Scientists for Labour

Climate Change and Pandemics

22nd Febuary 2021

Daniel A. Villar
Tom Mitcham
Andrew Williams
Nick Walker
Matt Dwyer
Alice Richards
Izzy Creed
Adam Thompson
Benjamin Fernando

Authors

Daniel A. Villar is a Zoology DPhil student at the University of Oxford and a member of the executive committee of Scientists for Labour.
Tom Mitcham is a PhD student in glaciology at the University of Bristol.
Andrew Williams is a DPhil student in Climate Physics at the University of Oxford.
Nick Walker has been working for over 30 years as a satellite earth observation specialist, currently focused on tackling the UN Sustainable Development Goals.
Matt Dwyer is a trade union organiser with a PhD in theoretical chemistry from the University of Sheffield.
Alice Richards is a DPhil student in physical oceanography at the University of Oxford.
Izzy Creed is a DPhil Student in Theoretical Chemistry at the University of Oxford and a Stipendiary lecturer in Physical Chemistry at Exeter College University of Oxford.
Adam Thompson is the Vice-Chair (Policy) of Scientists for Labour and a research fellow in metrology at the University of Nottingham.
Benjamin Fernando is the chair of Scientists for Labour and works as a postgraduate researcher in numerical modelling at the University of Oxford.

Scientists for Labour

Scientists for Labour is a socialist society affiliated to the Labour Party. Our aims are to both promote good science in politics, and to promote Labour values in science. More information about Scientists for Labour, including how to join, can be found at www.scientistsforlabour.org.uk. You can follow us on Twitter @scientists4lab.

Contents

Executive summary

The global COVID-19 pandemic has diverted attention of many policy makers and politicians away from a variety of pressing issues, with good reason. However, those other issues do not go on hold as we as a society attempt to cope, and eventually overcome, this pandemic. Paramount amongst these other issues is that of climate change. In this report, we seek to outline what climate change is, how is relates to COVID-19, what changes it is predicted to cause in human behaviour and society, and how it will exacerbate existing inequalities.

Since the beginning of the industrial revolution, humans have been pumping greenhouse gases into the atmosphere at a rate unseen before in human history, and have caused an increased concentration of greenhouse gases unseen in recent earth history. The effects of these increases are well known, and include, but are not limited to, more extreme weather and higher water levels. Additionally, increased greenhouse gas emissions have knock on effects relating to diseases, and especially to emergent zoonotic diseases like COVID-19. Emerging zoonotic diseases are spilling over into human populations at an increasing rate for a variety of factors, but one of the most important is land use change in previously wild areas. As areas that previously were agriculturally fertile grow fallow, there will be greater need for humans to disrupt ecosystems and come in contact with new pathogens, increasing the odds of a new spillover event. In addition to that, increased temperature is changing the range of many disease vectors, most notably mosquitos. Climate change also threatens to release new diseases, long dormant in the permafrost, against which no one alive has any natural immunity.

Climate change can also have an impact on human behaviour in a way that makes it easier for disease to spread. One of the major drivers of the fast spread of COVID-19 is the existence of modern transportation. With climate change, we can expect that there will be more natural disasters leading to the mass displacement of people, and with them the displacement of their diseases. This includes both the temporary displacement of towns and villages affected by climate change, and potentially states and regions made unliveable by climate change's long-term effects. However, there is some hope; COVID-19 seems to have increased the awareness of the importance of long-term global planning to avert natural catastrophe, rather than to just respond to it. Although climate change is a far trickier problem to solve, there is some hope that people will learn the preventative lessons from COVID-19 to prevent the next international catastrophe.

Climate change, like any other natural disaster, does not kill on its own; who it kills, and to what degree, is determined by the social forces that it meets. In our unequal world, that means that those who are most likely to suffer the consequences of climate change are those who have contributed the least to it; the global poor. Most notably, the poor in developing tropical countries whose agricultural land is becoming more marginal, whose slums are heating up faster, and in whose countries the next plagues are most likely to emerge. But even in wealthy countries like Britain, where the effects of climate change will not be as dire in the short term, the disadvantaged are still more likely to be hit, and hit hardest, by the effects of climate change.

1. Introduction

1.1. What is climate change?

Since the beginning of the industrial revolution, and accelerating since the turn of the 20th century, human activity has driven the concentration of atmospheric greenhouse gases to levels unprecedented in Earth's recent history (Keeling et al., 2017). One particularly important greenhouse gas is carbon dioxide, produced by the burning of fossil fuels. Carbon dioxide is a powerful greenhouse gas and, once produced, will persist in the atmosphere for many thousands of years, as opposed to other powerful (but short-lived) greenhouse gases such as methane or water vapour.

The Earth's present-day climate is governed by many physical processes, but on a fundamental level our climate is determined by a balance between the rate of energy input from the absorbed solar radiation and the rate of energy loss due to re-emission by the Earth (Trenberth et al., 2009). Any 'climate forcer' which impacts on these processes will begin to alter this balance and, as a result, the climate will readjust in order to maintain equilibrium.

Natural climate forcings include variations in the Sun's brightness and small changes in the Earth's orbit, which occur over many thousands of years and change the amount of solar radiation absorbed by the Earth (Haigh, 2011). Additionally, large volcanic eruptions can inject aerosol particles into the stratosphere (an upper layer of the atmosphere), where they scatter and absorb incoming radiation, preventing it from heating the Earth (Friberg et al., 2018). Such an example would be the Mt. Pinatubo eruption of 1991, which injected large quantities of aerosol into the stratosphere, and caused a global cooling of 0.5 °C the following year (McCormick et al., 1995). However, despite these sources of natural variability, the Earth's climate has remained relatively stable since the rise of human civilisation.

Conversely, the large increase in carbon dioxide emission over the last century through the burning of fossil fuels constitutes a large man-made ('anthropogenic') climate forcing. Carbon dioxide disrupts the Earth's energy balance by reducing the rate at which the planet is able to re-emit excess heat to space, thus causing temperatures to rise in response.

As a result of this human activity, the Intergovernmental Panel on Climate Change (IPCC) estimates that the Earth has already experienced around 1.0 °C of global warming, with a further 1.5 °C of warming likely to occur between 2030 and 2052. Furthermore, global temperatures will continue to increase until the point at which global greenhouse gas emissions fall to zero (IPCC, 2018).

1.2. What is climate change causing?

Given the central role that global temperature plays in the Earth's energy balance, it is useful to focus on temperature to help understand climate change and the impact of anthropogenic greenhouse gas emissions. However, this focus belies the diverse range of other changes that we will experience as a result of global warming.

Beyond the simple increase in global temperatures, the impacts of climate change are complex and unescapably regional, and quantitative predictions require the use of large computer models such as those used in the Coupled Model Intercomparison Project (CMIP) (Taylor et al., 2012).

Many of the impacts of global-warming can be understood simply and are robust, in the sense that they are based firmly on simple physical principles and enjoy wide agreement amongst state-of-the-art climate models (Held and Soden, 2006). Three such predictions for the UK are that climate change will cause rivers and coastal sea levels to rise, an increase in the severity of wintertime floods through an increase in rainfall and an increase in the number and severity of summertime heatwaves.

On sea level rise: the global oceans are a vast reservoir of heat and absorb about 90% of the excess heat produced through global warming. As salt water expands upon heating, a simple yet impactful consequence of global warming is that global sea levels are expected to rise, with around 0.5 m of coastal sea level rise expected around the UK by 2100 under a significant mitigation scenario (Jackson et al., 2018). However, if mitigation measures are not taken and climate change continues unabated, Bamber et al. (2019) estimate that the rise will likely be beyond 2 m by 2100, which could cause displacement of up to 187 million people worldwide.

On increased wintertime rainfall and flooding: a warmer atmosphere is able to hold more moisture, about 7% more per degree of warming. As such, even if everything else about Earth's climate remains fixed, we would expect a marked increase in the rainfall intensity of the UK's most extreme storms, solely due to the increased temperatures (Allen and Ingram, 2002; Pfahl et al., 2017). This is rainfall increase is expected to lead to an increased risk of flooding, due in part to the direct increase in extreme rainfall. However, prolonged rains can also cause the land around a river to reach its holding capacity and become saturated, causing flash floods, such as those experienced during the 2019 – 2020 wintertime flood events over much of England and Wales.

Recently, a number of 'detection-and-attribution' studies have also used observations and climate models to determine the impact that anthropogenic climate change has had on recent extreme weather events such as floods or heatwaves (Allen, 2003). Although such an assessment has not yet been conducted for the recent 2019 – 2020 UK floods mentioned above, Otto et al. (2018) found that similar heavy rainfall associated with Storm Desmond (in December 2015) had been made around 59% more likely as a result of climate change. Similarly, Schaller et al. (2016) also demonstrated the influence of human-induced climate change on the 2014 Southern England winter floods.

Additionally, many observational studies have noted an increase in river flow across most of the UK over the past four or five decades, consistent with an increased risk of flooding. More importantly in relation to flooding and flood-risk, there have been consistent increases in peak river flows (the highest river level in each year) and, as a result, floods have become more frequent and severe (Hannaford, 2015).

Aside from the impacts that climate change will have on extreme weather events, climate change is able to impact the emergence and spread of infectious diseases around the globe.

With rising temperatures and the changes in rainfall and moisture associated with climate change, the geographical set of countries with ideal conditions for reproduction and virus replication grows, allowing pests to conquer new parts of the world.

A recent Lancet Countdown report (Watts et al., 2020) examined the interaction between climate change and infectious diseases such as COVID-19. The research was led by University College London and involved experts from several other institutions including the World Health Organization and the World Bank. The authors highlight that some of the drivers of climate change (for example, urbanisation and intensive agriculture) are leading to increased contact between humans and animals, thereby making is easier for pathogens to pass between them. The research team have also warned that climate change is leading to more favourable conditions for the spread of infectious diseases such as dengue fever and malaria. In addition, new evidence is presented showing that over the last two decades there has been a 54% increase in worldwide heat-related deaths in older people, while in the UK there were twice as many heat-related deaths among older people in 2018, compared to the early 2000s. The authors emphasise that the recovery from the COVID-19 pandemic offers a key moment to act on climate change.

2. Zoonotic disease transmission

2.1. Introduction

Zoonotic diseases, or zoonoses, are a subset of diseases that originated in animals, and at some point, transmitted from their animal hosts to humans (Palmer et al., 2011). Most infectious diseases which have caused death and misery in human history are zoonoses (McNeill, 1976). However, while the majority of historic zoonoses originated in livestock (Wolfe et al., 2007), the majority of emerging zoonoses come from wildlife. Not only does an increasing number of the emerging zoonoses emerge from wildlife rather than from livestock, the number of emerging zoonoses has been increasing for the past several decades (Jones, et al., 2008; Christou, 2011). This increase has caused many scientists to predict that eventually there would be a major wildlife zoonosis which would cause a global pandemic (Morens et al., 2004; Morse, et al., 2012) a predicted event which finally occurred in 2019 with COVID-19 (Wu et al., 2020).

2.2. Drivers of increased zoonotic diseases

To understand why there are an increasing number of zoonotic diseases, it is necessary to understand how a disease transmits from animals to humans. There are three main factors that determine whether a disease in animals passes on to humans; pathogen pressure, which is the interaction between reservoir and human populations, human and vector behaviour, which determines human exposure, and the physiological and immunological responses in the human host (Plowright et al., 2017). Of these, immune response and physiology is the only factor which is not being altered by climate change. However, human actions, both in terms of biodiversity loss and climate change, are changing both pathogen pressure and human and vector behaviour in such a way as to make spillover events (where diseases cross from animals to humans) more likely.

The greatest driver of increasing numbers of zoonoses is increased pathogen pressure (Plowright et al., 2017). Most increased pathogen pressure comes from human land use change (Woolhouse & Gowtage-Sequeira, 2005). While humans have been altering the landscape for tens of thousands of years (Willis & Birks, 2006), the amount of human influence has drastically increased in the last few decades, to the point that less than 10% of the terrestrial surface can now be said to be 'natural' (Allan et al., 2017). This human land change brings humans into greater contact with wild animal populations, which can act as reservoirs of possible zoonoses.

Even without human interruptions to ecosystems, this increased presence of humans in the natural environment would be expected to increase the incidence of spillover events, and thus lead to a higher number of zoonoses from wildlife. However, humans do alter ecosystems they are in, and one of the most notable ways they do so which increases the odds of new zoonoses is defaunation. Since 1970, the majority of the world's wild terrestrial biomass has been wiped out (Grooten & Almond, 2018). The dramatic loss in host species has forced many parasites to look for alternative hosts (Cascio et al., 2011). In many cases, these new hosts are our livestock (Gummow, 2010), but in others, it is us. The rate of human habitat destruction does not show any signs of abating, and indeed, as climate change forces humans to move away from land which was previously suitable agriculture to new lands, may increase in the 21st century (Powers & Jetz, 2019). Defaunation and extinctions are also expected to increase due to climate change, which is expected to play a greater role in extinctions in the future.

Even once a disease crosses from animals to humans, it is not necessarily a dangerous zoonosis. A disease only becomes a problem when that human then manages to spread it to other humans, and it therefore becomes self-perpetuating (Plowright et al., 2017). How it does so can vary depending on the disease, but in almost every case this must involve changes in the host behaviour. In some cases, the disease can manipulate human behaviour (Funk et al., 2010; Parris et al., 2008). However, in many other cases, changes to how humans live and interact with each other is sufficient to aid in the spread of the disease. In the case of infectious disease, two major changes have greatly aided the rapid spread of emerging disease: urbanisation and travel. Urbanisation has always been associated with disease (Neiderud, 2015), and as a higher percentage of the human population is expected to live in denser cities in the coming decades (Zhang, 2016), in part driven by climate change (Parnell & Walawege, 2011), emerging diseases will have an easier time spreading. But for a global pandemic, like COVID-19, the ease of international travel is more important (Morens et al., 2004). While once, international travel was confined to a miniscule minority of humanity, and took days or weeks, today hundreds of millions have easy access to daily travel that can take them across the world within a day. International travel by aeroplane is also a major driver of climate change (Higham et al., 2016), in addition to being a driver of faster spread of emerging disease.

Land use changes, such as deforestation, agricultural development, and urbanisation are known to impact disease transmission between humans and animals (Gibb et al., 2020). In a review of 305 papers, more than half found that anthropogenic land use changes led to increased pathogen transmission between humans and animals, whilst only 10% observed a decrease (Gottdenker et al., 2014). The common explanations given across these studies were changes to the composition of the populations of pathogen hosts, and to the movement and spatial redistribution of pathogen hosts. The current, unprecedented rate of biodiversity loss is causing wildlife to move closer to human settlements (Jenkins et al., 2020).

There is clear evidence that climate change is already causing species migration, and that this migration is accelerating. An analysis of recent studies suggests that, on average, terrestrial species have moved poleward at 17 km per decade, whilst marine species have moved poleward at 72 km per decade (Pecl et al., 2017). This migration changes which species human populations encounter. For example, the movement of certain species of mosquitos is likely to expose up to one billion new people to diseases including dengue fever, yellow fever and Zika by the end of the century under the most severe warming scenarios (Ryan et al., 2019). This climate-change-induced mosquito migration may also produce epidemics of malaria, as the virus reaches populations that have not previously been exposed and lack any immunity (Pecl et al., 2017).

2.3. Permafrost and ancient diseases

Permafrost thawing presents another potential intersection between climate change and future pandemic risk. Permafrost, defined as any Earth material at or below 0 °C for at least 2 consecutive years, is most commonly found around the Arctic, covering vast swathes of land in regions including northern Russia, Canada and Scandinavia. Climate change is causing a rapid increase in Arctic air temperatures, that is notably larger than the global average temperature increase (Previdi et al., 2020) in a process known as "Arctic amplification". The average annual land surface air temperature north of 60 ° (where most permafrost lies) from October 2018 to August 2019 was the second warmest since 1990 (NOAA, 2020). This amplification has, in turn, caused an increase in global permafrost temperature of between 0.5 °C and 2 °C since the late 1970s (IPCC, 2014), and has resulted in permafrost thawing. Even if the global warming is limited to well below 2 °C, approximately 25% of the near-surface (3 m – 4 m depth) permafrost is expected to thaw by 2100 (IPCC, 2019).

Recent studies have drawn a potential link between thawing permafrost and pandemic risk from ancient diseases. In 2015, two viruses recovered from Russian permafrost were found to have retained their infectivity despite being 30,000 years old (Lengendre et al., 2015). There is, therefore, a concern that pathogens which have caused past pandemics (such as the Spanish Flu and smallpox) could re-infect humans due to permafrost thawing, after fragments of Spanish flu RNA were found in corpses buried in Alaskan tundra (Taubenbergen et al., 2007). A similar mechanism has already been linked to an outbreak of anthrax in the Russian Arctic in 2016, which caused the death of a 12-year-old boy and over 2,000 reindeer. The outbreak was linked to unusually hot weather and a resultant increase in permafrost thawing. This increased thawing caused buried, infected carcasses to release anthrax spores which were ingested by the reindeer before passing into the local, nomadic herder population (Guardian, 2016; Stella et al. 2020).

In addition to the increased risk of viral emergence due to thawing permafrost, an increase in both human exploitation of permafrost regions and northern migration of animals due to climate change heightens the risk of a virus rapidly spreading if it does infect a host.

The impact of thawing permafrost on pandemic risk is an emerging field of research, but one of increasing importance in the changing climate.

3. Human behavioural changes

3.1. How the climate change makes pandemics and public health crises harder to manage

As discussed, there are links between climate change the spread of infectious diseases around the globe. Rising global temperatures may increase the spread of infectious diseases, by allowing emerging diseases to survive in new parts of the world, as well as by generating preferential conditions for reproduction and virus replication (Parnell & Walawege, 2011). However, in the context of a pandemic, some of the most consequential impacts of climate change arise at the intersection between climatic extremes and regional public health crises, termed 'compound risks' (Philips et al., 2020; Pei et al., 2020).

A variety of intersections between climate hazards and public health responses exist which can complicate a governments' response to ongoing crises such as COVID-19 (Philips et al., 2020). Hurricanes, flooding, wildfires, heatwaves and droughts have recently been identified as examples of compound risks to COVID-19 across the world, in their capacity as sources of displacement and disruption during the pandemic.

Flooding, for example, displaces people from their homes and forces large congregations of people into emergency shelters during evacuations (Dahl, 2020). The logistics are further complicated when considering whether and how hospitals – especially intensive care units, with potentially vulnerable patients – can be evacuated safely. If many people are injured in a natural disaster, the injured could further overwhelm a hospital system already strained by pandemic response.

Furthermore, with so many government resources directed toward pandemic-related issues and many non-profit sector service providers furloughing staff due to the economic impacts of the pandemic, mounting a prompt and comprehensive response to climate change-related natural disasters could be further complicated (Groom, 2020).

It is also possible for extreme weather events and the pandemic to negatively reinforce each other economically. Extreme weather events and other natural hazards have the capacity to damage homes, schools and businesses; and disrupt the usual transportation infrastructures that local economies rely on. When such events are followed by a public health crisis such as COVID-19, the crisis can potentially compound the initial economic shock by delaying the necessary work of rebuilding these communities and their public services.

To illustrate, in February 2020 the UK was hit by both Storm Ciarra and Storm Dennis within the space of a week, making it the wettest February since records began and causing catastrophic flooding across large parts of London, Wales, Yorkshire and the Midlands (BBC, 2020). These storms followed an unprecedentedly wet winter in the UK (Tandon and Schultz, 2020), with much of the topsoil already saturated from rain, generating flash flooding events which damaged local high streets, homes and businesses and caused a sharp drop-in economic activity. Since the beginning of the COVID-19 crisis, the economic recovery in many of these regions has stalled, with families initially having to self-isolate in still-damaged homes and local shops unable to carry out the necessary repairs to re-open (Morris, 2020; BBC, 2020). As Philips et al. (2020) discuss, these compound events exacerbate long-standing socioeconomic and racial inequities within a region in a way which compromises economic recovery and puts specific populations at heightened risk.

3.1.1. Questions

Based on the issues discussed throughout this section, we propose the following questions to ask of the Government:

- How is the government planning on dealing with the combined effects of the pandemic and the possibility of flooding in England and Wales this winter?
- How is the government planning to help those local communities who are still recovering from the floods last year? Will post-COVID recovery measures be directed particularly towards these areas?
- How does the government plan to structure emergency housing or evacuation for possible natural disasters over the coming year, without relying on mass care that might further spread COVID-19?

3.2. Climate change driving migration

Obviously, the main factor that is driving mass migration and movement of refugees across the world is war and political unrest. However, climate change and environmental destruction is a major contributor to the unprecedented movement of people throughout the world. Although displacement due to these factors do not meet the UN's definition of a refugee set out in its convention, the term "climate refugee" or "environmental refugee" has found increased use. A paper presented at the world economic forum by Myers (2005) estimated that by 2050 there could be as many as 200 million climate refugees moving from their homes, either across borders or internally within states. A report by Christian Aid put the figure even higher, with the often-cited figure being a potential 1 billion, although this number represents refugees from all causes (Christian Aid, 2007).

Even if this figure is an over-estimate, the 2 figures certainly represent a pressing challenge to governments. However, predicting the true number of people pushed from their home due to climate change is difficult due to the lack of data on migration, particularly within national borders (Tacoli, 2009). These figures represent the number of people most at risk of environmental degradation due to climate change, as not all will have the resources to be able to move. Most cases studies from previous droughts indicate that people are more likely to travel within their own country, mostly between rural centres, rather than internationally. In situations where rural-urban migration has occurred following drought and environmental degradation, it is likely to be after years of political and economic marginalisation of these groups, inappropriate development of policies that constrain mobility, a much lower access to basic services than national averages and limited opportunities for income diversification. Cyclical migration for income diversification still appears to be the main form of migration as a response to climate change when farming incomes fall.

This effect can be seen in the statements by Ban Ki-moon, that the war that engulfed Darfur was at least partially caused by the ecological crisis that reduced farming land. Similarly, the movement that precipitated from the Syrian civil war, was magnified by the environmental destruction caused by the desertification. In 2018, the UNHCR estimated that there were currently 16.1 million people displaced due to climate related hazards, with 2.2 million from the drought in Somalia alone (UNHCR, 2019).

The largest threat to people's home from climate change is that of sea level rises, with around 600 million people estimated to live in low-lying areas at threat of flooding from these rises (McGranahan, 2007). These communities are fairly evenly split between high- and low-income nations, with 247 million living in low-income nations. It is not clear if migration will be the primary response of these communities.

This mass movement of people caused by climate change represents not only a humanitarian disaster, but also a potential public health disaster, as endemic diseases that have been eradicated in the UK and Europe are still prevalent in many parts of the world. Even internal movement within counties represents increased risk of disease, as public health is not spread evenly through nations, and the mixing of geographically separated people can cause diseases to spread. During the COVID-19 pandemic, some literature points to the event of Chinese New Year dramatically increasing the spread of the disease.

In a working paper on the impact that climate change could have on migration in Senegal, Tanzania and Bolivia, Tacoli (2011) stated that it is difficult to know the full impacts due to the uncertainty around local impacts of climate change. However, non-environmental factors will determine who is affected the most by the climate changes and forced to move. Climate tipping point events, such as a drought, are usually the driver for people to migrate to secure their livelihoods (Tacoli, 2011). Similarly, extreme weather events (such as floods and hurricanes) can trigger populations vulnerable to climate change to migrate. These events only become disasters when they effect populations that are already vulnerable (Tacoli, 2009). This fact is not only true for low-income countries – compare the impacts of hurricane Katrina in New Orleans, to hurricane Harvey in Houston.

In a paper in *Science*, Missirian (2017) found that weather variations in 103 source countries translated into asylum applications to the European Union, with an average of 351,000 application per year. The data showed a non-linear trend, with the greater the increase in temperature, the greater the number of asylum applications. However, the predictions for future changes had large confidence intervals. These findings were supported by the Abel et al. (2019), who used data from 157 countries over the period 2006 – 2015 and found that climate factors had a significant role in increasing asylum applications over that period. This was by driving droughts and related conflicts. However, the authors found that this result was limited to a small number of specific and deadly conflicts, particularly those related to the Arab Spring. When these conflicts were excluded the link was much weaker.

In 2000, John C. Gannon, chairman of the US National Intelligence Council highlighted the threat of the re-emergence of diseases, with tuberculosis (TB), malaria, and cholera having become more prevalent and spread since 1973, and others, such as HIV, Ebola, Hepatitis C, and the Nipah virus, which have no known cures, have also emerged since that year (Gannon, 2000).

In this report, Gannon suggested that acute lower respiratory infections - including pneumonia and influenza - would have peaked at high incidence levels by the year 2020, with HIV/AIDS and TB being the major cause of death due to infectious disease by that date. The report highlights that most infectious diseases originate outside the US and are imported through international travel, immigration and imported animals and food stuff, and that the risk of an unknown pathogen is high.

When migrants and refugees move to a country, they do not often have access to healthcare in their resident country, as they are barred from these services. In Germany, it was found that this restriction to healthcare of migrants and refugees resulted in increased long-term costs, as it meant that conditions that were easy to treat commonly developed into more complex (and expensive) healthcare problems. There are also public health benefits, as, although it is rare that migrant populations bring diseases that are a risk to the host population, migrant diseases can pose risks to the local public if not treated. An example of such a scenario is a measles outbreak in an asylum seeker shelter, where vaccination would have overall reduced treatment costs by 50% (Legido-Quigley, 2019).

A WHO report highlighted that the risk to Europe of communicable diseases is increased in migrants populations, not only due to the increased prevalence of the diseases in their country of origin, but also because of their lack of access to healthcare in the host country (WHO, 2010).

In a report in *The Lancet*, Watts et al. (2018) highlighted that the global disease burden has reduced since the 1990s, however, there is an increase in Dengue fever across the globe. The population of the 2 principle mosquitos vector species, Aedes aeqypti and Aedes albopictus, has increased 3% and 5.9% respectively since the 1990s in regions that they are present in due to climate change. Annual numbers of cases of Dengue have doubled every decade since 1990, with 58.4 million (23.6 million – 121.9 million) apparent cases in 2013, accounting for over 10,000 deaths. The authors state that the increase in Dengue fever could also be seen in other climate related diseases, as other emerging or re-emerging arboviruses, including Yellow Fever, Chikungunya, Mayaro and Zika viruses, are also carried by the disease vectors. The report states that understanding the link between climate change and infectious diseases is important to mitigate the impacts of the climate crisis (Watts et al., 2018).

A WHO report looking at the impacts of globalisation on the spread of infectious diseases highlighted that diseases carried by mosquitoes are sensitive to changes caused by the climate change, as the larvae are killed by temperatures below 10 °C. Increased temperatures have been found to increase their bite rate, and thus increase the chances of coming into contact with an infected individual and then biting a healthy individual and passing on the disease (WHO, 2004). The IPCC has concluded that climate change is likely to extend the range of many vector-borne diseases to higher latitudes and longitudes. These diseases include Malaria, Dengue, Leishmaniasis. However, there is also a chance that it could reduce the spread of some diseases in specific regions due to a decrease in rainfall (IPCC, 2014). Similar changes have been predicted for a range of vector-borne diseases. It has also been speculated that ocean warming could result in the increase of toxic algae that can make its way into the food chain, or that harbour human pathogens, with Cholera outbreaks in Bangladesh being linked to increase ocean temperatures (Lipp, 2002).

3.3. COVID-19 and attitudes to climate change

The COVID crisis has had a profound impact on many people's lives and livelihoods, both in the UK and worldwide. It is useful to consider whether, as a consequence, people are now feeling that the efforts to combat the virus mean we cannot now also afford (in terms of effort and finance) to tackle climate change, or has the global response and the benefits seen, for example, in reduced air pollution, inspired people to be keener to see greater efforts employed to tackle climate change.

A recent briefing paper by the Centre for Climate Change and Social Transformations (CAST, 2020), based on two nationally representative surveys has shown that concern about climate change in August 2020 has increased since August 2019, and there is greater support for climate change mitigation policies including measures to decrease meat consumption and flying. The percentage of people agreeing that climate change requires a 'high' or 'very high' level of priority has risen since 2019.

Furthermore, a recent Ipsos Earth Day survey (Ipsos, 2020) found that concern over climate change is still high globally, despite the very high levels of attention being devoted to the immediate COVID crisis. Their online study covered 14 countries between 16th April and 19th April 2020, and showed that seven in ten people consider climate change as serious a crisis as COVID-19, and a similar proportion feel their government will be failing them if it doesn't act on climate change now. Two thirds globally support a green economic recovery from the crisis. From a politician's perspective it is useful to note that the Ipsos survey found that 59% of respondents in the UK agreed with the statement "If a political party's policies don't deal seriously with climate change, this would put me off voting for them".

It is interesting to note that the trends described above, whereby awareness and concern about climate change has remained high (despite the presence of another crisis, i.e. the global pandemic), were not observed following the financial crisis of 2008 – 2009. An overview by Capstick et al. (2015) of international trends in public perceptions of climate change summarised several studies which indicated an economic explanation for declines in concern about climate change in the late 2000s. The authors concluded that this was consistent with the 'finite pool of worry' hypothesis which predicts that concern about one issue will decrease as concerns about another become more relevant. This hypothesis appears not to be applicable to concerns about the climate crisis in the face of COVID crisis.

The national and international response to the COVID-19 crisis has demonstrated that people have the capacity to change their lives, often very significantly, in response to an immediate threat. It is useful to consider whether there are lessons to be learnt from the COVID-19 policy actions that could enhance efforts in fighting global climate change, as well as preparing humanity for future crises.

In a recent paper, Klenert et al. (2020) discussed policy lessons from the early stages of the pandemic with respect to the COVID-19 pandemic. Klenert et al. emphasise that there are key differences between the COVID and climate crisis, and it is important to understand these differences. One marked difference is that climate change mitigation requires a much more anticipatory and global response. An individual country taking effective unilateral action against COVID-19, will protect its citizens, but this is not necessarily the case with climate change. Also, the immediacy and urgency of the threat from COVID has galvanised populations in a way in which climate change has not done to the same extent, especially in the countries where its effects are currently being felt the least. When the impacts of a crisis are very evident, most citizens are generally collaborative and willing to accept harsh limitations on their freedoms, at least temporarily, however citizens appear less willing to accept much less stringent measures to combat climate change, because it feels less imminent.

Overall, although Klenert et al. argue that climate change is more difficult to confront than the COVID-19 crisis there are is a potential for lessons to be learnt. In particular, the lesson, which has been widely understood, that acting early has made the difference between prolonged lockdowns and high numbers of casualties, compared to less dramatic measures with shorter periods of inconvenience. The importance of acting early is a message that it would be good to emphasise with respect to climate policy and that delays are costly, both economically and in terms of disruption.

4. Wider Societal Context

Although climate change will undoubtedly effect all of us, the impact of climate change is unlikely to be felt equally. Pre-existing inequalities are likely to make some individuals more susceptible to climate change both within the UK and more generally globally.

In the UK, factors such as age, ethnicity, socio-economic status, and geographical location, will have an impact on how bad an individual health is affected by climate change (Paavola, 2017). Climate change will cause several issues in the UK which will have an impact on health, including hotter summer and heatwaves, extreme weather events, flooding and an increase in infections or outbreaks.

Hotter summers and heatwaves are likely to have a disproportionate impact on older people, those from disadvantaged backgrounds, those in the South and East of the country and those living in urban areas (Paavola, 2017). Heatwave related deaths typically occur as a result of respiratory or cardio-vascular illness.

Urban areas are more exposed to heat than rural areas, due to the urban heat effect (Heaviside et al., 2016; Ola, 2017). Densely built neighbourhoods with little green space are more at risk of the effects of heatwaves (Oikonomou, 2012). Architectural features that are used to prevent crime or reduce noise pollution can make a building more vulnerable to the effects of heat (Vardoulakis, 2015). All these features mean people from disadvantaged areas are disproportionately affected by heatwaves.

Additionally, elderly people are more susceptible to the effects of heat (Pavola, 2017) due to their lower ability to thermally regulate (Oikonomou, 2012). They also may be prescribed medication which makes them more susceptible to heat (Arbuthnott, 2017).

Extreme weather events are likely to occur with increased frequency and intensity as a result of climate change. These extreme weather events are likely to not effect society equally. Hospital inpatients and those in need of urgent medical care (Pavola, 2017) are likely to be disproportionally affected. Elderly people are also likely to be significantly affected due to care disruption and more common need for more urgent care due to underlying medical conditions (Pavola, 2017).

The effects of flooding caused by climate change are unlikely to be felt equally across the population. For example, people living in affordable housing or disadvantaged household are more likely to be affected by coastal flooding (Pavola, 2017). The young, disabled people and those with chronic health conditions are likely to be disproportionally affected by the disruption in public transport due to flooding (Pavola, 2017). In addition to this, there is evidence that there may be a gender difference in the health outcome due to flooding (Lowe, 2013).

One thing that the current COVID-19 pandemic has taught us is that pre-existing inequalities in our society make individuals more susceptible to the effects of a global pandemic. Emerging infections are predicted to increase with climate change, and the same factors as for COVID-19 are likely to make individuals more susceptible.

In addition to inequalities within the UK, current global inequalities are likely to be exasperated by climate change (Timmons, 2001). Lower income countries will be less able to adapt to climate change and will be disproportionally affected by issue such as food and water shortages and damage to infrastructure.

References

Abel, Guy J., et al. “Climate, Conflict and Forced Migration.” Global Environmental Change, vol. 54, 2019, pp. 239–249., doi:10.1016/j.gloenvcha.2018.12.003.
Allan, James R., et al. “Temporally Inter-Comparable Maps of Terrestrial Wilderness and the Last of the Wild.” Scientific Data, vol. 4, no. 1, 2017, doi:10.1038/sdata.2017.187.
Allen, Myles R., and William J. Ingram. “Constraints on Future Changes in Climate and the Hydrologic Cycle.” Nature, vol. 419, no. 6903, 2002, pp. 228–232., doi:10.1038/nature01092.
Allen, Myles. “Liability for Climate Change.” Nature, vol. 421, no. 6926, 2003, pp. 891–892., doi:10.1038/421891a.
Arbuthnott, K., and S. Hajat. 2017 “Hotter Summers and Heat Waves.” Environmental Health, vol. 16, no. 1, pp. 119
Bamber, Jonathan L., et al. “Ice Sheet Contributions to Future Sea-Level Rise from Structured Expert Judgment.” Proceedings of the National Academy of Sciences, vol. 116, no. 23, 2019, pp. 11195–11200., doi:10.1073/pnas.1817205116.
BBC. “Coronavirus: Shropshire Flood Recovery 'Stalled'.” BBC News, BBC, 26 Mar. 2020, www.bbc.co.uk/news/uk-england-52036241.
Capstick, Stuart, et al. “International Trends in Public Perceptions of Climate Change over the Past Quarter Century.” Wiley Interdisciplinary Reviews: Climate Change, vol. 6, no. 1, 2014, pp. 35–61., doi:10.1002/wcc.321.
Cascio, A., et al. “The Socio-Ecology of Zoonotic Infections.” Clinical Microbiology and Infection, vol. 17, no. 3, 2011, pp. 336–342., doi:10.1111/j.1469-0691.2010.03451.x.
CAST. Centre for Climate Change and Social Transformations, 2020, HOW HAS COVID-19 IMPACTED LOW-CARBON LIFESTYLES AND ATTITUDES TOWARDS CLIMATE ACTION?
Christian Aid. “Human Tide: the Real Migration Crisis.” Christian Aid, 2007, www.christianaid.org.uk/resources/about-us/human-tide-real-migration-crisis-2007.
Christou, L. “The Global Burden of Bacterial and Viral Zoonotic Infections.” Clinical Microbiology and Infection, vol. 17, no. 3, 2011, pp. 326–330., doi:10.1111/j.1469-0691.2010.03441.x.
Dahl, Kristy. “Continued Social Distancing Critical for US Regions Where Flooding and COVID-19 Are Set to Collide.” Union of Concerned Scientists, 6 July 2020, blog.ucsusa.org/kristy-dahl/continued-social-distancing-critical-for-us-regions-where-flooding-and-COVID-19-are-set-to-collide.
Friberg, Johan, et al. “Volcanic Impact on the Climate – the Stratospheric Aerosol Load in the Period 2006–2015.” Atmospheric Chemistry and Physics, vol. 18, no. 15, 2018, pp. 11149–11169., doi:10.5194/acp-18-11149-2018.
Funk, Sebastian, et al. “Modelling the Influence of Human Behaviour on the Spread of Infectious Diseases: a Review.” Journal of The Royal Society Interface, vol. 7, no. 50, 2010, pp. 1247–1256., doi:10.1098/rsif.2010.0142.
Gannon, J. C. National Intelligence Council Report, 2000, The Global Infectious Disease Threat and Its Implications for the United States.
Gibb, Rory, et al. “Zoonotic Host Diversity Increases in Human-Dominated Ecosystems.” Nature, vol. 584, no. 7821, 2020, pp. 398–402., doi:10.1038/s41586-020-2562-8.
Gottdenker, Nicole L., et al. “Anthropogenic Land Use Change and Infectious Diseases: A Review of the Evidence.” EcoHealth, vol. 11, no. 4, 2014, pp. 619–632., doi:10.1007/s10393-014-0941-z.
Graeden, Ellie, et al. “Answering the Right Questions for Policymakers on COVID-19.” The Lancet Global Health, vol. 8, no. 6, 2020, doi:10.1016/s2214-109x(20)30191-1.
Groom, Nichola. “Trump Administration Halts Wildfire Prevention Tool in California over Coronavirus.” Reuters, Thomson Reuters, 15 Apr. 2020, www.reuters.com/article/us-health-coronavirus-usa-wildfires/trump-administration-halts-wildfire-prevention-tool-in-california-over-coronavirus-idUSKCN21X1HD.
Grooten, A., and R. E. A. Almond. WWF International, 2018, Living Planet Report 2018 – Aiming Higher.
Gummow, B. “Challenges Posed by New and Re-Emerging Infectious Diseases in Livestock Production, Wildlife and Humans.” Livestock Science, vol. 130, no. 1-3, 2010, pp. 41–46., doi:10.1016/j.livsci.2010.02.009.
Haigh, Joanna. Grantham Institute for Climate Change, Imperial College London, 2011, Solar Influences on Climate.
Hannaford, Jamie. “Climate-Driven Changes in UK River Flows.” Progress in Physical Geography: Earth and Environment, vol. 39, no. 1, 2015, pp. 29–48., doi:10.1177/0309133314536755.
Heaviside, Clare, et al. “Attribution of Mortality to the Urban Heat Island during Heatwaves in the West Midlands, UK.” Environmental Health, vol. 15, no. S1, 2016, doi:10.1186/s12940-016-0100-9.
Held, Isaac M., and Brian J. Soden. “Robust Responses of the Hydrological Cycle to Global Warming.” Journal of Climate, vol. 19, no. 21, 2006, pp. 5686–5699., doi:10.1175/jcli3990.1.

Higham, James, et al. “Climate Change, Tourist Air Travel and Radical Emissions Reduction.” Journal of Cleaner Production, vol. 111, 2016, pp. 336–347., doi:10.1016/j.jclepro.2014.10.100.
IPCC. IPCC, 2014, AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability.
IPCC. IPCC, 2019, Special Report on the Ocean and Cryosphere in a Changing Climate.
IPCC. World Meteorological Organization, 2018, Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty.
IPSOS Global Advisor. “Earth Day 2020: How Does the World View Climate Change and COVID-19?” Earth Day 2020, IPSOS, www.ipsos.com/sites/default/files/ct/news/documents/2020-04/earth-day-2020-ipsos.pdf .
Jackson, Luke P., et al. “21st Century Sea-Level Rise in Line with the Paris Accord.” Earth's Future, vol. 6, no. 2, 2018, pp. 213–229., doi:10.1002/2017ef000688.
Jenkins, Aaron, et al. “Nested Ecology and Emergence in Pandemics.” The Lancet Planetary Health, vol. 4, no. 8, 2020, doi:10.1016/s2542-5196(20)30165-0.
Jones, Kate E., et al. “Global Trends in Emerging Infectious Diseases.” Nature, vol. 451, no. 7181, 2008, pp. 990–993., doi:10.1038/nature06536.
Keeling, Ralph F., and Charles D. Keeling. “Atmospheric Monthly In Situ CO2 Data - Mauna L...” UC San Diego Library | Digital Collections, 2020, library.ucsd.edu/dc/object/bb3859642r.
Klenert, David, et al. “Five Lessons from COVID-19 for Advancing Climate Change Mitigation.” Environmental and Resource Economics, vol. 76, no. 4, 2020, pp. 751–778., doi:10.1007/s10640-020-00453-w.
Knutti, Reto, and Jan Sedláček. “Robustness and Uncertainties in the New CMIP5 Climate Model Projections.” Nature Climate Change, vol. 3, no. 4, 2012, pp. 369–373., doi:10.1038/nclimate1716.
Legendre, Matthieu, et al. “In-Depth Study of Mollivirus Sibericum, a New 30,000-y-Old Giant Virus Infecting Acanthamoeba.” Proceedings of the National Academy of Sciences, vol. 112, no. 38, 2015, doi:10.1073/pnas.1510795112.
Legido-Quigley, Helena, et al. “Healthcare Is Not Universal If Undocumented Migrants Are Excluded.” BMJ, 2019, p. l4160., doi:10.1136/bmj.l4160.
Lipp, Erin K., et al. “Effects of Global Climate on Infectious Disease: the Cholera Model.” Clinical Microbiology Reviews, vol. 15, no. 4, 2002, pp. 757–770., doi:10.1128/cmr.15.4.757-770.2002.
Lowe, Dianne, et al. “Factors Increasing Vulnerability to Health Effects before, during and after Floods.” International Journal of Environmental Research and Public Health, vol. 10, no. 12, 2013, pp. 7015–7067., doi:10.3390/ijerph10127015.
Luhn, Alec. “Anthrax Outbreak Triggered by Climate Change Kills Boy in Arctic Circle.” The Guardian, 1 Aug. 2016.
McCormick, M. Patrick, et al. “Atmospheric Effects of the Mt Pinatubo Eruption.” Nature, vol. 373, no. 6513, 1995, pp. 399–404., doi:10.1038/373399a0.
McGranahan, Gordon, et al. “The Rising Tide: Assessing the Risks of Climate Change and Human Settlements in Low Elevation Coastal Zones.” Environment and Urbanization, vol. 19, no. 1, 2007, pp. 17–37., doi:10.1177/0956247807076960.
McNeill, William Hardy. Plagues and People. Anchor Books, 197AD.
Missirian, Anouch, and Wolfram Schlenker. “Asylum Applications Respond to Temperature Fluctuations.” Science, vol. 358, no. 6370, 2017, pp. 1610–1614., doi:10.1126/science.aao0432.
Morens, David M., et al. “The Challenge of Emerging and Re-Emerging Infectious Diseases.” Nature, vol. 430, no. 6996, 2004, pp. 242–249., doi:10.1038/nature02759.
Morris, Steven. “Horrendous': Welsh Residents Endure Lockdown in Flood-Hit Homes.” The Guardian, 27 Apr. 2020.
Morse, Stephen S, et al. “Prediction and Prevention of the next Pandemic Zoonosis.” The Lancet, vol. 380, no. 9857, 2012, pp. 1956–1965., doi:10.1016/s0140-6736(12)61684-5.
Myers, Norman. “Contribution by Prof. Norman Myers, Green College, Oxford University, U.K., ‘Environmental Refugees: An Emergent Security Issue.’” OSCE, 2005, www.osce.org/eea/14851.
National Ocean and Atmospheric Administration. “2019 Headlines.” Arctic Program, National Ocean and Atmospheric Administration, 16 Sept. 2020, www.arctic.noaa.gov/Report-Card/Report-Card-2019.
Neiderud, Carl-Johan. “How Urbanization Affects the Epidemiology of Emerging Infectious Diseases.” Infection Ecology & Epidemiology, vol. 5, no. 1, 2015, p. 27060., doi:10.3402/iee.v5.27060.
Oikonomou, Eleni, et al. “Modelling the Relative Importance of the Urban Heat Island and the Thermal Quality of Dwellings for Overheating in London.” Building and Environment, vol. 57, 2012, pp. 223–238., doi:10.1016/j.buildenv.2012.04.002.

Otto, Friederike E L, et al. “Climate Change Increases the Probability of Heavy Rains in Northern England/Southern Scotland like Those of Storm Desmond—a Real-Time Event Attribution Revisited.” Environmental Research Letters, vol. 13, no. 2, 2018, p. e024006., doi:10.1088/1748-9326/aa9663.
Paavola, Jouni. “Health Impacts of Climate Change and Health and Social Inequalities in the UK.” Environmental Health, vol. 16, no. S1, 2017, doi:10.1186/s12940-017-0328-z.
Pachauri, Rajendra K. Climate Change 2014: Synthesis Report. IPCC, 2015.
Palmer, Stephen R., et al. Oxford Textbook of Zoonoses: Biology, Clinical Practice, and Public Health Control. 2nd ed., Oxford University Press, 2011.
Parnell, Susan, and Ruwani Walawege. “Sub-Saharan African Urbanisation and Global Environmental Change.” Global Environmental Change, vol. 21, 2011, doi:10.1016/j.gloenvcha.2011.09.014.
Parrish, Colin R., et al. “Cross-Species Virus Transmission and the Emergence of New Epidemic Diseases.” Microbiology and Molecular Biology Reviews, vol. 72, no. 3, 2008, pp. 457–470., doi:10.1128/mmbr.00004-08.
Pecl, Gretta T., et al. “Biodiversity Redistribution under Climate Change: Impacts on Ecosystems and Human Well-Being.” Science, vol. 355, no. 6332, 2017, doi:10.1126/science.aai9214.
Pei, Sen, et al. “Compound Risks of Hurricane Evacuation amid the COVID-19 Pandemic in the United States.” GeoHealth, 2020, doi:10.1029/2020gh000319.
Pfahl, S., et al. “Understanding the Regional Pattern of Projected Future Changes in Extreme Precipitation.” Nature Climate Change, vol. 7, no. 6, 2017, pp. 423–427., doi:10.1038/nclimate3287.
Phillips, Carly A., et al. “Compound Climate Risks in the COVID-19 Pandemic.” Nature Climate Change, vol. 10, no. 7, 2020, pp. 586–588., doi:10.1038/s41558-020-0804-2.
Plowright, Raina K., et al. “Pathways to Zoonotic Spillover.” Nature Reviews Microbiology, vol. 15, no. 8, 2017, pp. 502–510., doi:10.1038/nrmicro.2017.45.
Powers, Ryan P., and Walter Jetz. “Global Habitat Loss and Extinction Risk of Terrestrial Vertebrates under Future Land-Use-Change Scenarios.” Nature Climate Change, vol. 9, no. 4, 2019, pp. 323–329., doi:10.1038/s41558-019-0406-z.
Previdi, Michael, et al. “Arctic Amplification: A Rapid Response to Radiative Forcing.” Geophysical Research Letters, vol. 47, no. 17, 2020, doi:10.1029/2020gl089933.
Roberts, J. Timmons. “Global Inequality and Climate Change.” Society & Natural Resources, vol. 14, no. 6, 2001, pp. 501–509., doi:10.1080/08941920118490.
Ryan, Sadie J., et al. “Global Expansion and Redistribution of Aedes-Borne Virus Transmission Risk with Climate Change.” PLOS Neglected Tropical Diseases, vol. 13, no. 3, 2019, doi:10.1371/journal.pntd.0007213.
Saker, L., et al. WHO, 2004, Globalization and Infectious Diseases: a Review of the Lickages.
Schaller, Nathalie, et al. “Human Influence on Climate in the 2014 Southern England Winter Floods and Their Impacts.” Nature Climate Change, vol. 6, no. 6, 2016, pp. 627–634., doi:10.1038/nclimate2927.
Stella, Elisa, et al. “Permafrost Dynamics and the Risk of Anthrax Transmission: a Modelling Study.” Scientific Reports, vol. 10, no. 1, 2020, doi:10.1038/s41598-020-72440-6.
Tacoli, C. “Not Only Climate Change: Mobility, Vulnerability and Socio-Economic Transformations in Environmentally Fragile Areas in Bolivia, Senegal and Tanzania.” Not Only Climate Change: Mobility, Vulnerability and Socio-Economic Transformations in Environmentally Fragile Areas in Bolivia, Senegal and Tanzania - Pubs.iied.org., 2011, pubs.iied.org/10590IIED/.
Tacoli, Cecilia. “Crisis or Adaptation? Migration and Climate Change in a Context of High Mobility.” Environment and Urbanization, vol. 21, no. 2, 2009, pp. 513–525., doi:10.1177/0956247809342182.
Tandon, Ayesha, and Annie Schultz. “Met Office: The UK's Wet and Warm Winter of 2019-20.” Carbon Brief, 3 Apr. 2020, www.carbonbrief.org/met-office-the-uks-wet-and-warm-winter-of-2019-20.
Taubenberger, Jeffrey K., et al. “Discovery and Characterization of the 1918 Pandemic Influenza Virus in Historical Context.” Antiviral Therapy, 2007, pp. 581–591.
Taylor, Karl E., et al. “An Overview of CMIP5 and the Experiment Design.” Bulletin of the American Meteorological Society, vol. 93, no. 4, 2012, pp. 485–498., doi:10.1175/bams-d-11-00094.1.
Trenberth, Kevin E., et al. “Earth's Global Energy Budget.” Bulletin of the American Meteorological Society, vol. 90, no. 3, 2009, pp. 311–324., doi:10.1175/2008bams2634.1.
United Nations High Commissioner for Refugees. “UNHCR Warns of Growing Climate-Related Displacement in Somalia.” UNHCR, 2019, www.unhcr.org/uk/news/briefing/2019/6/5cf61d304/unhcr-warns-growing-climate-related-displacement-somalia.html.
Vardoulakis, Sotiris, et al. “Impact of Climate Change on the Domestic Indoor Environment and Associated Health Risks in the UK.” Environment International, vol. 85, 2015, pp. 299–313., doi:10.1016/j.envint.2015.09.010.

Watts, Nick, et al. “The Lancet Countdown on Health and Climate Change: from 25 Years of Inaction to a Global Transformation for Public Health.” The Lancet, vol. 391, no. 10120, 2018, pp. 581–630., doi:10.1016/s0140-6736(17)32464-9.
Watts, Nick, et al., “The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises”, Published: December 02, 2020, https://doi.org/10.1016/S0140-6736(20)32290-X
WHO. Copenhagen, WHO Regional Office for Europe, 2010, How Health Systems Can Address Health Inequities Linked to Migration and Ethnicity.
Willis, K. J., and H. J. B. Birks. “What Is Natural? The Need for a Long-Term Perspective in Biodiversity Conservation.” Science, vol. 314, no. 5803, 2006, pp. 1261–1265., doi:10.1126/science.1122667.
Wolfe, Nathan D., et al. “Origins of Major Human Infectious Diseases.” Nature, vol. 447, no. 7142, 2007, pp. 279–283., doi:10.1038/nature05775.
Woolhouse, Mark E.j., and Sonya Gowtage-Sequeria. “Host Range and Emerging and Reemerging Pathogens.” Emerging Infectious Diseases, vol. 11, no. 12, 2005, pp. 1842–1847., doi:10.3201/eid1112.050997.
Wu, Fan, et al. “A New Coronavirus Associated with Human Respiratory Disease in China.” Nature, vol. 579, no. 7798, 2020, pp. 265–269., doi:10.1038/s41586-020-2008-3.
Zhang, Xing Quan. “The Trends, Promises and Challenges of Urbanisation in the World.” Habitat International, vol. 54, 2016, pp. 241–252., doi:10.1016/j.habitatint.2015.11.018.