.[102]

Mortalities are not uncommon when it comes to floods. The Countries with lower incomes are more likely to have more fatalities, because of the lack of resources they have and the supplies to prepare for a flood. This does depend on the type and properties of the flood. For example, if there is a flash flood it would not matter how prepared you are. Fatalities connected directly to floods are usually caused by drowning; the waters in a flood are very deep and have strong currents.[102] Deaths do not just occur from drowning, deaths are connected with dehydration, heat stroke, heart attack and any other illness that needs medical supplies that cannot be delivered.[102] Due to flooding mud, grit or sand particles can be deposited into the lakes and rivers. These particles cause the water to become dirty and this becomes a problem as the dirty water leads to water related diseases. For example, cholera and guinea worm disease are caused by dirty water.[103]

Injuries can lead to an excessive amount of morbidity when a flood occurs. Victims who already have a chronic illness and then sustain a non-fatal injury are put at a higher risk for that non-fatal injury to become fatal. Injuries are not isolated to just those who were directly in the flood, rescue teams and even people delivering supplies can sustain an injury. Injuries can occur anytime during the flood process; before, during and after.[102] Before the flood people are trying to evacuate as fast as they can, motor vehicle accidents, in this case, are a primary source of injuries obtained post flood. During floods accidents occur with falling debris or any of the many fast moving objects in the water. After the flood rescue attempts are where large numbers injuries can occur.[102]

Communicable diseases are increased due to many pathogens and bacteria that are being transported by the water. In floods where there are many fatalities in the water there is a hygienic problem with the handling of bodies, due to the panic stricken mode that comes over a town in distress.[102] There are many water contaminated diseases such as cholera, hepatitis A, hepatitis E and diarrheal diseases, to mention a few. There are certain diseases that are directly correlated with floods they include any dermatitis and any wound, nose, throat or ear infection. Gastrointestinal disease and diarrheal diseases are very common due to a lack of clean water during a flood. Most of clean water supplies are contaminated when flooding occurs. Hepatitis A and E are common because of the lack of sanitation in the water and in living quarters depending on where the flood is and how prepared the community is for a flood.[102]

Respiratory diseases are a common after the disaster has occurred. This depends on the amount of water damage and mold that grows after an incident. Vector borne diseases increase as well due to the increase in still water after the floods have settled. The diseases that are vector borne are malaria, dengue, West Nile, and yellow fever.[102]

Non-communicable diseases are a long-term effect of floods. They are either caused by a flood or they are worsened by a flood; they include cancer, lung disease and diabetes. Floods have a huge impact on victims' psychosocial integrity. People suffer from a wide variety of losses and stress. One of the most treated illness in long-term health problems are depression caused by the flood and all the tragedy that flows with one.[102]

10.3. Hurricanes

Another result of the warming oceans are stronger hurricanes, which will wreak more havoc on land, and in the oceans,[104] and create more opportunities for vectors to breed and infectious diseases to flourish.[5] Extreme weather also means stronger winds. These winds can carry vectors tens of thousands of kilometers, resulting in an introduction of new infectious agents to regions that have never seen them before, making the humans in these regions even more susceptible.

10.4. Glacial Melting

A glacier is a mass of ice that has originated from snow that has been compacted via pressure and have definite lateral limits and movements in definite directions.[105] They are found in areas where the temperatures do not get warm enough to melt annual snow accumulation, thus resulting in many layers of snow piling up over many years, creating the pressure needed to make a glacier. Global climate change and fluctuation is causing an increasingly exponential melting of Earth's glaciers. These melting glaciers have many social and ecological consequences that directly or indirectly impact the health and well-being of humans.[106] The recession of glaciers change sea salt, sediment, and temperature ratios in the ocean which changes currents, weather patterns, and marine life.[98] The melt also increases ocean levels and decreases the availability of water for human consumption, agriculture, and hydroelectricity. This aggravates and increases the likelihood of issues such as sanitation, world hunger, population shifts, and catastrophic weather such as flooding, drought, and worldwide temperature fluctuations.[98]

“Glacier mass-balances show consistent decreases over the last century in most regions of the world and retreat may be accelerating in many locations" [107] with an average loss of ten meters per year,[106] nearly twice as fast as ten years ago.[108] Glaciers currently cover ~10% of the Earth's surface, or ~15 million km² and holds ~75% of Earth's fresh water supply. Glacial retreat first gained the attention of alpinists and the tourist industry shortly after 1940 – when the globe warmed ~0.5 °C.[105] Even with 62 years of awareness, climate change is just becoming an issue for some parts of society. Over this time period the cirque and steep alpine glaciers were able to acclimatize to the new temperatures posed by climate change; large valley glaciers have not yet made this adjustment. This means the large valley glaciers are rapidly retreating, as their mass is attempting to achieve equilibrium with the current climate. If regional snow lines stay constant, then the glaciers remain constant.[105] Today this is clearly not the case as global warming is causing mountain snow lines to rapidly retreat. Even the United States’ famous Glacier National Park is receding. More than two-thirds of its glaciers have disappeared and it is expected for them to be nonexistent in the park by the year 2030.[109]

Glacial melt will affect low-lying coastal wetlands via sea level rise, change key drivers of fresh-water ecosystems, shift the timing of snow packs, and alter the unique character of associated fresh water streams off of snow pack.[110] It has also been stated that the sea level will rise 28–43 cm by 2100;[110] if all the ice on Earth melts, it is predicted that the ocean level will increase 75 meters, destroying many coastal cities.[98] In addition, the freshwater swaps in northern areas are already affected by the intrusion of salt water. “Sea level rise will cause a change of state from freshwater to marine or estuarine ecosystems, radically altering the composition of biotic communities".[110]

Not only are glaciers causing a rise in sea level, they are causing an increase in El Niño Southern Oscillation (ESNO) and global temperature itself.[105] Glacier loss adds to global heat rise through a decrease in what is called ice-albedo feedback. As more ice melts, there is less solar reflectivity and less heat is reflected away from the Earth, causing more heat to be absorbed, and retained in the atmosphere and soil [98] In addition to the El Niño events, glacial melt is contributing to the rapid turnover of sea surface temperatures [105] and ocean salt content by diluting the ocean water and slowing the Atlantic conveyor belt's usually swift dive because of a top layer of buoyant, cold, fresh water that slows the flow of warm water to the north.[98]

Fifty percent of the world's fresh water consumption is dependent glacial runoff.[109] Earth's glaciers are expected to melt within the next forty years, greatly decreasing fresh water flow in the hotter times of the year, causing everyone to depend on rainwater, resulting in large shortages and fluctuations in fresh water availability which largely effects agriculture, power supply, and human health and well-being.[98] Many power sources and a large portion of agriculture rely on glacial runoff in the late summer. “In many parts of the world, disappearing mountain glaciers and droughts will make fresh, clean water for drinking, bathing, and other necessary human (and livestock) uses scarce" and a valuable commodity.[98]

11. Deforestation

11.1. Effects of Deforestation in the African Highlands

The Ethiopian Highlands. https://handwiki.org/wiki/index.php?curid=1862987

Environmental changes such as deforestation could increase local temperatures in the highlands thus could enhance the vectorial capacity of the anopheles.[111] Anopheles mosquitoes are responsible for the transmission of a number of diseases in the world, such as, malaria, lymphatic filariasis and viruses that can cause such ailments, like the O'nyong'nyong virus.[111]

Environmental changes, climate variability, and climate change are such factors that could affect biology and ecology of Anophelse vectors and their disease transmission potential.[111] Climate change is expected to lead to latitudinal and altitudinal temperature increases. Global warming projections indicate that the best estimate of surface air warming for a “high scenario” is 4 C, with a likely range of 2.4-6.4 C by 2100.[112] A temperature increase of this size would alter the biology and the ecology of many mosquito vectors and the dynamics of the diseases they transmit such as malaria. Anopheles mosquitoes in highland areas are to experience a larger shift in their metabolic rate due to the climate change. This climate change is due to the deforestation in the highland areas where these mosquitoes dwell. When temperature rises, the larvae take a shorter time to mature [113] and, consequently, there is a greater capacity to produce more offspring. In turn this could potentially lead to an increase in malaria transmission when infected humans are available.

Biodiversity. https://handwiki.org/wiki/index.php?curid=1862987

11.2. Biodiversity

Deforestation is directly linked with a decrease in plant biodiversity.[114] This decrease in biodiversity has several implications for human health. One such implication is the loss of medicinal plants. The use of plants for medicinal purposes is extensive, with ~70 to 80% of individuals worldwide relying solely on plant-based medicine as their primary source of healthcare.[115] This dependency on plants for medicinal purposes is especially rife in developing countries that only consume 15% of manufactured pharmaceutical drugs, many of which are fake.[115] Local knowledge surrounding medicinal plants is useful for screening for new herbal medicines that may be useful for treating disease.[116] Villages and communities which reside continually in a single geographic area over time, create, transmit and apply widespread information surrounding the medicinal resources in the area.[116] Formal scientific methods have been useful in identifying the active ingredients used in ethnopharmacy and applying them to modern medicines. However, it is important that medicinal resources are managed appropriately as they become globally traded in order to prevent species endangerment.[116]

11.3. Extinction of Indigenous Groups

Deforestation is also a primary cause of dislocation and in some cases, extinction of indigenous people.[117] The Malaysian state Sarawak is an example where rampant deforestation has overrun many Dayak groups.[117] The indigenous Sarawakians relied on shifting agriculture, hunting and gathering in order to sustain their relatively low population density.[118] With the advent of modern logging technology the Sarawak forests entered 'mainstream' economic development.[117] This has led to massive forced evacuations and relocation of the Dayak people causing a loss of their traditions and culture.[119]

11.4. Mountain Pine Beetle, Forest Ecosystems and Forest Fires

Adult mountain pine beetle. https://handwiki.org/wiki/index.php?curid=1230683

Climate change and the associated changing weather patterns occurring worldwide have a direct effect on biology, population ecology, and the population of eruptive insects, such as the mountain pine beetle (MPB). This is because temperature is a factor which determines insect development and population success.[120] Mountain Pine Beetle are a species native to Western North America.[121] Prior to climatic and temperature changes, the mountain pine beetle predominately lived and attacked lodgepole and ponderosa pine trees at lower elevations, as the higher elevation Rocky Mountains and Cascades were too cold for their survival.[122] Under normal seasonal freezing weather conditions in the lower elevations, the forest ecosystems that pine beetles inhabit are kept in a balance by factors such as tree defense mechanisms, beetle defense mechanisms, and freezing temperatures. It is a simple relationship between a host (the forest), an agent (the beetle) and the environment (the weather & temperature).[121] However, as climate change causes mountain areas to become warmer and drier, pine beetles have more power to infest and destroy the forest ecosystems, such as the whitebark pine forests of the Rockies.[121] This is a forest so important to forest ecosystems that it is called the “rooftop of the rockies”. Climate change has led to a threatening pine beetle pandemic, causing them to spread far beyond their native habitat. This leads to ecosystem changes, forest fires, floods and hazards to human health.[121]

The whitebark pine ecosystem in these high elevations plays many essential roles, providing support to plant and animal life.[121] They provide food for grizzly bears and squirrels, as well as shelter and breeding grounds for elk and deer; protects watersheds by sending water to parched foothills and plains; serves as a reservoir by dispensing supplies of water from melted snowpacks that are trapped beneath the shaded areas; and creates new soil which allows for growth of other trees and plant species.[121] Without these pines, animals do not have adequate food, water, or shelter, and the reproductive life cycle, as well as quality of life, is affected as a consequence.[121] Normally, the pine beetle cannot survive in these frigid temperatures and high elevation of the Rocky Mountains.[121] However, warmer temperatures means that the pine beetle can now survive and attack these forests, as it no longer is cold enough to freeze and kill the beetle at such elevations.[121] Increased temperatures also allow the pine beetle to increase their life cycle by 100%: it only takes a single year instead of two for the pine beetle to develop. As the Rockies have not adapted to deal with pine beetle infestations, they lack the defenses to fight the beetles.[121] Warmer weather patterns, drought, and beetle defense mechanisms together dries out sap in pine trees, which is the main mechanism of defense that trees have against the beetle, as it drowns the beetles and their eggs.[121] This makes it easier for the beetle to infest and release chemicals into the tree, luring other beetles in an attempt to overcome the weakened defense system of the pine tree. As a consequence, the host (forest) becomes more vulnerable to the disease-causing agent (the beetle).[121]

The whitebark forests of the Rockies are not the only forests that have been affected by the mountain pine beetle. Due to temperature changes and wind patterns, the pine beetle has now spread through the Continental Divide of the Rockies and has invaded the fragile boreal forests of Alberta, known as the “lungs of the Earth”.[121] These forests are imperative for producing oxygen through photosynthesis and removing carbon in the atmosphere. But as the forests become infested and die, carbon dioxide is released into the environment, and contributes even more to a warming climate. Ecosystems and humans rely on the supply of oxygen in the environment, and threats to this boreal forest results in severe consequences to our planet and human health.[121] In a forest ravaged by pine beetle, the dead logs and kindle which can easily be ignited by lightning. Forest fires present dangers to the environment, human health and the economy.[121] They are detrimental to air quality and vegetation, releasing toxic and carcinogenic compounds as they burn.[121] Due to human induced deforestation and climate change, along with the pine beetle pandemic, the strength of forest ecosystems decrease. The infestations and resulting diseases can indirectly, but seriously, effect human health. As droughts and temperature increases continue, so does the frequency of devastating forest fires, insect infestations, forest diebacks, acid rain, habitat loss, animal endangerment and threats to safe drinking water.[121]

11.5. Smoke from Wildfires

Climate change increases wildfire potential and activity.[123] Climate change leads to a warmer ground temperature and its effects include earlier snowmelt dates, drier than expected vegetation, increased number of potential fire days, increased occurrence of summer droughts, and a prolonged dry season.[124]

Warming spring and summer temperatures increase flammability of materials that make up the forest floors.[124] Warmer temperatures cause dehydration of these materials, which prevents rain from soaking up and dampening fires. Furthermore, pollution from wildfires can exacerbate climate change by releasing atmospheric aerosols, which modify cloud and precipitation patterns.

Wood smoke from wildfires produces particulate matter that has damaging effects to human health.[125] The primary pollutants in wood smoke are carbon monoxide and nitric oxide.[124] Through the destruction of forests and human-designed infrastructure, wildfire smoke releases other toxic and carcinogenic compounds, such as formaldehyde and hydrocarbons.[126] These pollutants damage human health by evading the mucociliary clearance system and depositing in the upper respiratory tract, where they exert toxic effects.[124] Research by Naeher and colleagues.[125] found that physician visits for respiratory diseases increased by 45-80% during wildfire activity in urban British Columbia.

The health effects of wildfire smoke exposure include exacerbation and development of respiratory illness such as asthma and chronic obstructive pulmonary disorder; increased risk of lung cancer, mesothelioma and tuberculosis; increased airway hyper-responsiveness; changes in levels of inflammatory mediators and coafulation factors; and respiratory tract infection.[125] It may also have intrauterine effects on fetal development, resulting in low birth weight newborns.[127] Because wildfire smoke travels and is often not isolated to a single geographic region, the health effects are widespread among populations.[126] The suppression of wild fires also takes up a large amount of a country's gross domestic product which directly affects the country's economy.[128] In the United States, it was reported that approximately $6 million was spent between 2004-2008 to suppress wildfires in the country.[128]

12. Displacement/migration

Climate change causes displacement of people in several ways, the most obvious—and dramatic—being through the increased number and severity of weather-related disasters which destroy homes and habitats causing people to seek shelter or livelihoods elsewhere. Slow onset phenomena, including effects of climate change such as desertification and rising sea levels gradually erode livelihoods and force communities to abandon traditional homelands for more accommodating environments. This is currently happening in areas of Africa's Sahel, the semi-arid belt that spans the continent just below its northern deserts. Deteriorating environments triggered by climate change can also lead to increased conflict over resources which in turn can displace people.[129]

Extreme environmental events are increasingly recognized as a key driver of migration across the world. According to the Internal Displacement Monitoring Centre, more than 42 million people were displaced in Asia and the Pacific during 2010 and 2011, more than twice the population of Sri Lanka. This figure includes those displaced by storms, floods, and heat and cold waves. Still others were displaced drought and sea-level rise. Most of those compelled to leave their homes eventually returned when conditions improved, but an undetermined number became migrants, usually within their country, but also across national borders.[130]

Asia and the Pacific is the global area most prone to natural disasters, both in terms of the absolute number of disasters and of populations affected. It is highly exposed to climate impacts, and is home to highly vulnerable population groups, who are disproportionately poor and marginalized. A recent Asian Development Bank report highlights “environmental hot spots” that are particular risk of flooding, cyclones, typhoons, and water stress.[131]

To reduce migration compelled by worsening environmental conditions, and to strengthen resilience of at-risk communities, governments should adopt policies and commit financing to social protection, livelihoods development, basic urban infrastructure development, and disaster risk management. Though every effort should be made to ensure that people can stay where they live, it is also important to recognize that migration can also be a way for people to cope with environmental changes. If properly managed, and efforts made to protect the rights of migrants, migration can provide substantial benefits to both origin and destination areas, as well as to the migrants themselves. However, migrants – particularly low-skilled ones – are among the most vulnerable people in society and are often denied basic protections and access to services.[131]

The links between the gradual environmental degradation of climate change and displacement are complex: as the decision to migrate is taken at the household level, it is difficult to measure the respective influence of climate change in these decisions with regard to other influencing factors, such as poverty, population growth or employment options.[130] This situates the debate on environmental migration in a highly contested field: the use of the term 'environmental refugee', although commonly used in some contexts, is disrecommended by agencies such as the UNHCR who argue that the term 'refugee' has a strict legal definition which does not apply to environmental migrants.[132] Neither the UN

Framework Convention on Climate Change nor the Kyoto Protocol, an international agreement on climate change, includes any provisions concerning specific assistance or protection for those who will be directly affected by climate change.[133]

References

1. Sherwood, S.C.; Huber, M. (25 May 2010). "An adaptability limit to climate change due to heat stress". Proc. Natl. Acad. Sci. U.S.A. 107 (21): 9552–5. doi:10.1073/pnas.0913352107. PMID 20439769. PMC 2906879. Bibcode: 2010PNAS..107.9552S. http://www.pnas.org/content/107/21/9552.full.
2. Sherwood, Steven C.; Huber, Matthew (19 November 2009). "An adaptability limit to climate change due to heat stress". Proceedings of the National Academy of Sciences 107 (21): 9552–9555. doi:10.1073/pnas.0913352107. PMID 20439769. Bibcode: 2010PNAS..107.9552S. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=2906879
3. Morca, Camilo; Counsell, Chelsie W.W.; Bielecki, Coral R.; Louis, Leo V (November 2017), "Twenty-Seven Ways a Heat Wave Can Kill You: Deadly Heat in the Era of Climate Change", Circulation: Cardiovascular Quality and Outcomes 10 (11), doi:10.1161/CIRCOUTCOMES.117.004233, PMID 29122837 https://dx.doi.org/10.1161%2FCIRCOUTCOMES.117.004233
4. Epstein, Paul R. (2001). "Climate change and emerging infectious diseases". Microbes and Infection 3 (9): 747–754. doi:10.1016/s1286-4579(01)01429-0. PMID 11489423. https://dx.doi.org/10.1016%2Fs1286-4579%2801%2901429-0
5. Epstein, Paul R.; Ferber, Dan (2011). "Sobering Predictions". Changing Planet, Changing Health: How the Climate Crisis Threatens Our Health and what We Can Do about it. University of California Press. ISBN 978-0-520-26909-5. https://books.google.com/books?id=nnOkFhXo8rEC&pg=PA62.
6. Meehl, Gerald A.; Stocker, Thomas F.; Collins, W.D. et al. (2007). "Global Climate Projections". Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. pp. 747–845. https://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter10.pdf.
7. Reiter, Paul (2001). "Climate Change and Mosquito-Borne Disease". Environmental Health Perspectives 109 (1): 141–161. doi:10.1289/ehp.01109s1141. PMID 11250812. PMC 1240549. Archived from the original on 2011-08-24. https://web.archive.org/web/20110824222504/http://ehpnet1.niehs.nih.gov/docs/2001/suppl-1/141-161reiter/abstract.html.
8. Hunter, P.R. (2003). "Climate change and waterborne and vector-borne disease". Journal of Applied Microbiology 94: 37S–46S. doi:10.1046/j.1365-2672.94.s1.5.x. PMID 12675935. https://dx.doi.org/10.1046%2Fj.1365-2672.94.s1.5.x
9. Süss, J.; Klaus, C.; Gerstengarbe, F.W.; Werner, P.C. (2008). "What Makes Ticks Tick? Climate Change, Ticks, and". The Journal of Travel Medicine 15 (1): 39–45. doi:10.1111/j.1708-8305.2007.00176.x. PMID 18217868. https://dx.doi.org/10.1111%2Fj.1708-8305.2007.00176.x
10. Subak, Susan (2003). "Effects of Climate on Variability in Lyme Disease Incidence in the Northeastern". American Journal of Epidemiology 157 (6): 531–538. doi:10.1093/aje/kwg014. PMID 12631543. https://dx.doi.org/10.1093%2Faje%2Fkwg014
11. Glaser (2016). "Climate Change and the Emergent Epidemic of CKD from Heat Stress in Rural Communities: the Case for Heat Stress Nephropathy". Clin J Am Soc Nephrol 11 (8): 1472–83. doi:10.2215/CJN.13841215. PMID 27151892. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=4974898
12. Klempa, B. (June 2009). "Hantaviruses and Climate Change". Clinical Microbiology and Infection 15 (6): 518–523. doi:10.1111/j.1469-0691.2009.02848.x. PMID 19604276. https://dx.doi.org/10.1111%2Fj.1469-0691.2009.02848.x
13. Shaftel, Holly (2016). "A blanket around the earth". A Blanket Around the Earth 1: 42.
14. Pal, Jeremy S.; Eltahir, Elfatih A. B. (2015). "Future temperature in southwest Asia projected to exceed a threshold for human adaptability". Nature 6 (2): 197–200. doi:10.1038/nclimate2833. Bibcode: 2016NatCC...6..197P. https://dx.doi.org/10.1038%2Fnclimate2833
15. Padhy, Susanta (2015). "Mental health effects of climate change". Indian Journal of Occupational and Environmental Medicine 19 (1): 3–7. doi:10.4103/0019-5278.156997. PMID 26023264. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=4446935
16. Epstein, Paul R.; Ferber, Dan (2011). "Mozambique". Changing Planet, Changing Health: How the Climate Crisis Threatens Our Health and what We Can Do about it. University of California Press. pp. 6–28. ISBN 978-0-520-26909-5. https://books.google.com/books?id=nnOkFhXo8rEC&pg=PP1.
17. St. Louis, Michael E.; Hess, Jeremy J. (2008). "Climate Change Impacts on and Implications for Global Health". American Journal of Preventive Medicine 35 (5): 527–538. doi:10.1016/j.amepre.2008.08.023. PMID 18929979. https://dx.doi.org/10.1016%2Fj.amepre.2008.08.023
18. Greenwood, Brian M.; Bojang, Kalifa; Whitty, Christopher J.M.; Targett, Geoffrey A.T. (23 April 2005). "Malaria". The Lancet 365 (9469): 1487–1498. doi:10.1016/S0140-6736(05)66420-3. PMID 15850634.

https://dx.doi.org/10.1016%2FS0140-6736%2805%2966420-3

19. "10 facts on malaria" (in en-GB). http://www.who.int/features/factfiles/malaria/en/.
20. Mia, S.; Begum, Rawshan A.; Er, Ah-Choy; Abidin, Raja D.Z.R. Zainal; Pereira, Joy J. (2010). "Malaria and Climate Change: Discussion on Economic Impacts". American Journal of Environmental Sciences 7 (1): 65–74. doi:10.3844/ajessp.2011.73.82. https://dx.doi.org/10.3844%2Fajessp.2011.73.82
21. Githeko, Andrew K.. "Malaria and climate change". Commonwealth Health Ministers' Update 2009/2010. Archived on 2011-09-26. Error: If you specify |archivedate=, you must also specify |archiveurl=. http://idl-bnc.idrc.ca/dspace/bitstream/10625/44031/1/130440.pdf. Retrieved 2015-02-14.
22. Pates, Helen; Curtis, Christopher (2005). "Mosquito Behaviour and Vector Control". Annual Review of Entomology 50 (1): 57–70. doi:10.1146/annurev.ento.50.071803.130439. PMID 15355233. https://dx.doi.org/10.1146%2Fannurev.ento.50.071803.130439
23. Epstein, Paul R (2005). "Climate Change and Human Health". The New England Journal of Medicine 353 (14): 1433–1436. doi:10.1056/nejmp058079. PMID 16207843. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=2636266
24. Goklany, Indur M.; King, Sir David A. (2004). "Climate Change and Malaria". Science 306 (5693): 55–57. doi:10.1126/science.306.5693.55. PMID 15459370. https://zenodo.org/record/1231205.
25. "Dengue and Severe Dengue, Fact Sheet". Media Centre. World Health Organization. 2012. http://www.who.int/mediacentre/factsheets/fs117/en/.
26. Simmon, Cameron; Farrar, Jeremy J.; Chau, Nguyen van Vinh; Wills, Bridget (12 April 2012). "Dengue". The New England Journal of Medicine 366 (15): 1423–1432. doi:10.1056/NEJMra1110265. PMID 22494122. http://minerva-access.unimelb.edu.au/bitstream/11343/191104/1/Current%20Concepts%20-%20Dengue.pdf.
27. Gubler, DJ (2010). Human and Medical Virology: Dengue Viruses. Academic Press. pp. 372–382. ISBN 978-0-12-378559-6. https://books.google.com/books?id=nsh48WKIbhQC&pg=PA372.
28. "Dengue Fever". National Institutes of Health. https://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0002350/.
29. Epstein, Paul R.; Ferber, Dan (2011). Changing Planet, Changing Health: How the Climate Crisis Threatens Our Health and what We Can Do about it. University of California Press. pp. 69–71. ISBN 978-0-520-26909-5. https://books.google.com/books?id=nnOkFhXo8rEC&pg=PA69.
30. Hopp, Marianne J.; Foley, Jonathan A. (February 2001). "Global-Scale Relationships Between Climate and the Dengue Fever Vector, Aedes Aegypti". Climatic Change 48 (2/3): 441–463. doi:10.1023/a:1010717502442. https://dx.doi.org/10.1023%2Fa%3A1010717502442
31. "Dengue: Guidelines for Diagnosis, Treatment, Prevention and Control". World Health Organization. 2009. https://www.who.int/tdr/publications/documents/dengue-diagnosis.pdf.
32. Süss, Jochen; Klaus, Christine; Gerstengarbe, Friedrich-Wilhelm; Werner, Peter C. (2008-01-01). "What Makes Ticks Tick? Climate Change, Ticks, and Tick-Borne Diseases" (in en). Journal of Travel Medicine 15 (1): 39–45. doi:10.1111/j.1708-8305.2007.00176.x. ISSN 1195-1982. PMID 18217868. https://dx.doi.org/10.1111%2Fj.1708-8305.2007.00176.x
33. John, Brownstein; Holford, Theodore; Fish, Durland (February 12, 2003). "A Climate-Based Model Predicts the Spatial Distribution of the Lyme Disease Vector Ixodes scapularis in the United States". Environmental Health Perspectives 11 (9): 1152–1157. doi:10.1289/ehp.6052. PMID 12842766. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=1241567
34. USGCRP. "Life Cycle of Blacklegged Ticks, Ixodes scapularis | Climate and Health Assessment" (in en). https://health2016.globalchange.gov/climate-and-health-assessment/vectorborne-diseases/boxes/life-cycle-blacklegged-ticks-ixodes.
35. Esteve-Gassent, Maria D.; Castro-Arellano, Ivan; Feria-Arroyo, Teresa P.; Patino, Ramiro; Li, Andrew Y.; Medina, Raul F.; Pérez de León, Adalberto A.; Rodríguez-Vivas, Roger Iván (May 2016). "Translating ecology, physiology, biochemistry and population genetics research to meet the challenge of tick and tick-borne diseases in North America". Archives of Insect Biochemistry and Physiology 92 (1): 38–64. doi:10.1002/arch.21327. ISSN 0739-4462. PMID 27062414. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=4844827
36. Luber, George; Lemery, Jay (2015-11-02) (in en). Global Climate Change and Human Health: From Science to Practice. John Wiley & Sons. ISBN 9781118505571. https://books.google.com/?id=U0E1CAAAQBAJ&pg=PR11&dq=luber+lemry+climate+health#v=onepage&q=luber%20lemry%20climate%20health&f=false.
37. Monaghan, Andrew J.; Moore, Sean M.; Sampson, Kevin M.; Beard, Charles B.; Eisen, Rebecca J. (2015-07-01). "Climate change influences on the annual onset of Lyme disease in the United States" (in en). Ticks and Tick-borne Diseases 6 (5): 615–622. doi:10.1016/j.ttbdis.2015.05.005. ISSN 1877-959X. PMID 26025268. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=4631020
38. Nadelman, Robert B.; Nowakowski, John; Forseter, Gilda; Goldberg, Neil S.; Bittker, Susan; Cooper, Denise; Aguero-Rosenfeld, Maria; Wormser, Gary P. (May 1996). "The clinical spectrum of early lyme borreliosis in patients with culture-confirmed erythema migrans" (in English). The American Journal of Medicine 100 (5): 502–508.

doi:10.1016/S0002-9343(95)99915-9. ISSN 0002-9343. PMID 8644761. https://www.amjmed.com/article/S0002-9343(95)99915-9/pdf.

39. Steere, Allen C.; Sikand, Vijay K. (2003-06-12). "The Presenting Manifestations of Lyme Disease and the Outcomes of Treatment" (in EN). New England Journal of Medicine 348 (24): 2472–2474. doi:10.1056/nejm200306123482423. ISSN 0028-4793. PMID 12802042. https://dx.doi.org/10.1056%2Fnejm200306123482423
40. Mimura, Nobuo; Pulwarty, Roger; Duc, Do Minh; Elshinnawy, Ibrahim; Redsteer, Margaret; Huang, He-Qing; Nkem, Johnson; Sanchez Rodriguez, Roberto (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. pp. 869–898. http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap15_FINAL.pdf.
41. "As disease-bearing ticks head north, weak government response threatens public health". Center for Public Integrity. https://www.publicintegrity.org/2018/08/06/21999/disease-bearing-ticks-head-north-weak-government-response-threatens-public-health.
42. Health, National Center for Environmental. "CDC - Climate and Health - CDC's Building Resilience Against Climate Effects (BRACE) Framework" (in en-us). https://www.cdc.gov/climateandhealth/BRACE.htm.
43. "State's Reluctance to Address Climate and Tick Link May Threaten Public Health" (in en-US). Natural Resources Council of Maine. 2018-08-12. https://www.nrcm.org/maine-environmental-news/tick-threat-explodes-states-reluctance-address-climate-link-threaten-public-health/.
44. Angela, Cheng; Chen, Dongmei; Woodstock, Katherine; Ogden, Nicholas; Wu, Xiaotian; Wu, Jianhong (June 2017). "Analyzing the Potential Risk of Climate Change on Lyme Disease in Eastern Ontario, Canada Using Time Series Remotely Sensed Temperature Data and Tick Population Modelling". Remote Sensing 609 (6): 609. doi:10.3390/rs9060609. https://dx.doi.org/10.3390%2Frs9060609
45. Chand, Prabhat Kumar; Murthy, Pratima (2008). "Climate change and mental health". Regional Health Forum 12 (1). http://www.uncclearn.org/sites/default/files/inventory/who44.pdf#page=51.
46. Doherty, Susan; Clayton, Thomas J (2011). "The psychological impacts of global climate change". American Psychologist 66 (4): 265–276. doi:10.1037/a0023141. PMID 21553952. http://psycnet.apa.org/journals/amp/66/4/265/.
47. Berry, Helen; Kathryn, Bowen; Kjellstrom, Tord (2009). "Climate change and mental health: a causal pathways framework". International Journal of Public Health 55 (2): 123–132. doi:10.1007/s00038-009-0112-0. PMID 20033251. https://dx.doi.org/10.1007%2Fs00038-009-0112-0
48. "Global warming risk: Rising temperatures from climate change linked to rise in suicides". USA Today. 2018. https://amp.usatoday.com/amp/817731002.
49. "Climate Change May Cause 26,000 More U.S. Suicides by 2050". 2018-07-23. https://www.theatlantic.com/science/archive/2018/07/high-temperatures-cause-suicide-rates-to-increase/565826/.
50. "Mental Health and Stress-Related Disorders". National Institute of Environment Health Services. National Institutes of Health. 1 October 2015. Archived from the original on 21 April 2012. https://web.archive.org/web/20120421191355/http://www.niehs.nih.gov/health/assets/docs_a_e/climatereport2010.pdf.
51. World Health Organization. "Climate change and health". World Health Organization. http://www.who.int/mediacentre/factsheets/fs266/en/. Retrieved 27 February 2018.
52. Westerling, Anthony. "Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring". University of California. http://ulmo.ucmerced.edu/pdffiles/16RSTB_Westerling.pdf.
53. Lorna, Bowlby-West (1983). "The impact of death on the family system". Journal of Family Therapy 5 (3): 279–294. doi:10.1046/j..1983.00623.x. https://dx.doi.org/10.1046%2Fj..1983.00623.x
54. Anderson, C (2001). Heat and Violence. Iowa: American Psychological Association. pp. 33–38. https://public.psych.iastate.edu/caa/abstracts/2000-2004/01A.pdf.
55. Epstein, Paul R.; Ferber, Dan (2011). Changing Planet, Changing Health: How the Climate Crisis Threatens Our Health and what We Can Do about it. University of California Press. ISBN 978-0-520-26909-5. https://books.google.com/books?id=nnOkFhXo8rEC&pg=PP1.
56. Abbott, Chris (January 2008). An Uncertain Future: Law Enforcement, National Security and Climate Change (Report). Oxford Research Group. http://www.oxfordresearchgroup.org.uk/sites/default/files/uncertainfuture.pdf.
57. Nelson, Donald R.; West, Colin Thor; Finan, Timothy J. (September 2009). "Introduction to "In focus: Global change and adaptation in local places."". American Anthropologist 111 (3): 271–274. doi:10.1111/j.1548-1433.2009.01131.x. https://dx.doi.org/10.1111%2Fj.1548-1433.2009.01131.x
58. Hinkel, Kenneth M; Nelson, Frederick E.; Parker, Walter et al. (2003). "Climate Change, Permafrost, and Impacts on Civil Infrastructure". U.S. Arctic Research Commission Permafrost Task Force: 1–61. Archived from the original on 2014-01-12. https://web.archive.org/web/20140112164129/http://www.arctic.gov/publications/other/permafrost.pdf.
59. "A Deadly Dinner | Global Health Corps". https://ghcorps.org/a-deadly-dinner-2/.
60. "'Water-Related Diseases Responsible For 80 Per Cent Of All Illnesses, Deaths In Developing World', Says Secretary-General In Environment Day Message". 16 May 2003. https://www.un.org/press/en/2003/sgsm8707.doc.htm.

61. "Reports: Drought-Stricken Somalis Dying From Contaminated Water". Voice of America. 31 October 2009. http://www.voanews.com/content/a-13-2006-03-22-voa28/324586.html.

62. Kankya, Clovice; Muwonge, Adrian; Djønne, Berit et al. (16 May 2011). "Isolation of non-tuberculous mycobacteria from pastoral ecosystems of Uganda: Public Health significance". BMC Public Health 11 (320): 320. doi:10.1186/1471-2458-11-320. PMID 21575226. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=3123205

63. "NRDC: Climate Change Threatens Health: Drought". nrdc.org. http://www.nrdc.org/health/climate/drought.asp.

64. Paerl, Hans W.; Huisman, Jef (4 April 2008). "Blooms Like It Hot". Science 320 (5872): 57–58. doi:10.1126/science.1155398. PMID 18388279. https://dx.doi.org/10.1126%2Fscience.1155398

65. "Blue-Green Algae (Cyanobacteria) Blooms". California Department of Public Health. 18 September 2013. http://www.cdph.ca.gov/healthinfo/environhealth/water/pages/bluegreenalgae.aspx.

66. "U.S. Faces Era Of Water Scarcity". WaterNews. Circle of Blue. 9 July 2008. http://www.circleofblue.org/waternews/2008/world/us-faces-era-of-water-scarcity/.

67. Miller, Kathleen. "Climate Change Impacts on Water". Climate Change and Water Research. Institute for the Study of Society and Environment (ISSE) at the National Center for Atmospheric Research. http://www.isse.ucar.edu/water_climate/impacts.html.

68. "The Food Gap: The Impacts of Climate Change on Food Production: a 2020 Perspective". 2011. Archived from the original on 2012-04-16. https://web.archive.org/web/20120416214231/http://www.feu-us.org/images/The_Food_Gap.pdf.

69. Friel, Sharon; Dangour, Alan D.; Garnett, Tara et al. (2009). "Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture". The Lancet 374 (9706): 2016–2025. doi:10.1016/S0140-6736(09)61753-0. PMID 19942280. https://dx.doi.org/10.1016%2FS0140-6736%2809%2961753-0

70. Thornton, P.K.; van de Steeg, J.; Notenbaert, A.; Herrero, M. (2009). "The impacts of climate change on livestock and livestock systems in developing countries: A review of what we know and what we need to know". Agricultural Systems 101 (3): 113–127. doi:10.1016/j.agsy.2009.05.002. https://dx.doi.org/10.1016%2Fj.agsy.2009.05.002

71. Kurukulasuriya, Pradeep; Rosenthal, Shane (June 2003). Climate Change and Agriculture: A Review of Impacts and Adaptions (Report). World Bank. http://www.uoguelph.ca/~c-ciarn/documents/World_Bank_Paper.pdf.

72. McMichael, A.J.; Campbell-Lendrum, D.H.; Corvalán, C.F. et al. (2003). Climate Change and Human Health: Risks and Responses (Report). World Health Organization. ISBN 92 4 156248 X. http://www.who.int/globalchange/publications/climchange.pdf.

73. Hertel, Thomas W.; Rosch, Stephanie D. (June 2010). "Climate Change, Agriculture, and Poverty". Applied Economic Perspectives and Policy 32 (3): 355–385. doi:10.1093/aepp/ppq016. https://dx.doi.org/10.1093%2Faepp%2Fppq016

74. Kulshreshtha, Surendra N. (March 2011). "Climate Change, Prairie Agriculture and Prairie Economy: The new normal". Canadian Journal of Agricultural Economics 59 (1): 19–44. doi:10.1111/j.1744-7976.2010.01211.x. https://dx.doi.org/10.1111%2Fj.1744-7976.2010.01211.x

75. Climate Change Impacts and Adaptation: A Canadian Perspective (Report). Natural Resources Canada. 2004. ISBN 0-662-33123-0. http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/27428.pdf.

76. Beddington, John R.; Asaduzzaman, Mohammed; Clark, Megan E. et al. (2012). "The role for scientists in tackling food insecurity and climate change". Agriculture & Food Security 1 (10): 10. doi:10.1186/2048-7010-1-10. https://dx.doi.org/10.1186%2F2048-7010-1-10

77. Chakraborty, S.; Newton, A. C. (10 January 2011). "Climate change, plant diseases and food security: an overview". Plant Pathology 60 (1): 2–14. doi:10.1111/j.1365-3059.2010.02411.x. https://dx.doi.org/10.1111%2Fj.1365-3059.2010.02411.x

78. Connor, Jeffery D.; Schwabe, Kurt; King, Darran; Knapp, Keith (May 2012). "Irrigated agriculture and climate change: The influence of water supply variability and salinity on adaptation". Ecological Economics 77: 149–157. doi:10.1016/j.ecolecon.2012.02.021. https://dx.doi.org/10.1016%2Fj.ecolecon.2012.02.021

79. Sindhu, J.S. (March 2011). "Potential Impacts of Climate Change on Agriculture". Indian Journal of Science and Technology 4 (3): 348–353. ISSN 0974-6846. http://www.indjst.org/index.php/indjst/article/view/29998/25953.

80. Tubiello, Francesco N.; Rosenzweig, Cynthia (2008). "Developing climate change impact metrics for agriculture". The Integrated Assessment Journal 8 (1). http://journals.sfu.ca/int_assess/index.php/iaj/article/viewFile/276/240.

81. Thomson, Linda J.; Macfadyen, Sarina; Hoffmann, Ary A. (March 2010). "Predicting the effects of climate change on natural enemies of agricultural pests". Biological Control 52 (3): 296–306. doi:10.1016/j.biocontrol.2009.01.022. https://dx.doi.org/10.1016%2Fj.biocontrol.2009.01.022

82. Kristjanson, Patti; Neufeldt, Henry; Gassner, Anja et al. (2012). "Are food insecure smallholder households making changes in their farming practices? Evidence from East Africa". Food Security 4 (3): 381–397. doi:10.1007/s12571-012-0194-z. https://dx.doi.org/10.1007%2Fs12571-012-0194-z

83. Rodenburg, Jonne; Riches, Charles R.; Kayeke, Juma M. (2010). "Addressing current and future problems of parasitic weeds in rice". Crop Protection 29 (3): 210–221. doi:10.1016/j.cropro.2009.10.015.

https://dx.doi.org/10.1016%2Fj.cropro.2009.10.015

84. Rodenburg, J.; Meinke, H.; Johnson, D. E. (August 2011). "Challenges for weed management in African rice systems in a changing climate". The Journal of Agricultural Science 149 (4): 427–435. doi:10.1017/S0021859611000207. http://ecite.utas.edu.au/69596.
85. Taub, Daniel R.; Miller, Brian; Allen, Holly (March 2008). "Effects of elevated CO2 on the protein concentration of food crops: a meta-analysis". Global Change Biology 14 (3): 565–575. doi:10.1111/j.1365-2486.2007.01511.x. https://dx.doi.org/10.1111%2Fj.1365-2486.2007.01511.x
86. Loladze, Irakli (1 October 2002). "Rising atmospheric CO2 and human nutrition: toward globally imbalanced plant stoichiometry?". Trends in Ecology & Evolution 17 (10): 457–461. doi:10.1016/s0169-5347(02)02587-9. https://dx.doi.org/10.1016%2Fs0169-5347%2802%2902587-9
87. Gregory, Peter J.; Johnson, Scott N.; Newton, Adrian C.; Ingram, John S.I. (2009). "Integrating pests and pathogens into the climate change/food security debate". Journal of Experimental Botany 60 (10): 2827–2838. doi:10.1093/jxb/erp080. PMID 19380424. https://dx.doi.org/10.1093%2Fjxb%2Ferp080
88. Nelson, Gerald C.; Rosegrant, Mark W.; Koo, Jawoo et al. (October 2009). Climate Change: Impact on Agriculture and Costs of Adaptation (Report). Washington, DC: International Food Policy Research Institute. Archived on 2016-05-05. Error: If you specify |archivedate=, you must also specify |archiveurl=. http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/16557/filename/16558.pdf. Retrieved 2016-08-12.
89. "Oceans & Coasts". National Oceanic and Atmospheric Administration. http://www.noaa.gov/oceans-coasts. Retrieved 12 August 2016.
90. Raven, J.A.; Falkowski, P.G. (June 1999). "Oceanic sinks for atmospheric CO2". Plant, Cell & Environment 22 (6): 741–755. doi:10.1046/j.1365-3040.1999.00419.x. https://dx.doi.org/10.1046%2Fj.1365-3040.1999.00419.x
91. "Carbon Cycle". http://www.search.eb.com/eb/article-9020247. Retrieved 29 Nov 2012.
92. Terry, James; Chui, Ting Fong May (May 2012). "Evaluating the fate of freshwater lenses on atoll islands after eustatic sea-level rise and cyclone driven inundation: A modelling approach". Global and Planetary Change 88–89: 76–84. doi:10.1016/j.gloplacha.2012.03.008. Bibcode: 2012GPC....88...76T. https://dx.doi.org/10.1016%2Fj.gloplacha.2012.03.008
93. Khan, Aneire Ehmar; Ireson, Andrew; Kovats, Sari et al. (September 2011). "Drinking Water Salinity and Maternal Health in Coastal Bangladesh: Implications of Climate Change". Environmental Health Perspectives 119 (9): 1328–1332. doi:10.1289/ehp.1002804. PMID 21486720. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=3230389
94. Small, Christopher; Nicholls, Robert J. (Summer 2003). "A Global Analysis of Human Settlement in Coastal Zones". Journal of Coastal Research 19 (3): 584–599.
95. Delorenzo, Marie E.; Wallace, Sarah C.; Danese, Loren E.; Baird, Thomas D. (2008). "Temperature and Salinity effects on the toxicity of common pesticides to the grass shrimp, Palaemonetes pugio". Journal of Environmental Science and Health 44 (5): 455–460. doi:10.1080/03601230902935121. PMID 20183050. https://zenodo.org/record/1234438.
96. Sandifer, Paul A.; Holland, A. Frederick; Rowles, Teri K.; Scott, Geoffrey I. (June 2004). "The Oceans and Human Health". Environmental Health Perspectives 112 (8): A454–A455. doi:10.1289/ehp.112-a454. PMID 15175186. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=1242026
97. Tatters, Avery O.; Fu, Fei-Xue; Hutchins, David A. (February 2012). "High CO2 and Silicate Limitation Synergistically Increase the Toxicity of Pseudo-nitzschia fraudulenta". PLOS ONE 7 (2): e32116. doi:10.1371/journal.pone.0032116. PMID 22363805. Bibcode: 2012PLoSO...732116T. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=3283721
98. Epstein, P.; Ferber, D. (2011). Changing Planet, changing health. Los Angeles, California: University of California Press. ISBN 978-0520269095. https://archive.org/details/unset0000unse_c1j4.
99. Mattson, William J.; Haack, Robert A. (February 1987). "Role of Drought in Outbreaks of Plant-Eating Insects". BioScience 37 (2): 110–118. doi:10.2307/1310365. http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1054&context=barkbeetles.
100. Christian, Parul (January 2010). "Impact of the Economic Crisis and Increase in Food Prices on Child Mortality: Exploring Nutritional Pathways". Journal of Nutrition 140 (1): 177S–181S. doi:10.3945/jn.109.111708. PMID 19923384. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=2793127
101. Vigran, Anna (14 January 2008). "With Climate Change Comes Floods". NPR. https://www.npr.org/templates/story/story.php?storyId=18022014.
102. Alderman, Katarzyna; Turner, Lyle R.; Tong, Shilu (June 2012). "Floods and human health: A systematic review". Environment International 47: 37–47. doi:10.1016/j.envint.2012.06.003. PMID 22750033. https://espace.library.uq.edu.au/view/UQ:346602/UQ346602_OA.pdf.
103. thewaterproject.org brighter futures begins with clean water
104. Epstein, Paul R.; Ferber, Dan (2011). "Storms and Sickness". Changing Planet, Changing Health: How the Climate Crisis Threatens Our Health and what We Can Do about it. University of California Press. ISBN 978-0-520-26909-5.

https://books.google.com/books?id=nnOkFhXo8rEC&pg=PA161.

105. Chinn, T.J. (2001). "Distribution of the glacial water resources of New Zealand". Journal of Hydrology 40 (2): 139–187. http://hydrologynz.co.nz/downloads/20071015-094857-JoHNZ_2001_v40_2_Chinn.pdf.
106. Orlove, Ben (2009). "Glacier Retreat: Reviewing the Limits of Human Adaptation to Climate Change". Environment 51 (3): 22–34. doi:10.3200/envt.51.3.22-34. https://dx.doi.org/10.3200%2Fenvt.51.3.22-34
107. Dyurgerov, Mark D.; Meier, Mark F. (2000). "Twentieth century climate change: Evidence from small glaciers". Proceedings of the National Academy of Sciences 97 (4): 1406–1411. doi:10.1073/pnas.97.4.1406. PMID 10677474. Bibcode: 2000PNAS...97.1406D. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=26446
108. Vergano, Dan. "Greenland glacier runoff doubled over past decade". USA Today. http://usatoday30.usatoday.com/tech/science/2006-02-16-glacier-melt_x.htmy.
109. Hall, Myrna H.P.; Fagre, Daniel B. (2003). "Modeled Climate Change in Glacier National Park, 1850-2100". BioScience 53 (2): 131. doi:10.1641/0006-3568(2003)053[0131:mcigci2.0.co;2]. https://dx.doi.org/10.1641%2F0006-3568%282003%29053%5B0131%3Amcigci%5D2.0.co%3B2
110. Jenkins, K.M.; Kingsford, R.T.; Closs, G.P. et al. (2011). "Climate change and freshwater ecosystems in Oceania: an assessment of vulnerability and adaption opportunities". Pacific Conservation Biology 17 (3): 201–219. doi:10.1071/PC110201. https://dx.doi.org/10.1071%2FPC110201
111. Afrane, Y. A.; Githeko, A.K.; Yan, G. (February 2012). "The ecology of Anopheles mosquitoes under climate change: case studies from the effects of deforestation in East African highlands". Annals of the New York Academy of Sciences 1249 (1): 204–210. doi:10.1111/j.1749-6632.2011.06432.x. PMID 22320421. Bibcode: 2012NYASA1249..204A. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=3767301
112. IPCC (2007). Climate Change 2007: Impacts, Adaptation, and Vulnerability.. Cambridge: Cambridge University Press.. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerabilit
113. Munga, S.; Minakawa, N.; Zhou, G.; Githenko, A.K.; Yan, G. (September 2007). "Survivorship of Immature Stages of Anopheles gambiae s.l. (Diptera: Culicidae) in Natural Habitats in Western Kenya Highlands". Journal of Medical Entomology 44 (5): 758–764. doi:10.1603/0022-2585(2007)44[758:SOISOA2.0.CO;2]. https://dx.doi.org/10.1603%2F0022-2585%282007%2944%5B758%3ASOISOA%5D2.0.CO%3B2
114. Muhammad, Ashraf; Hussain, M.; Ahmad, M.S.A; Al-Quariny, F.; Hameed, M. (May 2012). "Strategies for conservation of endangered ecosystems". Pakistan Journal of Botany 44 (Special Issue): 1–6. http://www.pakbs.org/pjbot/PDFs/44(SI2)/01.pdf. Retrieved 25 November 2012.
115. Hamilton, Alan (2006). "2". Plant Conservation: An Ecosystem Approach. London: Earthscan. pp. 37–39. ISBN 9781844070831.
116. Mirsanjari, Mir Mehrdad; Mirsanjari, Mitra. (May 2012). "The role of biodiversity for sustainable environment". International Journal of Sustainable Development 4 (3): 71–86.
117. Laurance, William F (1 December 1999). "Reflections on the tropical deforestation crisis". Biological Conservation 91 (2–3): 109–117. doi:10.1016/S0006-3207(99)00088-9. https://dx.doi.org/10.1016%2FS0006-3207%2899%2900088-9
118. Kaur, Amarjit (February 1998). "A History of Forestry in Sarawak". Modern Asian Studies 32 (1): 117–147. doi:10.1017/S0026749X98003011. https://dx.doi.org/10.1017%2FS0026749X98003011
119. Goroh, Eleanor. "Update 2011-Malaysia". International Work Group for Indigenous Affairs. http://www.iwgia.org/regions/asia/malaysia/877-update-2011-malaysia. Retrieved 26 November 2012.
120. Sambaraju, Kishan R.; Carroll, Allan L.; Zhu, Jun et al. (2012). "Climate change could alter the distribution of mountain pine beetle outbreaks in western Canada". Ecography 35 (3): 211–223. doi:10.1111/j.1600-0587.2011.06847.x. https://dx.doi.org/10.1111%2Fj.1600-0587.2011.06847.x
121. Epstein, P.; Ferber, D. (2011). Changing Planet, changing health. Los Angeles, California: University of California Press. pp. 138–160. ISBN 978-0520269095. https://archive.org/details/unset0000unse_c1j4/page/138.
122. Kurz, W. (April 2008). "Mountain pine beetle and forest carbon feedback to climate change". Nature 452 (7190): 987–990. doi:10.1038/nature06777. PMID 18432244. https://dx.doi.org/10.1038%2Fnature06777
123. Liu, Y.; Stanturf, J.; Goodrick, S. (February 2010). "Trends in global wildfire potential in a changing climate". Forest Ecology and Management 259 (4): 685–697. doi:10.1016/j.foreco.2009.09.002. https://dx.doi.org/10.1016%2Fj.foreco.2009.09.002
124. Westerling, A.; Hidalgo, H.; Cayan, D.; Swetnam, T. (August 2006). "Warming and earlier spring increase Western U.S. Forest Wildfire Activity". Science 313 (5789): 940–943. doi:10.1126/science.1128834. PMID 16825536. Bibcode: 2006Sci...313..940W. https://dx.doi.org/10.1126%2Fscience.1128834
125. Naeher, Luke P.; Brauer, Mmichael; Lipsett, Michael et al. (January 2007). "Woodsmoke health effects: A review". Inhalation Toxicology 19 (1): 67–106. doi:10.1080/08958370600985875. PMID 17127644. https://dx.doi.org/10.1080%2F08958370600985875
126. Epstein, Brian (2011). Changing Planet, Changing Health: How the Climate Crisis Threatens our Health and What We Can Do About It. Berkeley and Los Angeles, California: University of California Press. pp. 138–160.

ISBN 9780520272637. https://archive.org/details/unset0000unse_c1j4.

127. Holstius, D.M.; Reid, C. E.; Jesdale, B. M.; Morello-Frosch, R. (September 2012). "Birth Weight following Pregnancy during the 2003 Southern California Wildfires". Environmental Health Perspectives 120 (9): 1340–1345. doi:10.1289/ehp.1104515. PMID 22645279. http://www.pubmedcentral.nih.gov/articlerender.fcgi?tool=pmcentrez&artid=3440113

128. Ellison, A; Evers, C.; Moseley, C.; Nielsen-Pincus, M. (2012). "Forest service spending on large wildfires in the West". Ecosystem Workforce Program 41: 1–16. http://ewp.uoregon.edu/sites/ewp.uoregon.edu/files/WP_41.pdf.

129. "Environment a Growing Driver in Displacement of People". Worldwatch Institute. http://www.worldwatch.org/node/5888.

130. Terminski, Bogumil (2012). Environmentally-Induced Displacement: Theoretical Frameworks and Current Challenges (PDF) (Thesis). Centre d'Etude de l'Ethnicité et des Migrations, Université de Liège. http://labos.ulg.ac.be/cedem/wp-content/uploads/sites/14/2012/09/Environmentally-Induced-Displacement-Terminski-1.pdf

131. Addressing Climate Change in Asia and the Pacific (Report). Asian Development Bank. 2012. ISBN 978-92-9092-611-5. http://beta.adb.org/sites/default/files/pub/2012/addressing-climate-change-migration.pdf.

132. Black, Richard (March 2001). Environmental refugees: myth or reality? (Report). New Issues in Refugee Research. UNHCR. Working Paper No. 34. http://www.unhcr.org/research/RESEARCH/3ae6a0d00.pdf.

133. Ferris, Elizabeth (14 December 2007). "Making Sense of Climate Change, Natural Disasters, and Displacement: A Work in Progress". The Brookings Institution. Archived from the original on 2011-06-06. https://web.archive.org/web/20110606095750/http://www.brookings.edu/speeches/2007/1214_climate_change_ferris.aspx.