The *Lancet* Countdown on Health and Climate Change

RESPONDING TO THE HEALTH RISKS OF CLIMATE CHANGE IN EUROPE

MARCH 2021

European Environment Agency

LANCET COUNTDOWN: TRACKING PROGRESS ON HEALTH AND CLIMATE CHANGE

ACKNOWLEDGEMENTS

This briefing is a collaborative effort of the ***Lancet*** Countdown on Health and Climate Change, a global academic collaboration focused on tracking the links between health and climate change through a series of more than 45 indicators, and the European Environment Agency (EEA), an European Union agency tasked to provide sound, independent information on the environment.

Main contributors in alphabetical order: Kim van Daalen[3], Hans-Martin Füssel[1], Aleksandra Kazmierczak[1], Maria Nilsson[2], Marina Romanello.[3]

Additional contributors in alphabetical order: Josep M. Anto[4-7], Anne Coleman[3], Niheer Dasandi[8], Frances MacGuire[3], Ian Hamilton[10], Slava Jankin[9], Vladimir Kendrovski[11]*, Joacim Rocklöv[12], Oliver Schmoll[11]*, Jan C. Semenza[13], Cathryn Tonne.[4, 6, 7]

1. European Environment Agency (EEA), Copenhagen, Denmark
2. Department of Epidemiology and Global Health, Umeå University, Umeå, Sweden
3. *Lancet* Countdown on Health and Climate Change, Institute for Global Health, University College London (UCL), London, United Kingdom
4. Barcelona Institute for Global Health (ISGlobal), Barcelona, Spain
5. Hospital del Mar Medical Research Institute (IMEM), Barcelona, Spain
6. Universitat Pompeu Fabra (UPF), Barcelona, Spain
7. Epidemiología y Salud Pública (CIBERESP), Barcelona, Spain
8. School of Government, University of Birmingham, Birmingham, United Kingdom
9. Data Science Lab, Hertie School, Berlin, Germany
10. Energy Institute, University College London, London, United Kingdom
11. WHO Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany
12. Department of Public Health and Clinical Medicine, Umeå University, Umeå, Sweden
13. Scientific Assessment Section, European Centre for Disease Prevention and Control (ECDC), Solna, Sweden

* Vladimir Kendrovski and Oliver Schmoll are staff members of the World Health Organization (WHO) Regional Office for Europe. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the decisions or policies of the World Health Organization. The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of WHO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Figure 1: Reprinted from Watts, Nick, et al. Health and climate change: policy responses to protect public health. The Lancet 386.10006 (2015): 1861-1914, with permission from Elsevier.

SUMMARY IMPACT AND POLICY CONTEXT

- European countries are increasingly affected by weather and climate extremes, which lead to fatalities and affect human health and well-being. For example, more European countries suffered from wildfires in 2018 than previously recorded, including several in north and central Europe.

- Vulnerability to heat extremes continues to rise in the World Health Organization (WHO) European Region, primarily due to a growing urban population, increasing incidence of underlying chronic conditions, and a growing number of people living to old age. In terms of mortality, the hot summer of 2003 resulted in an estimated 70,000 excess deaths in Europe, whilst the 2015 heatwaves caused over 3,275 deaths in France alone. Global excess mortality attributable to heat exposure in people over 65 is estimated to have increased by more than 50% during the period 2000-2018.

- Climate change is altering ecological conditions, and some areas are becoming more suitable for various infectious diseases. In 2018, the environmental suitability for the transmission of dengue by its mosquito vector in European countries increased by over 40% compared to the 1950-1954 baseline. In the past five years, the proportion of coastline suitable for the transmission of *Vibrio* bacteria, which can cause gastroenteritis through the consumption of contaminated seafood and potentially lethal wound infections through direct exposure, has increased by 61% in the Baltic region, compared to a 1980s baseline.

- Climate change impacts are addressed through key European Union (EU) strategies on adaptation and on health as well as through topic-specific policies. Emerging policies and initiatives under the European Green Deal suggest increasing integration between climate action and human health and well-being.

- At the national level, all EU Member States have National Adaptation Strategies and/or Plans in place, and most have recognised climate threats to health through risk and vulnerability assessments. Nonetheless, the implementation of actions addressing the climate threats to health lags behind and could be supported by more knowledge on effective solutions.

- At the local administration level, adaptation to climate change remains in the domain of the spatial planning, urban design, or environmental departments. There is a need for further involvement of public health professionals in local adaptation planning and implementation to reduce the human health impacts, including disproportionate impacts on vulnerable groups.

- The EU is taking steps to improve the knowledge base for policy action on climate change and health, championing the European Green Deal, EU4Health and the new EU strategy for adaptation to climate change. A key initiative in this context is the European Climate and Health Observatory, coordinated by the EC and the European Environment Agency (EEA), and hosted on their Climate-ADAPT platform. The *Lancet* Countdown on Health and Climate Change, the European Centre for Disease Prevention and Control (ECDC), the European Food Safety Authority (EFSA), the WHO Regional Office for Europe, and the Copernicus Climate Change Service (C3S) are central partners in this initiative, contributing indicators, insights and analyses.

INTRODUCTION

Climate change clearly shows adverse impacts on health, which are projected to worsen with inevitable further temperature rise in the coming decades. No country, whether rich or poor, is immune. In 2020, the *Lancet* Countdown reported the worst outlook since its establishment in 2015. Climate change threatens to undermine the past 50 years of gains in global public health. Citizens across Europe and beyond face increasing extremes of heat, threats to food and water systems, and changing patterns of infectious diseases, as a result of our changing climate (Figure 1).[1-3]

In 2016, the European Union (EU) ratified the Paris Agreement, and committed to limiting global warming to "well below 2 °C" compared to preindustrial levels. Yet, five years on, global carbon dioxide emissions continue to rise steadily[4]. The peak concentration for limiting the increase to 1.5 °C will be reached around 2021/2022.[5] Even under the most ambitious decarbonisation scenarios, global temperatures will continue to rise, putting the health and livelihoods of European populations under threat.[2,6,7] It is therefore imperative that the implementation of evidence-based adaptation measures is accelerated, with priority put to protecting health and health systems in Europe from these emerging risks.

COMMITMENT TO TACKLING CLIMATE CHANGE IN THE EUROPEAN UNION

EU has further increased its climate ambition since the ratification of the Paris Agreement (2016). Notably, EU greenhouse gas emissions were reduced by 24% between 1990 and 2019.[8] Taking into account the latest findings of the IPCC, the European Parliament (EP) declared a climate emergency in 2019, asking the European Commission (EC) to expedite action on climate change mitigation and to ensure emissions are in line with a 1.5 °C global warming limit.[9] Subsequently, in the European Green Deal the EU pledged to reach net zero emissions by 2050 and reduce greenhouse gas emissions to 55% by 2030.[10] This is supported by the EC's proposal for the first European Climate Law aiming to enshrine the 2050 climate-neutrality objective in EU law, as well as enhance adaptation efforts.[11,12]

2021: AN OPPORTUNITY FOR INCREASED AMBITION ON ADAPTATION

Looking ahead, 2021 brings a unique opportunity for accelerated progress by building on existing climate change mitigation and adaptation ambition at the global level. The United Nations Framework Convention on Climate Change (UNFCCC) 26th Conference of the Parties (COP26), scheduled for November 2021 in Glasgow, is a critical point for countries to deliver their updated Nationally Determined Contributions (NDCs), outlining commitments to long-term decarbonisation

plans to 2050. Combined with the investment and resources put into COVID-19 recovery plans, these two pivotal components offer the unique opportunity to promote "a green recovery", and ramp up ambitions for a climate resilient, healthier Europe.

EUROPEAN CLIMATE AND HEALTH OBSERVATORY

The EU is already taking further steps to recognise and act on the importance of health and climate change, by improving the knowledge base for policy change, pooling expertise and tools, facilitating learning across countries, and championing the European Green Deal, EU4Health and the new EU strategy for adaptation to climate change. A key initiative in this context is the European Climate and Health Observatory, coordinated by the EC and the European Environment Agency (EEA), and hosted on their Climate-ADAPT platform. The *Lancet* Countdown on Health and Climate Change, the European Centre for Disease Prevention and Control (ECDC), the European Food Safety Authority (EFSA), the WHO Regional Office for Europe, and the Copernicus Climate Change Service (C3S) are central partners in this initiative, contributing indicators, insights and analyses.

INVESTIGATING CLIMATE CHANGE IMPACTS ON HEALTH AND THE POLICY RESPONSE IN EUROPE

Published in line with the launch of the European Climate and Health Observatory in March 2021, this briefing is a collaborative effort from the *Lancet* Countdown and the EEA. It draws the attention of policymakers, public health professionals, and other interested parties to selected health impacts of climate change in the EU, and the health and climate change policy landscape at the European, national and local level. Drawing on scientific evidence, the report concludes by identifying further opportunities for increased ambition, with a specific focus on adaptation aimed at reducing climate-related health risks.

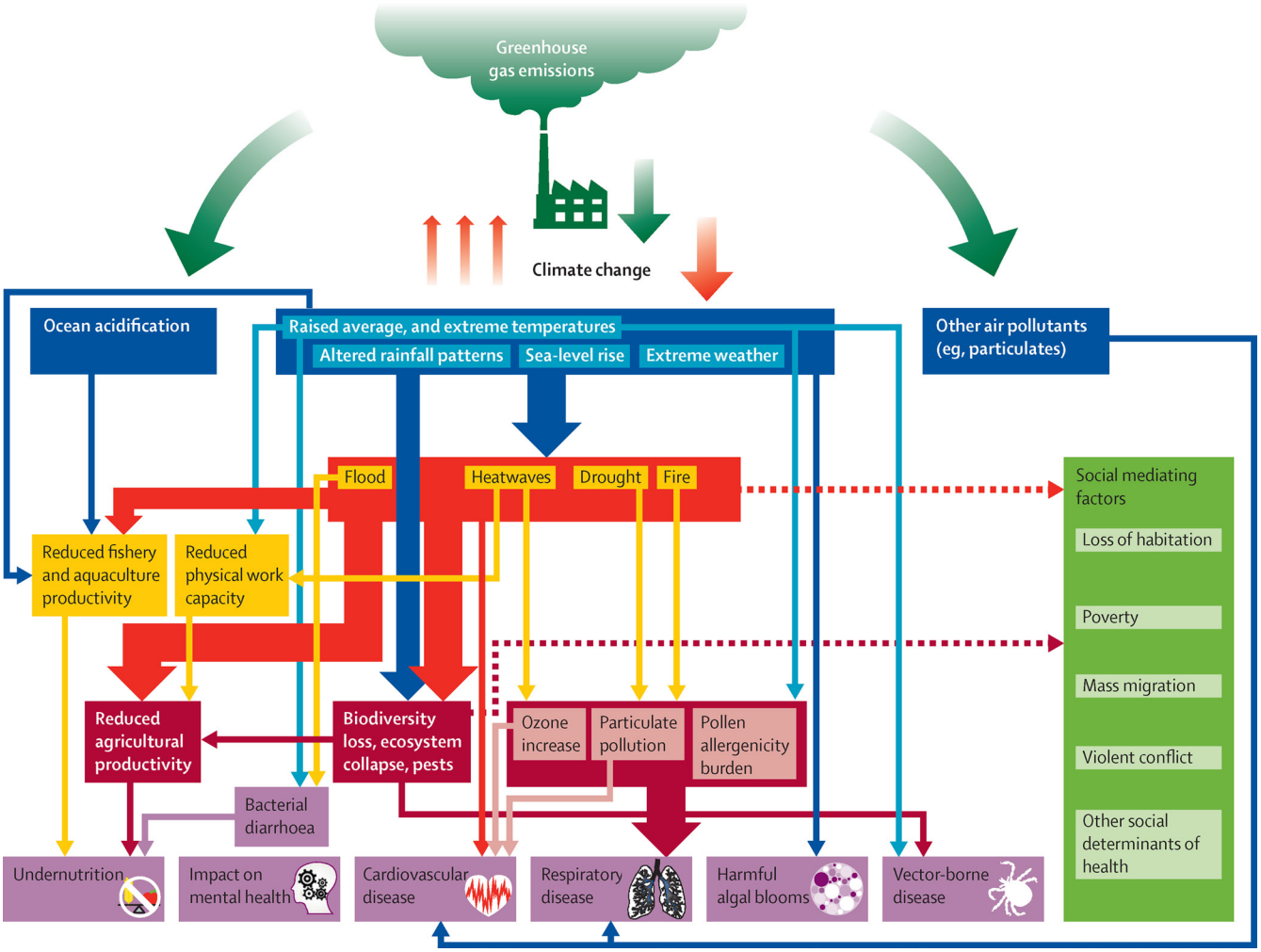


FIGURE 1. Overview of the links between GHG emissions, climate change and human health. *Figure source:* Watts *et al.*, 2015[3]

Rising temeratures

IMPACT OF CLIMATE CHANGE ON HEALTH IN EUROPE

HEAT, HEATWAVES AND HEALTH IN EUROPE

Since the end of the 19th century, long-term warming trends can be observed across the globe, including in Europe (Figure 2).[13-15] The last decade (2011-2020) was the warmest decade on record, as global mean near-surface temperatures were 1.0 to 1.1 °C higher than pre-industrial levels. In the same period, European temperatures increased even faster by 1.7 to 1.9 °C. [4,15-17] By the end of the 21st century, data from the EURO-CORDEX18 initiative projects that European land temperatures will increase further by 1.4 to 4.2 °C under intermediate emissions scenarios[i] and by 2.7 to 6.2 °C under the highest emission scenario[i], compared to the 1971-2000 period (Figure 2).[15,18]

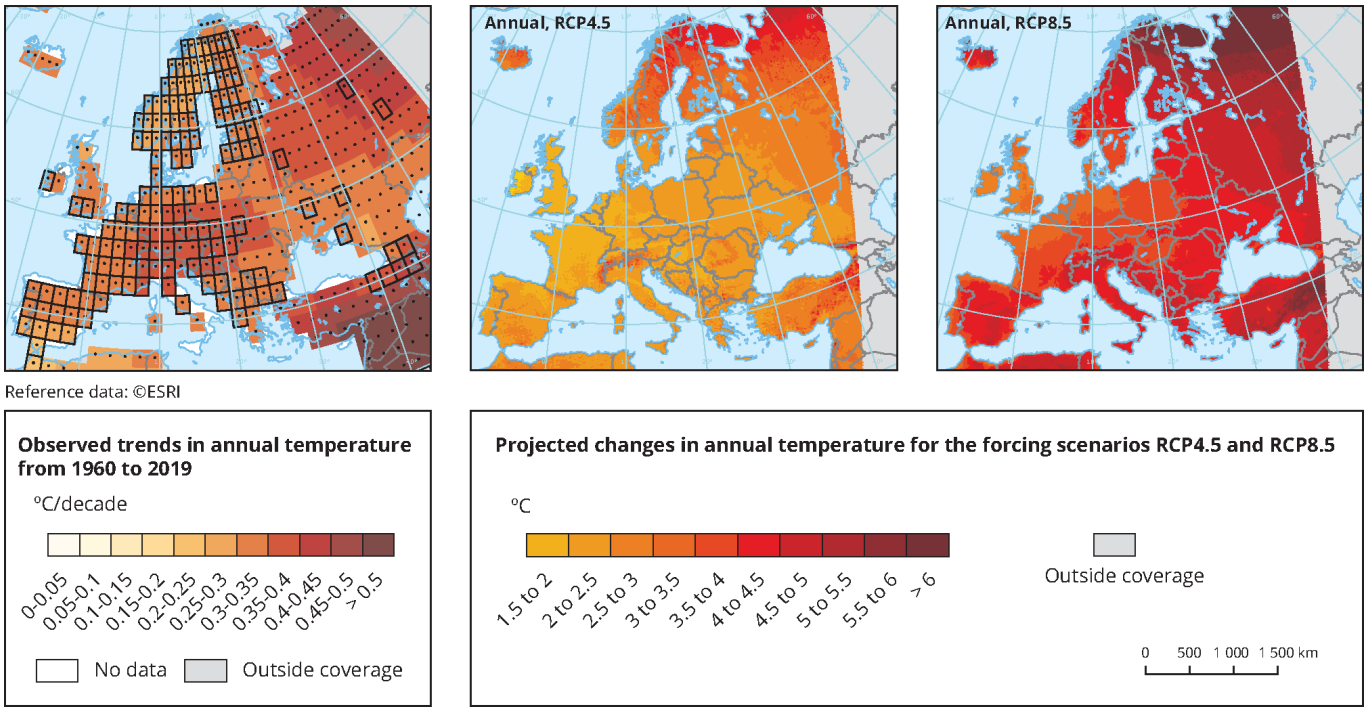


FIGURE 2. Observed annual mean temperature trends across Europe between 1960 -2019 and projected future changes under different emission scenarios. Left panel: solid black boxes contain at least three measuring stations and are therefore more representative of the grid. The black dot represents a significant ($p<0.05$) long-term trend. Right panel: projected changes in land temperature by 2071-2100 compared to 1971-2000 under the RCP4.5 and RCP8.5 scenarios[i]. *Figure source:* European Environment Agency. *Data source:* European Climate Assessment (left panel) and multi-model ensemble average simulations EURO-CORDEX initiative (right panel).[15]

Likewise in recent decades, Europe has experienced exceptional numbers of pronounced heatwave events[ii], negatively impacting local economies, human health and well-being.[2,19,20] 500-year-old temperature records were broken between 2003-2010 in over 65% of Europe[21], followed by more record-breaking heatwaves in the following decade.[2,22,23] A substantial number of recent heatwaves can be attributed to anthropogenic climate change, as shown in various detection and attribution studies over 2015-2020.[2,24] For example, evidence suggests that the 2018 Northern European

[i] Representative Concentration Pathways (RCPs) are scenarios that include time series of the full suite of greenhouse gasses, aerosols and chemically active gas concentrations describing different climate futures dependent on GHG emissions. Adopted by the IPCCC, these were originally described as RCP2.6 (GHG emissions decline by 2020, low emission scenario), RCP4.5 (GHG emissions peak in 2080 and further decline, intermediate emission scenario), RCP6 (baseline outcome) and RCP8.5 (GHG emissions continue to rise, high emission scenario).

[ii] A heatwave is defined as a climatic event equal or longer than 3 consecutive days with maximum temperature above the daily threshold.

heatwave and the 2019 Western European heatwave were at least five and ten times more likely to occur as a result of climate change, respectively.[2,23,25] Under the high emission scenario, it is projected that extreme heat waves, similar to or stronger than the 2003 heat wave, will occur in Europe every two years in the latter part of the 21st century (Figure 3).[26] Furthermore, a recent study indicated that all European metropolitan areas (EU28 plus Moscow, Oslo and Zurich) will be more vulnerable to extremes of heat in the next decades.[27]

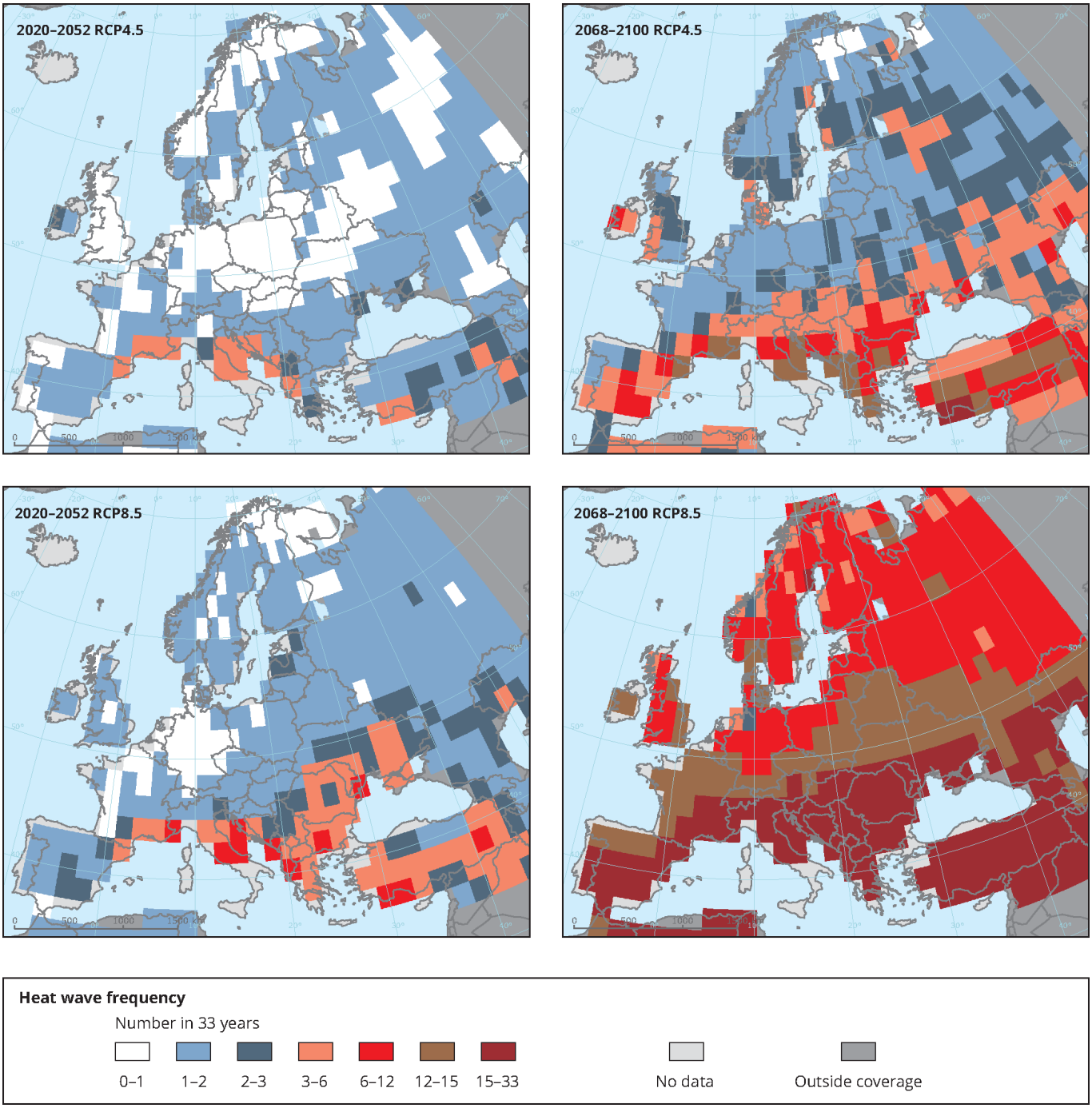


FIGURE 3. Extreme heat waves projected under RCP4.5 and RCP8.5 climate forcing scenarios in Europe. The maps show the median heatwaves projected in the near future (2020-2052) and second half of the 21st century (2068-2100) under the RCP4.5 scenario (top) and RCP 8.5 scenario (bottom). *Figure source:* European Environment Agency. *Data source:* Joint Research Centre.[26]

HEALTH IMPACTS OF HEAT IN EUROPE

Exposure to extreme heat can lead to adverse health outcomes, with increased mortality and morbidity from heatstroke, heat exhaustion and heat stress, and from the exacerbations of respiratory diseases, cardiovascular diseases, and kidney problems.[28,29] High temperatures are also associated with negative impacts on emotional and psychological health[30], increased interpersonal and group violence, and congenital and birth complications [31-34] Importantly, synergistic negative health effects from high temperatures and air pollution have been observed.[35]

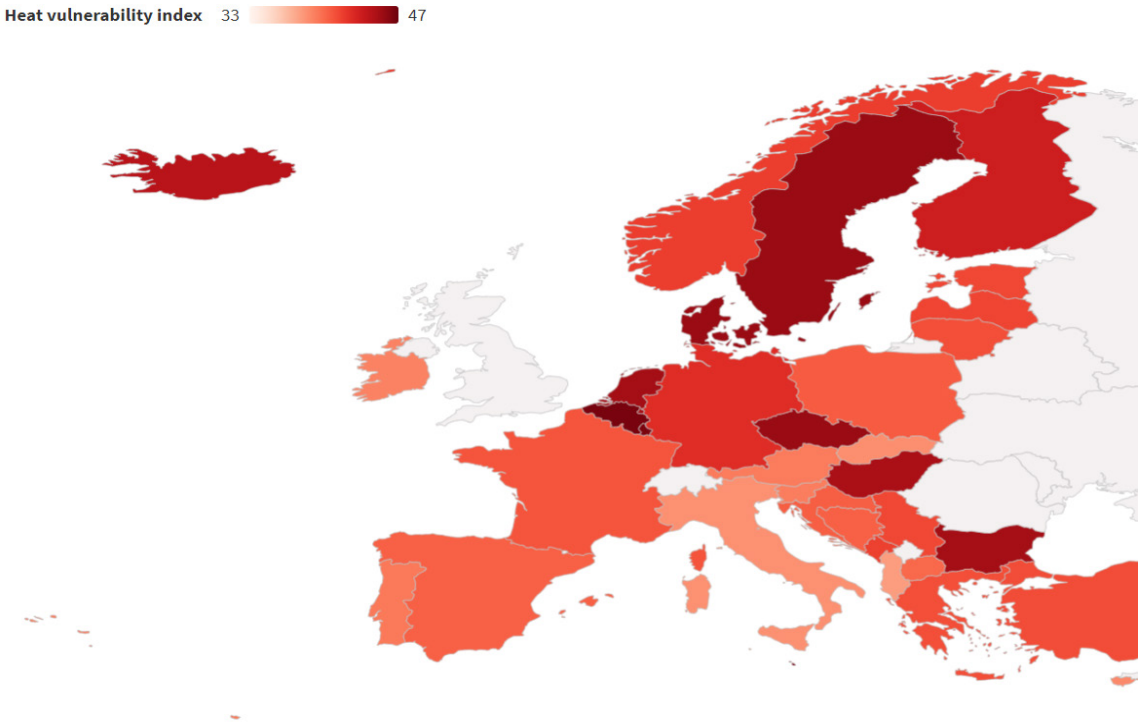


FIGURE 4. Vulnerabilities to the extremes of heat in Europe (EEA member and cooperating countries)iv in 2017. The heat vulnerability index tracks a populations vulnerability to heat using a composite index ranging from 0 (lowest) to 100 (highest). *Data from:* The ***Lancet*** Countdown, as published in Watts *et al.*, 2020.[2]

Individual risk to heat-related adverse health outcomes has increased with vulnerabilities due to e.g. old age, pre-existing conditions that affect cardiac output and skin blood flow, a lower socio-economic status, drug use, dehydration, bed confinement, social isolation, housing and neighbourhood quality.[2,36,37] In addition, heat exposure is greatest in urban areas, where the majority of the EU's population lives. This is, in part, a result of the urban heat island effect[iii] exposing city dwellers to higher temperatures than rural areas.[38] Taking this into account, the *Lancet* Countdown's heat vulnerability index (measured on a 0-100 scale at the country level), combines data on the proportion of people older than 65 years with the proportion of the total population living in urban areas, and the prevalence of chronic respiratory disease, cardiovascular disease and diabetes. According to the 2020 *Lancet* Countdown, the vulnerability to extremes of heat continues to increase in every region in the world, led by populations in Europe.[2] This is a result

[iii] The Urban Heat Island Effect occurs when natural land is replaced with dense concentrations of buildings, pavement and other surfaces that absorb and retain heat. As a result, an urban area or metropolitan area is significantly warmer than its surrounding rural areas.

of Europe's ageing populations, rising levels of urbanisation and the high prevalence of chronic diseases. In 2017, 7 out of the 10 countries with the highest heat vulnerability around the world were EU Member States, with Belgium being the second most vulnerable country in the world, with an index of 46 (Figure 4).[5] From 1990 to 2017, the heat vulnerability index increased for all European countries (Figure 5).[2]

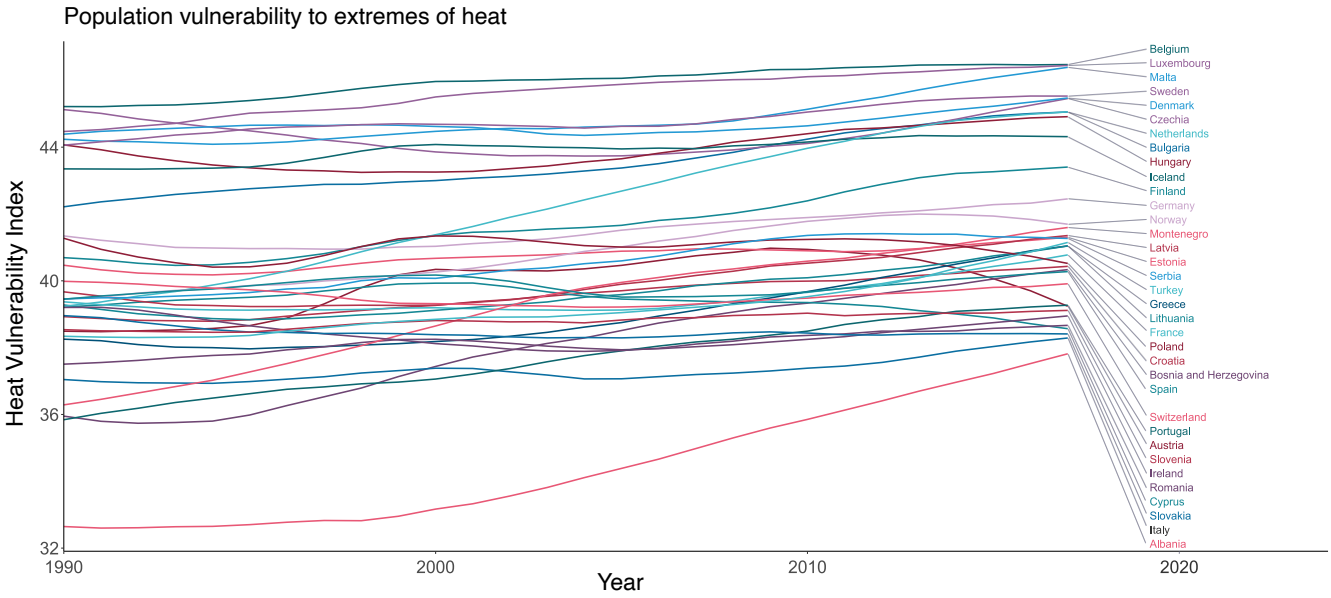


FIGURE 5. Vulnerability to the extremes of heat in Europe (EEA member and cooperating countries) from 1990 to 2017. The heat vulnerability index tracks a population's vulnerability to heat using a composite index ranging from 0 to 100. *Data source:* The *Lancet* Countdown, as published in Watts *et al.*, 2020.[2]

In terms of mortality, the heat wave of the summer of 2003 resulted in an estimated 70,000 excess deaths in Europe[1], whilst the 2015 heatwaves caused over 3,275 deaths in France alone.[39] Based on models from the 2020 *Lancet* Countdown, it is estimated that premature deaths that can be attributable to heat exposure increased globally by 53.7% in people older than 65 years from 2000 to 2018. Based on *Lancet* Countdown modelling, the WHO European region[iv] was the most affected among global regions with an estimated 104,000 premature deaths attributable to heat exposure in 2018.[2] Without increased mitigation and adaptation measures, such as heat-health action plans, climate change is bound to increase the heat-related burden of disease (mortality and morbidity) in the future.[15,40,41]

Excessive temperatures can affect the health of workers, as well as result in reduced work capacity and labour productivity – with adverse economic, social and health consequences. Temperatures above 24-26 °C are associated with a reduction in labour productivity, whilst at 33-34 °C, workers operating at moderate intensity lose up to 50% of their work capacity.[2,42] According to the 2020 *Lancet* Countdown report, 1.2 billion potential working hours were lost in association with high temperatures across Europe in 2019. Workers in all sectors are impacted, but those occupations involving a higher physical effort or those that take place outside are impacted most.

[iv] The WHO European Region comprises the following 53 countries: Albania, Andorra, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom and Uzbekistan.

European agricultural workers see the highest absolute reduction in labour capacity compared with workers in service, manufacturing and construction (Figure 6).[2] This occupational heat strain has important impacts on health and should receive increased attention in the light of climate change and the resulting rise in heat stress in coming years.[43]

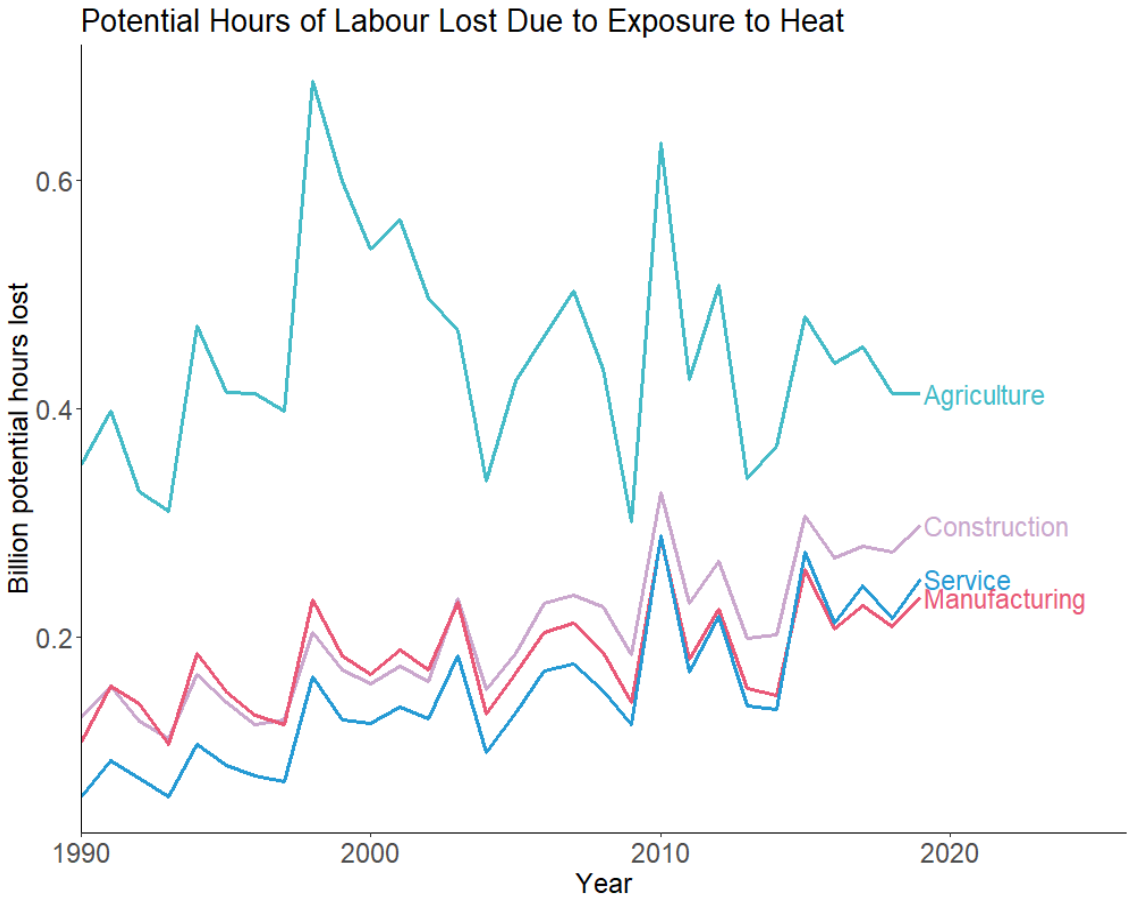


FIGURE 6. Potential hours of Labour Lost Due to Exposure to Heat in the WHO European region. Hours of work lost are calculated by linking Wet Bulb Globe Temperature with the amount of energy typically expended in agriculture, construction, service and industry. *Data source:* The *Lancet* Countdown, as published in Watts *et al.*, 2020.[2]

WILDFIRES AND DROUGHTS IN EUROPE

The intensity and frequency of extreme events, such as storms, floods, droughts, and wildfires, are changing because of climate change. This leads to many adverse outcomes on the economy, ecosystems, and human health and well-being. Extreme events can lead to injury and adverse health outcomes directly (such as increased incidence of infectious diseases following floods or drought, cardiovascular and respiratory symptoms from exposure to wildfire smoke, or impacts of floods or wildfires on mental ill health), as well as indirectly through social system disruption (for example through the disruption of health and sanitation services).[2]

WILDFIRES

Climate change, through rising temperatures and altered rainfall patterns, is leading to increased frequency and intensity of wildfire events in Europe and across the globe.[44,45] Direct exposure to wildfires can have devastating health impacts, causing burns, physical injury and heat-related illnesses (such as dehydration, heat cramps or heat stroke), which are frequently lethal.[46-48] Exposure to heavy smoke in areas near the fire can result in corneal abrasion and eye irritation[47], whilst wildfire smoke reaching populations up to thousands of kilometres from the fire can lead to the onset or exacerbation of acute and chronic respiratory disease and all-cause mortality.[46,49] Further indirect adverse health outcomes arise from socioeconomic mediators, including the loss of property, disruption of public and private services and destruction of essential infrastructure.[46] As with other extreme events, these direct and indirect exposures can result in major mental health impacts.[50]

In 2017 alone, 112 lives were lost in Portugal during two major fire incidents[48], and in 2018, more European countries experienced wildfires than ever before since records began, including several in north and central Europe. Sweden even required international assistance through the EU Civil Protection Mechanism in 2018, as it was its most severe fire season to date.[51] The 2020 report of the *Lancet* Countdown showed that Spain and Portugal were the EU countries that saw the biggest increases in human exposure to very high or extremely high meteorological wildfire risk, with an extra 11.4 and 7.1 days of exposure per person on average annually in 2016-2019 compared with 2001-2004 respectively.[2] In agreement with this, the EU's Joint Research Centre (JRC) indicated that in 2019 Spain and Portugal reported more fires than any other EU country, with 10,883 and 10,832 fires respectively. Interestingly, direct exposure to wildfires was estimated to have reduced in these countries during 2016-2019, with Portugal seeing a reduction of 33% and Spain a reduction of 1% in human exposures events to wildfires. Furthermore, there were only a few accidents and limited loss of life in 2019,[52] possibly resulting from better preparedness and a more efficient response. In addition, long time series analysis tracking burnt area in EUMED5 countries (southern France, Greece, Italy, Portugal and Spain), show a slight decreasing trend since 1980, although with high interannual variability. In contrast, meteorological fire risk has increased over the same time due to climate change. These reverse trends may mean that fire management has improved.[53]

Predictive Climate Models indicate that most of Europe may expect more severe fire weather, resulting from longer fire seasons and a substantial expansion of fire-prone areas in the future. Whilst absolute fire risk remains highest in southern Europe, western-central Europe is projected to experience the largest relative increase in fire danger risk (Figure 7).[53-55] Appropriate adaptation measures can substantially reduce these risks and limit loss of life. Importantly, as healthcare systems will suffer increasing shocks and stresses related to climate change such as wildfires interventions to build climate resilience need to be identified and implemented.

[v] Meteorological drought refers to a deficiency in precipitation, sometimes combined with increased potential evapotranspiration. Hydrological drought refers to a deficiency of water in the hydrological system, manifesting in e.g. abnormally low levels of groundwater, lakes, reservoirs and low river streamflow.[139]

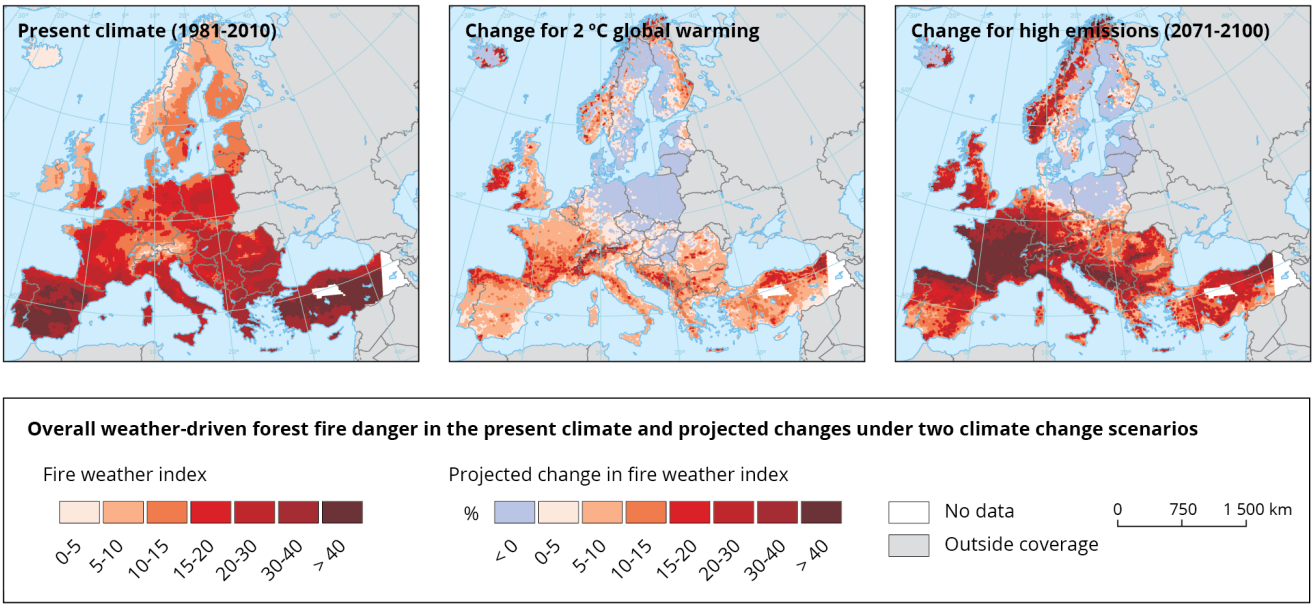
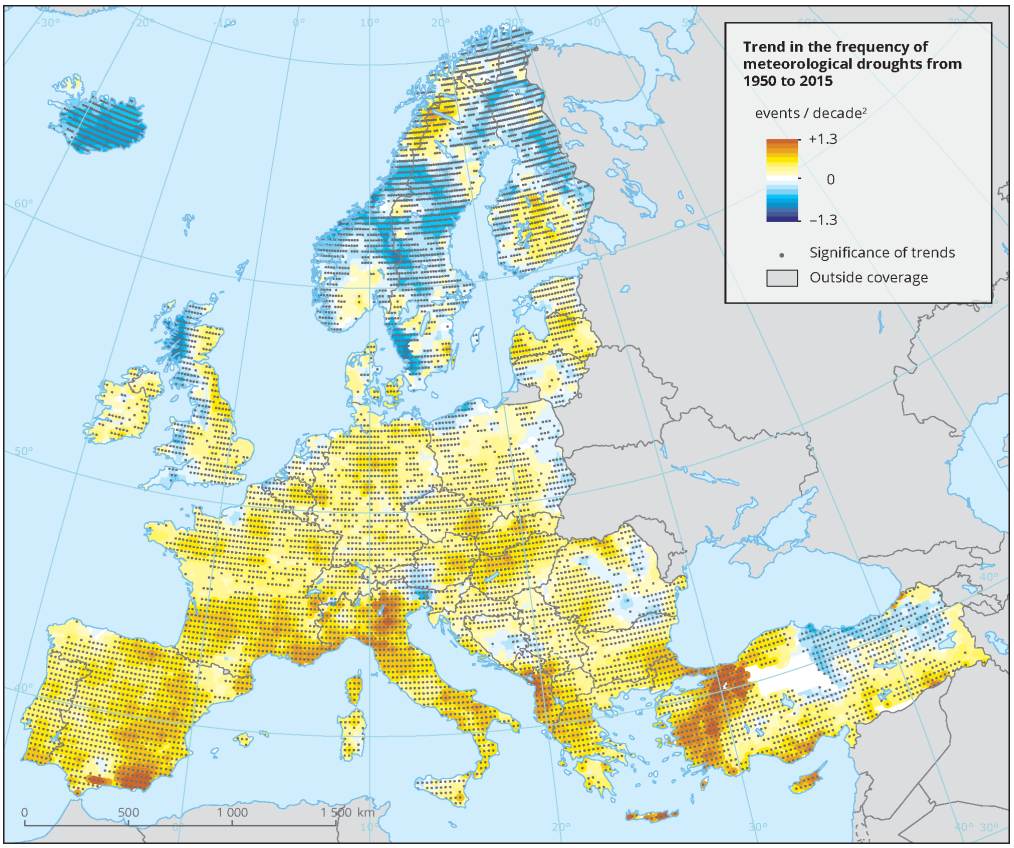


FIGURE 7. Weather-driven fire risk for current and predicted climate in Europe. The Canadian Fire Weather Index (FWI) is shown for present climate and for predicted climate (2071-2100) under two climate change scenarios (2 C° and high emissions). The FWI coverts a relative fire potential in a uniform numerical rating combining information from relative humidity, precipitation values, windspeed and local temperature. *Figure source:* European Environment Agency. *Data source:* Projections of the Fire Weather Index (PESETA III) provided by the Joint Research Centre.[53-55]

DROUGHTS

Droughts affect significant fractions of the European population yearly, both through their direct impacts on crop productivity and water supply, as well as by contributing to wildfire risk[56]. They pose multiple health risks, mediated by water shortage, reduced water quality, lower agricultural productivity and poor air quality. This can result in health outcomes such as air pollution-related cardiorespiratory impairments and nutritional risks.[57] Importantly, drought events can have adverse effects on mental health, particularly of agricultural communities because of the loss of crops, livestock and livelihoods.[58] Using the Standardised Precipitation-Evapotranspiration Index, which takes into account both precipitation and temperature-induced loss of soil moisture, the 2020 Report of the *Lancet* Countdown on Health and Climate Change estimates that meteorological drought impacted in 2018 more than twice the global land surface area than in the historical baseline years (1950-2005), with Europe being particularly affected.[2] Similar findings were made by the Joint Research Centre (JRC), using the Standardized Precipitation Index (Figure 8). Likewise, the EEA indicate that the severity and frequency of hydrological droughts also increased in most parts of Europe, with southern Europe experiencing the most severe consequences.[59,60] Under current climate trends, the patterns and duration of both meteorological and hydrological droughts are expected to change, with increases in their severity and frequency expected particularly in Southern and South-Eastern Europe (Figure 9), posing a rising threat to health, food and water systems in the region.[59,61,62]



Reference data: ©ESRI

FIGURE 8. Frequency of meteorological droughts in Europe over time (1950-2015). Hatched areas represent those where trends are statistically significant (p<0.05). *Figure source:* European Environment Agency. *Data source:* Trend in annual meteorological drought frequency provided by the Joint Research

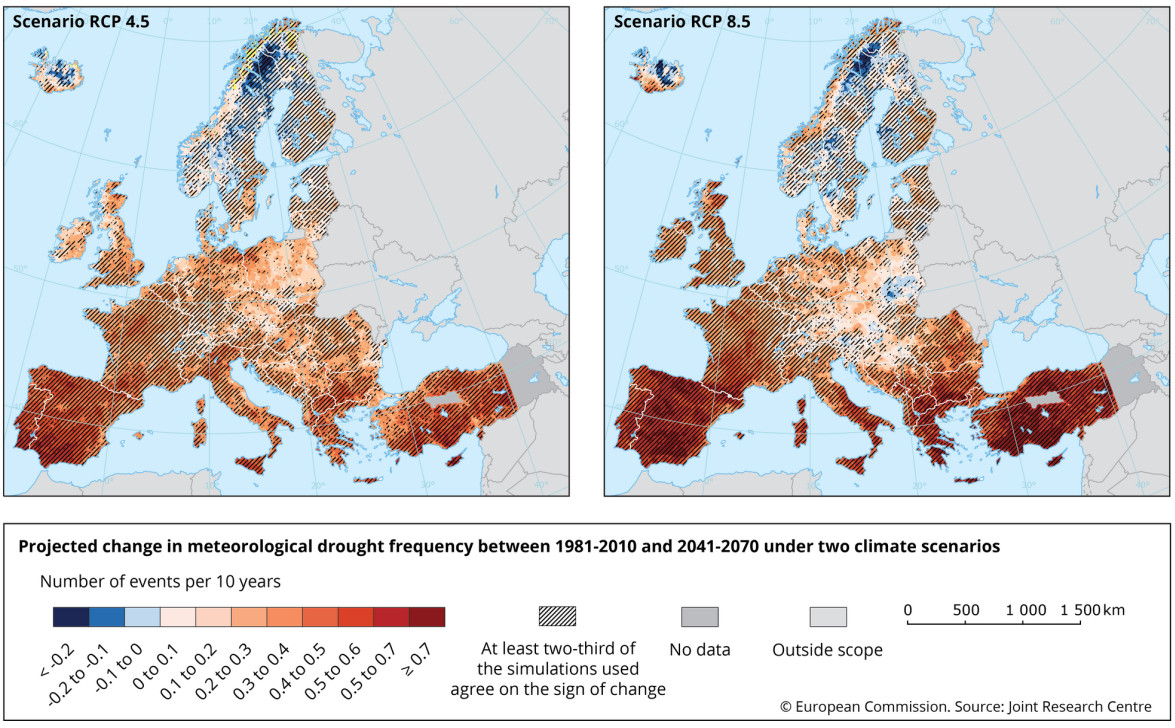


FIGURE 9. Projected change in meteorological droughts. Projections are provided for change between 1981-2010 compared with 2041-2070 for climate scenario RCP 4.5 and RCP 8.5. Lined areas reflect places where at least two-third of simulations are in accordance with the sign of change. *Figure source:* European Environment Agency. *Data source:* Trend in annual meteorological drought frequency provided by the Joint Research Centre.[59]

CLIMATE-SENSITIVE INFECTIOUS DISEASES

A number of infectious diseases are affected by climate variation, including waterborne and foodborne diseases, and diseases transmitted by arthropod vectors such as mosquitoes or ticks.[63] With respect to the latter, weather can influence the intensity and temporal pattern of arthropod vector activity, including by modifying feeding and biting rates, altering their survival, reproduction, and development, as well as by affecting the survival and reproduction of the pathogen within the vector. This is reflected by an increase in climatic suitability globally for all infectious diseases tracked by the 2020 *Lancet* Countdown report: dengue, malaria and *Vibrio* infections. This increase in climatic suitability creates the conditions for thes diseases to extend their geographic range. The global climate suitability for the transmission of dengue fever increased by 8.9% for *Aedes aegypti*, and 15.0% globally for *Ae. albopictus* from 1950 to 2018, for example.[64] Nearly half of over 50 infectious diseases that EU Member States currently have to report are directly or indirectly impacted by climate change[63] and accordingly, the European Centre for Disease Prevention and Control (ECDC) ranks climate among the most important infectious disease drivers.[64]

DENGUE FEVER

Dengue, transmitted by *Aedes spp.,* is a major global public health problem: it is the most rapidly spreading vector-borne disease, with particularly high levels of incidence in tropical and sub-tropical regions, and a steady growth in incidence at a global scale. Epidemics of dengue not only result in human suffering and lives lost, but also translate into unexpected challenges to health services, as well as significant economic losses from both increased healthcare demand and loss in labour.[65,66]

Until 1930, dengue fever was endemic in the countries of southern Europe where the vector *Ae. aegypti* was present. In 1927 and 1928, several outbreaks in Greece and Turkey affected more than a million people. After that, dengue remained undetected for decades.[67] Yet, after many years in which only a few cases were reported, dengue cases are now increasingly occurring in the WHO European Region; more than 3,000 cases in the last three years alone, principally due to imported cases and the presence of vectors for local transmission. These were largely a result of imported cases and the presence of Aedes vectors and suitable conditions for local transmission.[65] Recent locally transmitted dengue cases in Croatia[68], France[69], Spain, Italy and Portugal have shown that transmission is possible in different areas of continental Europe where *Ae. albopictus* is present.[65]

Changing rainfall patterns and rising temperatures (due to climate change) are consistently increasing the environmental suitability for dengue disease transmission in Europe, including through an expansion of the vector's environmental niches: *Ae. albopictus*, first recorded in Albania in 1979, has since then established itself in 27 countries.[70] Since other infectious diseases such as chikungunya, Zika or yellow fever are transmitted by the same vectors, the spread of these mosquitos may have impacts far beyond dengue outbreaks in the future.[71]

While the environmental suitability for dengue transmission in the region remains low, it is steadily increasing, reflecting an emerging risk for increased local transmission in the region.[72,73] The *Lancet* Countdown 2020 report shows that 2018 was the most environmentally suitable year in history for dengue transmission in the WHO European Region where the mosquito vector is present; a 40.7% increase for *Ae. albopictus* suitability compared to the 1950-1954 baseline was observed with, increasing trends in all EU countries over time (Figure 10).[2]

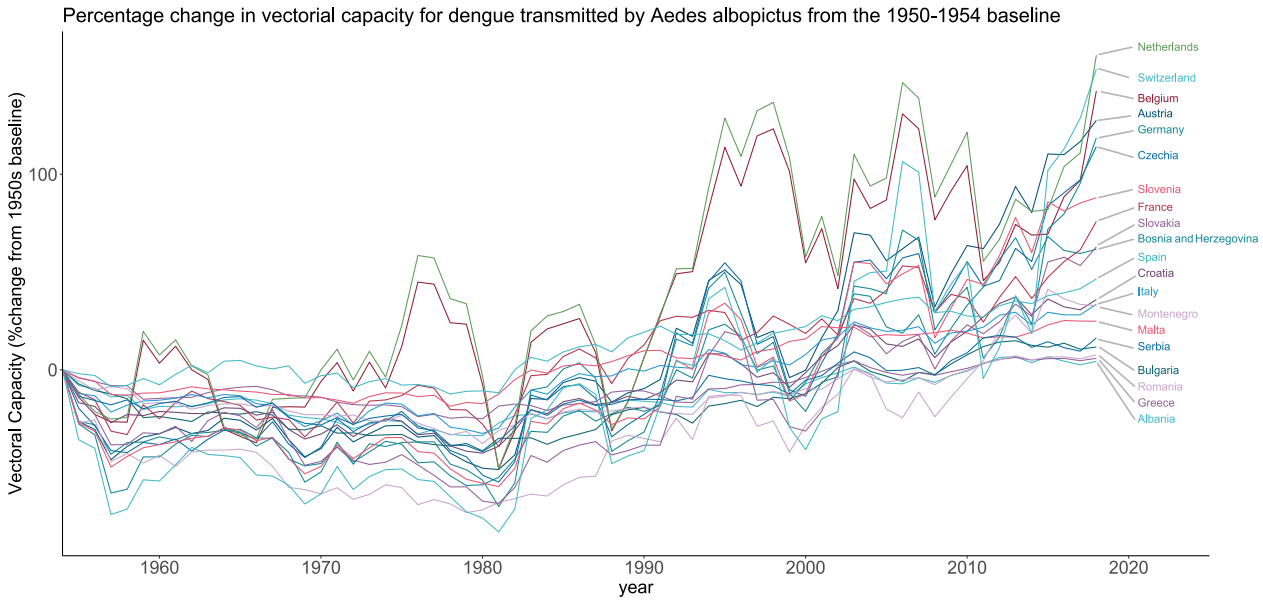


FIGURE 10. Percentage change in vectorial capacity for the dengue virus transmitted by *Aedes albopictus* from the 1950-1954 baseline to 2018 in Europe (EEA member and cooperating countries). Vectorial capacity refers to the ability of the mosquito (*Ae. albopictus*) carrying the virus to cause new infections. Only countries with the presence of *Ae. albopictus* are shown. *Data source:* The *Lancet* Countdown, as published in Watts *et al.*, 2020.[2]

VIBRIO BACTERIAL INFECTIONS

Water- and food-borne *Vibrio* bacterial infections can result in gastrointestinal, ear and wound infections, and severe sepsis, which can be fatal. These pathogens grow in warm, brackish waters, and climate-change driven alterations in sea water temperature and salinity (the latter as a result in changes in precipitation and hydrological patterns), alter its abundance, distribution, and patterns of infection.[74] The 2020 report of the *Lancet* Countdown showed that all EU countries with the exception of Ireland saw an increase in sea surface temperatures since the 1980s that would make estuarine waters more suitable for the transmission of *Vibrio* pathogens.[2]

Regionally, elevated levels of *Vibrio* have been observed during hot summer seasons in the Baltic Sea and the North Sea.[75-76] Based on the 2020 Report of the *Lancet* Countdown, the proportion of coastline suitable for the transmission of *Vibrio* bacteria in the Baltic region has increased by 61% compared to a 1980s baseline (Figure 11). This has been accompanied by an increase in the number of days suitable per year, which has doubled the length of the highest risk season to almost 100 days per year (Figure 12).[2] Accordingly, the incidence of vibriosis has exhibited a consistent increase over the past years, a trend which is expected to worsen in future years.[74]

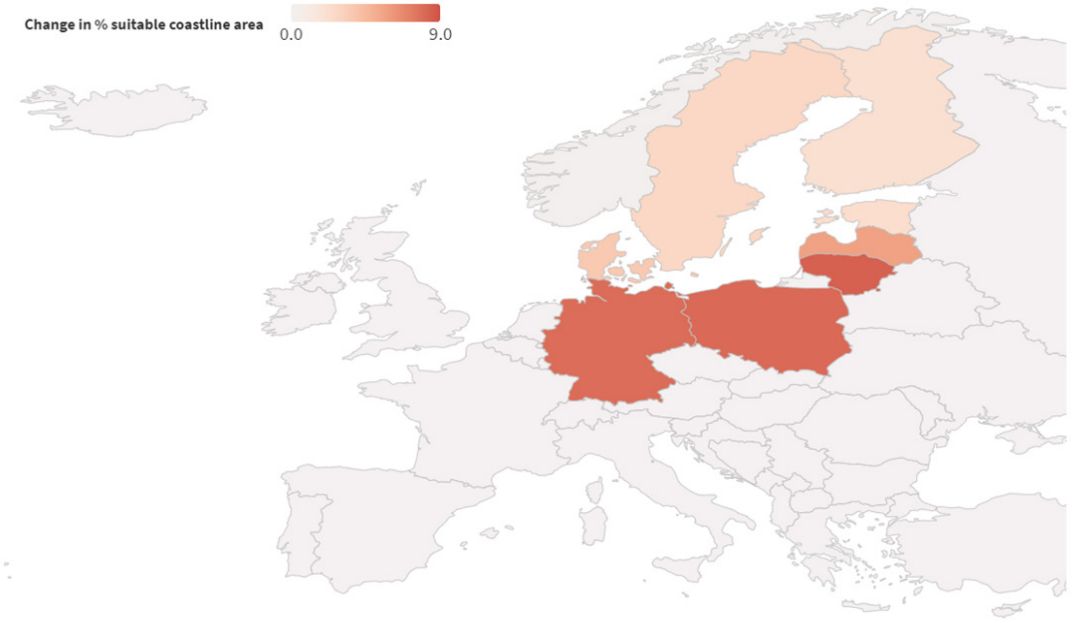


FIGURE 11. Climate suitability for *Vibrio* infections along the coastline of countries bordering the Baltic Sea. Absolute change in the percentage of suitable coastal area from 1982-1984 to 2017-2019. *Data source:* The *Lancet* Countdown, as published in Watts *et al.*, 2020.[2]

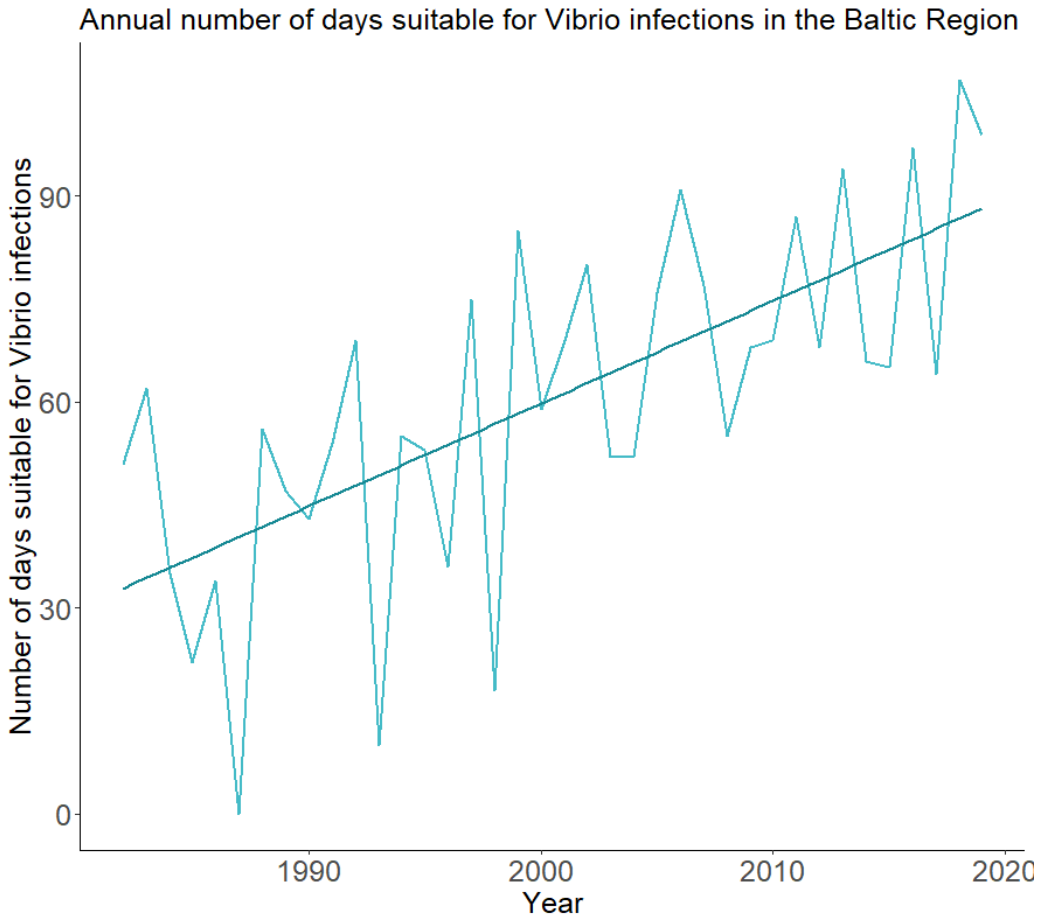


FIGURE 12. Annual number of days suitable for *Vibrio* infections in the Baltic region. *Figure source:* Watts *et al.*, 2020.[2]

OTHER INFECTIOUS DISEASES IN EUROPE

Malaria[77], chikungunya[78] and West Nile Fever[79] may likewise be increasingly transmitted in the European region. The 2010 West Nile Fever epidemic in Southeast Europe, and subsequent outbreaks, have been associated with exceptionally high temperatures in the region.[80,81] The potential expansion of leishmaniasis, caused by a protozoan parasitic infection with Leishmania infantum, from southern into central Europe has also been linked to the presence of more vector competent species (the *Phlebotomine* sand-fly) due to changes in climatic suitability.[82] Likewise, climate change is implicated in the change to elevated altitudes and latitudes observed in ticks; this includes the tick species (*Ixodes ricinus*) acting as a vector for tick-borne encephalitis and Lyme borreliosis.[77 63]

Infectious disease trends and their changes are more complex than conveyed by examining the climate suitability alone, and an exhaustive analysis of infectious disease risk also requires consideration of non-environmental factors driving their incidence (including land use, urbanization, demographics, socioeconomic development, technology, mobility patterns, and political and healthcare context)[83,84] However, the increasingly suitable climate results in a rising risk for infectious disease transmission and added pressure onto health systems and prevention programmes. Climate change has become a critical driver for infectious disease threats and its consideration must become central to the development of early warning systems, public health policies and health adaptation plans.[85]

Climate Change Adaptation and Health Policy in Europe

POLICY CONTEXT

The current and projected scale of the health impacts of the changing climate in Europe, outlined in this report, emphasises the urgent need for action to protect human lives, livelihoods and health. Adaptation to climate change is necessary both to prevent sharp increases in the burden of disease, as well as to build resilience in public health services.[41] From a policy and practice perspective, issues of climate change and health have historically been tackled by separate institutions at all governance levels, from European and national level to local administrations. Nonetheless, in recent years efforts have been made to integrate climate change and public health policy areas to prevent and respond to the devastating impacts of climate-related hazards on human health in the European context. This section provides an overview of the policy efforts in Europe to date, their effectiveness (where possible) and the outlook for the future.

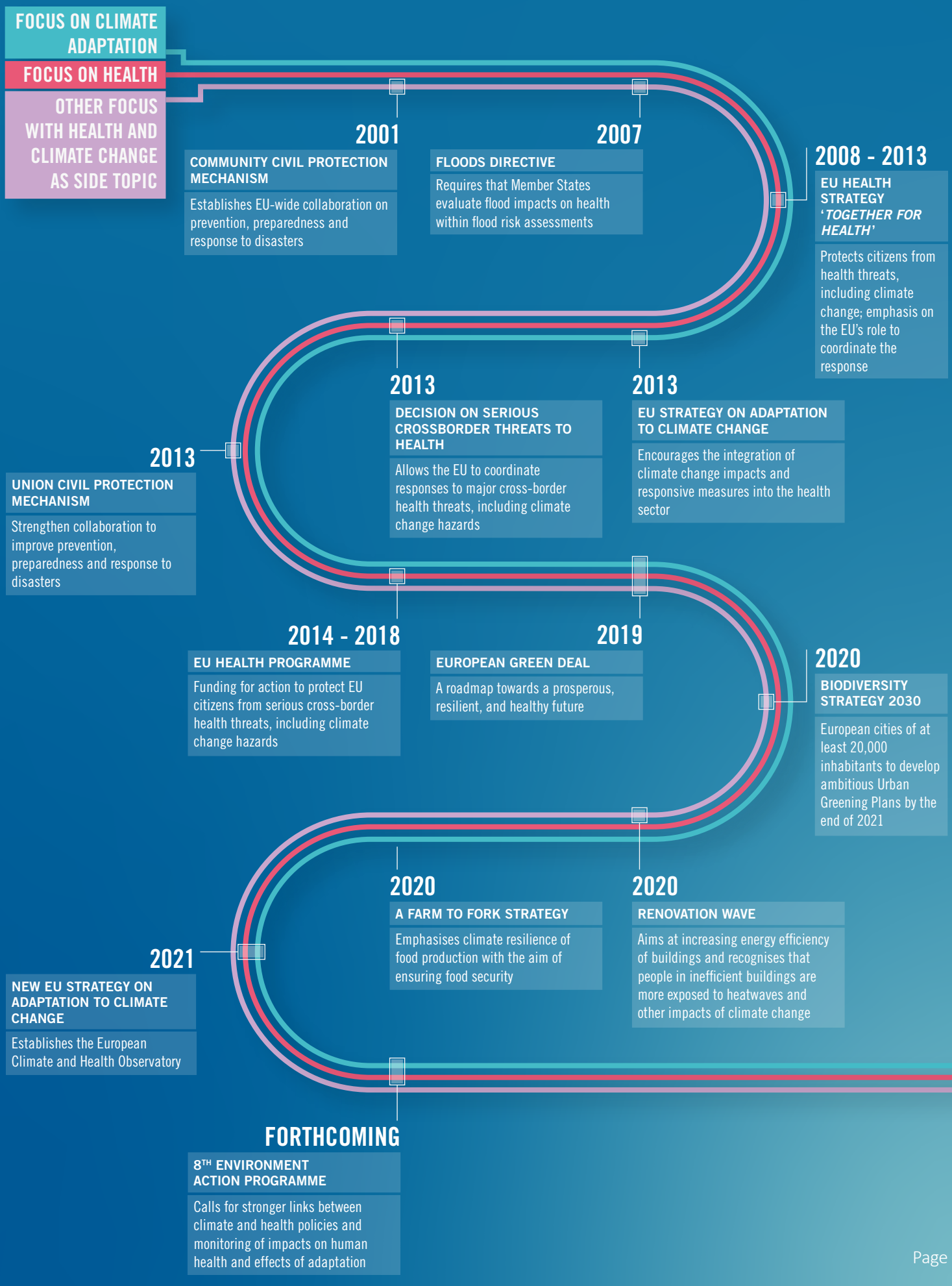
The WHO Regional Office for Europe has been advocating action on climate-related health risks since the 1990s, including through the European Environment and Health Process (EHP). The European Programme of Work 2020-2025: "United Action for Better Health"(EPW) in Europe sets out a vision of how the WHO Regional Office for Europe can support countries' health authorities towards meeting citizens' expectations to be able to thrive in healthy communities, where public health actions and appropriate public policies, including on climate change mitigation and adaptation, secure a better life and well-being.[86] Climate change and health is one of the seven priority areas of the 2017 Ostrava Declaration on Environment and Health, whereby, the 53 Member States of the WHO European Region committed to developing national portfolios of actions on environment and health.[87] Out of the 19 countries that had established their national portfolios for actions by 2019, 15 Member states identified climate change as a priority and included it in their portfolios. In the Netherlands, for example, the actions under the climate change priority include the requirement for climate stress tests to be carried out by all municipalities, a national risk analysis on drinking water supply, and measures to prevent water shortages during droughts.[88] In addition, three more countries, which did not list climate change as a priority, included climate change activities in their national portfolios.[89] While the EHP of WHO Regional Office for Europe has been instrumental in embedding climate change impacts on health in the national action planning, climate change is not among the most frequent priorities stated in the national portfolios developed to date (e.g. in comparison to air quality and chemical safety).[90]

Furthermore, WHO's manifesto for a healthy recovery from COVID-19 details six prescriptions to create a healthier society, fairer and greener, and more resilient to future outbreaks and epidemics. With the focus on "building back better" countries should address the ongoing COVID-19 pandemic whilst renewing emphasis on climate change.[91]

THE EU STRATEGY ON ADAPTATION TO CLIMATE CHANGE

In the EU, both climate change adaptation and health policies refer to climate change impacts. These are complemented by further specific policies with relevance to both climate change adaptation and public health (Figure 13).

EU POLICIES RELEVANT TO CLIMATE CHANGE IMPACTS ON HEALTH



The cornerstone of adaptive actions in the EU is the 2013 EU Strategy on adaptation to climate change. This set out a framework and mechanisms for raising the EU's preparedness for current and future climate impacts, and encouraging the integration of climate change impacts and responsive measures into the health sector.[92] The 2018 evaluation of the EU Strategy on adaptation to climate change found that whilst in general the strategy delivered on its main objectives (to promote action by Member States; 'climate-proof' action at the EU level; and support better-informed decision-making), substantial knowledge gaps remain in relation to climate change impacts on health, and adaptation is yet to be fully mainstreamed into EU health policies.[93] The evaluation report observes that in the future, the adaptation strategy could reinforce the links between public health and adaptation. Notably it can improve cross-sectoral cooperation on risk assessment and surveillance and to increase the awareness and capacity of the health sector, including at local level, to address current and emerging climate-related health risks.[94] This could be done by supporting the development and sharing of best practice and new knowledge on climate-related health risks.

Accordingly, the new EU Strategy on adaptation to climate change states the need for a deeper understanding of the climate risks for health.[95] A key development under the new strategy is the European Climate and Health Observatory[96], an initiative of the EC that aims to support Europe in preparing for and adapting to the health impacts of climate change by providing access to relevant information and tools. It also fosters information exchange and cooperation between relevant international, European, national and non-governmental actors. The observatory contains information and knowledge from multiple partners including the EC, EEA, ECDC, European Food Safety Authority (EFSA), the WHO Regional Office for Europe, the Copernicus Climate Change Service (C3S) and the *Lancet* Countdown; it is hosted by EEA on the existing European adaptation portal Climate-ADAPT.[97]

COORDINATING ROLE OF THE EUROPEAN UNION ON HEALTH

Under the Treaty of Lisbon, the primary responsibility for organising and providing health services and medical care lies with EU Member States. EU health policy therefore serves to complement national policies, and to ensure health protection in all EU policies.[98]

Nonetheless, the need for international cooperation to address health impacts of climate change is recognised in the EU. The EU health strategy 'Together for Health' emphasizes the EU's role in protecting its citizens from health threats including climate change, and in coordinating the response to such threats.[79] While this health strategy was initially developed for the period 2008 – 2013, the principles and objectives remain valid to this day and are translated into operational policies. The 2013 Decision on serious cross-border threats to health allows the EU to coordinate responses to major cross-border health threats, including those associated with climate change.[99] The EU Health Programme (2014–2020), a funding instrument to support cooperation among EU countries and underpin and develop EU health activities, included among its goals the need to protect EU citizens from serious cross-border health threats. Likewise, this includes those caused

by climate change.[99] Under the new EU strategy on adaptation to climate change, the EU will pursue cross-border health threats, in the new Health Emergency and Preparedness Agency.[95]

POLICY AND ACTIONS ON VARIOUS CLIMATE IMPACTS

To strengthen Europe's defenses against infectious disease the European Centre for Disease Prevention and Control (ECDC) was established in 2005. European countries report data from their surveillance systems to the ECDC on a regularly updated list of diseases and other sources of danger to health, including hazards related to climate change. ECDC issues assessment reports on those risks and guidance on countermeasures. Through the work of ECDC and C3S, some progress has been made in integrating climate induced diseases into the EU's common system of epidemiological surveillance, monitoring, early warning, preparedness, and response planning.[100]

In relation to extreme weather events, such as floods or forest fires, the Community Civil Protection Mechanism was established in 2001 to facilitate reinforced cooperation between the Community and the Member States in the area of civil protection in the event of major emergencies.[101] After a review of the legal framework, the Union Civil Protection Mechanism (UCPM) was established in 2013 to strengthen cooperation between the EU Member States (plus Iceland, Montenegro, North Macedonia, Norway, Serbia and Turkey) in the field of civil protection. The aim was to improve prevention, preparedness and response to disasters, including environmental disasters and acute health emergencies. The major innovation introduced in the current Mechanism is the establishment of a voluntary pool of pre-committed resources from the participating countries. Added to the UCPM in 2019, rescEU has the objective of enhancing both the protection of citizens from disasters and the management of emerging risks. In addition, rescEU establishes a new European reserve of resources such as airplanes, helicopters and medical equipment.[102] When the scale of an emergency overwhelms the response capabilities of a country, it can request assistance via the Mechanism.[103] Since 2001, the system under the Civil Protection Mechanism has been activated more than 420 times to respond to emergencies,[104] including for example the mobilization of fire-fighting personnel and equipment from seven EU countries in 2018 to assist Sweden in battling unprecedented forest fires.[51]

Regarding better prevention of and preparedness for disasters, UCPM requires that the Member States conduct comprehensive multi-hazard risk assessments at national or appropriate subnational level. The key elements of the national risk assessments are reported to the EC every three years. The interim evaluation of the UCPM in 2017 suggested that implementation of projects under UCPM improves the knowledge base on risks and prevention policies and enhanced cooperation between various actors. However, the evaluation also identified room for improvement in health and climate change adaptation. Increased coverage of these areas is anticipated in the next reporting cycles of the national risk assessments.[105]

Adaptation to climate change impact on human health is relevant to a wide range of other EU policy

areas, in which the EU competence for action is shared with the Member States, emphasizing the importance of mainstreaming both climate and health into all policies.[106] In relation to flood risk, for example, the EU Floods Directive (2007) requires that Member States carry out flood risk assessment, including the evaluation of the flood impacts on human health and life. However, there is no overview of how this is done in practice by the countries, and thus it is difficult to assess the effectiveness of this policy for reducing flood impacts on human health.

FUTURE POLICY OUTLOOK

Looking forward, the European Green Deal[107] sets out the EC's commitment to tackling climate and environmental-related challenges. It is a roadmap towards a prosperous, resilient, and healthy future. This is now even more necessary considering the severe effects of the COVID-19 pandemic on the health and economic well-being of Europeans. In line with the European Green Deal, the EU budget for 2021-27 is focussed on the recovery from the economic impacts of the COVID-19 pandemic and is boosted by NextGenerationEU- a €750 billion temporary recovery instrument to help repair the covid-19 related immediate economic and social damage.[108] Consequently, it has a strong focus on health alongside the aim of climate-neutrality by 2050 and reducing greenhouse gases emissions by 2030 by 55%, compared to 1990 levels. At least 25% of the EU budget for 2021-27 will be committed to climate action, covering both mitigation and adaptation.[109]

In addition, the proposal for the 8th Environment Action Programme calls for strengthening the links between environmental (including climate) and health policies, including by "monitoring of human health and impacts of and adaptation to climate change".[110]

The EC has proposed a new EU4Health programme to strengthen health security and prepare for future health crises.[111] The Proposal for a EU4Health Regulation intends, among others, to "contribute to tackling the negative impact of climate change and environmental degradation on human health".[112] In response to the COVID-19 pandemic, the EC announced in November 2020 the intention to build a European Health Union to strengthen crisis preparedness and response for Europe.[113] One element of this proposal is to replace the 2013 Decision on serious cross-border threats to health by a dedicated and stronger Regulation, which includes as ones of its objectives the "reinforcement of risk assessments for chemical, environmental and climate threats".[114]

A number of emerging topical policies – for example on biodiversity, energy efficiency of buildings or sustainable finance - also offer opportunities for promoting action addressing health impacts of climate change. The Biodiversity Strategy 2030 emphasises the importance of planting trees and developing green spaces as a means to cool urban areas and mitigate the impact of natural disasters such as flooding.[115] The Strategy calls on European cities of at least 20,000 inhabitants to develop ambitious Urban Greening Plans by the end of 2021. Importantly, greener cities and

towns could substantially reduce the health impacts from heat stress, while benefitting biodiversity.

The Renovation Wave Strategy aims to increase energy efficiency of buildings, recognising that people in energy inefficient buildings are more exposed to extremes of temperature causing hypothermia in winter and heat stress in summer among vulnerable populations.[116] A significant share of hazardous exposure to heat happens indoors and requires adaptation measures responding to building and dwelling characteristics, occupancy profiles and behavioural factors.[41] It is thus key to ensure that renovation actions consider the changing climate and the need to adapt to the increasing demand for cooling and withstand the extreme weather events that buildings may be exposed to in the future. The German heat health action plan, for example, recommends a number of measures preventing overheating in buildings; these could be implemented through the Renovation Wave actions.[41]

Finally, the EU taxonomy on sustainable finance, by directing more investments into environmentally sustainable activities and relating to climate change adaptation, aims to deliver a healthier and more climate-resilient living environment.[117] Systems and indicators are needed to monitor and assess whether it does.

INVESTMENT IN DEVELOPING AND EXCHANGING KNOWLEDGE

The research funding programme Horizon Europe (2021-2027) will amount to EUR 94 billion to increase European support for health and climate-related research and innovation activities.[4,109] However, it is unclear to what extent the funding would cover the areas of climate and health jointly because the way in which these themes are separated and structured within the EC hinder the joint design of research and innovation programmes.[93]

An integral part of the Horizon Europe research framework is the EU Missions, which are commitments to solve major societal challenges, including adaptation to climate change. The EU Mission on climate change adaptation, including societal transformation will operate as a portfolio of actions (research projects, policy measures or even legislative initiatives) to adapt to climate change. The proposed Mission's summary emphasises the need to protect human health and well-being from climate impacts (including high temperatures, extreme weather events and infectious diseases), through "integration of climate risks into health preparedness systems, development and adoption of early warning systems to ensure a rapid response from health services, and development of robust epidemiological surveillance and modelling tools for assessing and predicting impact of extreme events and disasters associated with climate change including impacts on mental health". The Mission has particular focus on vulnerable people - such as children, senior citizens, people with chronic diseases, and socially disadvantaged groups.[118] In addition, the Mission on climate-neutral and smart cities includes fostering a just transition to improve people's health and well-being. This includes co-benefits, such as improved air quality or healthier lifestyles,

emphasising the important nexus of climate change adaptation, mitigation and health.[119]

NATIONAL POLICY CONTEXT AND EXAMPLES

While the EU sets out a strategic framework and coordinates some actions related to climate change impacts on health, preventing and addressing the health impacts requires national and subnational policy and action. As of early 2021, all EU Member States have carried out national climate change impact, vulnerability and risk assessments and have a National Adaptation Strategy, National Adaptation Plan, or both in place.[120] According to an EEA survey in 2018, health is one of the most frequently covered sectors in national climate change impact, vulnerability and risk assessments across Europe; at the same time, health emerged as the sector in which the highest number of countries reported a need for more risk and vulnerability information to substantially improve their adaptation policies.[121]

These findings are echoed by a 2018 report from the WHO Regional Office for Europe[122] on the health coverage in national adaptation policies. Even though governance mechanisms for integrating climate action into health policy and planning seemed well established in EU Member States, awareness of the health implications of climate change was not uniform.[122] By 2018, only nine Member States in the WHO European Region directly promoted adaptation in the health sector in their national policy instruments.[93] Therefore, there continues to be a substantial gap between the recognition of the problem and the implementation of actions addressing the impacts of climate change on human health. Further information on the coverage of human health in the national adaptation policies of the EEA member countries can be found in the country profiles section of the European Climate and Health Observatory.[96] The profiles include the relevant information from the 2019 reporting on adaptation under the EU Greenhouse Gas Monitoring Mechanism Regulation (MMR reporting).[123]

In relation to addressing the risk of high temperatures discussed above, many EU countries have developed heat health action plans (HHAPs). Of a total of 35 countries participating in the 2019 survey of the WHO Regional Office for Europe,[16] indicated the existence of a national HHAP, with several more countries having established HHAPs at subnational or city level. Box 1 shows some examples of such plans collated in Climate-ADAPT platform. Additional case studies can be found in the latest WHO Regional Office for Europe report on HHAPs.[41]

The level of implementation of different core elements of HHAPs varies widely: warning systems are nearly universally fully implemented, while heat-protective long-term urban planning interventions are relatively uncommon. These plans are relatively well integrated with national climate change policies, but less so with national health, disaster/emergency or environmental policies.[41]

Similarly, various infectious diseases are monitored by the European countries and reported

to ECDC. Several European countries, including Belgium and Germany, are monitoring exotic mosquitoes, as a response to the threat that climate change poses to the transmission of mosquito-borne diseases explored above.[124] Nonetheless, a comprehensive overview of actions taken by individual countries is lacking in this respect.

Moreover, on average, only 3% of the national health budgets of EU Member States is committed to prevention and public health, under which actions related to addressing population's vulnerability to climate would be funded.[125] This raises a question about the role that public health systems can play in preventing the projected impacts from climate change on people and emphasises the importance of cross-sectoral collaborations to mobilise finance from various sources.

Adaptation planning for the health sector is crucial to ensure the continuous provision of service

BOX 1. EXAMPLES OF NATIONAL AND SUBNATIONAL HEAT-HEALTH ACTION PLANS

In **North Macedonia**, the National Heat-Health Action Plan has been developed within the National Strategy for Adaptation for the health sector to implement adaptation measures and prevent health consequences associated with extreme heat due to climate change. Its goal is to decrease morbidity connected with heat waves through issuing heat and health warnings, to encourage planning in the relevant sectors, to mainstream health in all policies, and to raise the public and health sector workers' awareness, as well as to mobilize the resources for managing the heat effects.[126]

Following the 2003 heatwave, the **Portuguese** Heatwave Contingency Plan was established and has been in operation every year from May to September, with the aim of preventing the adverse health effects of heat stress on the population during periods of elevated temperatures. Daily alerts are key to the successful implementation of this plan; they indicate what protection measures must be carried out to protect the population during periods of elevated temperatures.[127]

In **Austria**, the provinces Styria (2011) and Carinthia (2013) developed heat protection plans, based on recommendations from WHO. These informed the development of an Austrian heat protection plan, which was enacted in 2017 and led by the Ministry of Health and Woman´s Affairs, with involvement of several relevant actors on the national and provincial level. The plan sets out the connection between climate change and health as well as the meteorological baseline information for heat warnings, which is provided by the National Met Service. The information and warnings are directed to the citizen via a sound network of institutions and actors in the health field.[128]

In the **Kassel region, Germany**, the heat hotline parasol is a free of charge hotline that calls registered citizens and provides information on heat-warnings from the German Weather Service and suggest measures how to best deal with and adapt to higher temperatures and heat. With this hotline special support is provided to citizens, especially elderly and their families, to deal with heat in the urban area of the city of Kassel. The Elderly Committee of the City of Kassel and the Health Department of the Kassel region cooperates in the heat hotline parasol.[129]

The city of **Tatabánya, Hungary** has a heat and UV alert system in place. The protocol consists of a series of activities that provide advice to citizens on how to prepare for the predicted heat wave. As soon as an impending heat wave is forecast the National Medical Officer of Hungary is informed. Instructions for citizens, institutions, health care organisations and media, updated every 30 minutes, are distributed through various media channels. According to the Tatabánya Mayor's Office, an increasing number of inhabitants are now aware of what they should do during an alert.[130]

under the changing climate. In a survey conducted by the WHO Regional Office for Europe in 2017, 15 of the 20 responding countries from the WHO European Region had developed such strategies. Actions towards strengthening public health capacities and health systems to cope with impacts of climate change were reported by 19 of 20 responding countries. The examples of measures included strengthened early-warning systems and responses, infectious disease surveillance, as well as improved water and sanitation services.[131] Learning from the COVID-19 pandemic, WHO has called for climate resilient health and sustainable infrastructure, technologies and services.[91]

At the subnational level, there is no comprehensive overview of adaptation activities to climate change in Europe. In some countries, adaptation planning at the regional or local level is required by national regulations; some cities and towns act out of their own initiative on adaptation. In 2020, over 2.700 local authorities across the EEA member countries were signatories to the Covenant of Mayors for Climate and Energy, committed to adaptation action. Among the sample of local authorities acting on adaptation, investigated by the EEA, health was found to be the fourth most frequently addressed sector through adaptation actions – after water, land use planning and civil protection[vi]. At the same time, city representatives recognised that many adaptive actions have co-benefits for public health[vii].[132] However, adaptation planning and implementation at the local government level remains in the domain of the spatial planning, urban design or environmental departments. The social care and health departments or external stakeholders from the medical and social care field were involved in only a small proportion of the adaptation actions. This is somewhat surprising, as city representatives recognise that certain groups, including the recipients of social care and health care – the elderly, children, those with existing health conditions or disabilities – are more vulnerable to climate change.[132] Whilst some good examples of addressing the impacts of vulnerable groups exist (Box 2), there is a need for further involvement of public health professionals in climate adaptation planning at the local level to prevent impacts on the human health, including disproportionate impacts on the vulnerable groups. Further, actions targeted at vulnerable groups should be monitored and evaluated.[41]

[vi] Based on the analysis of planned adaptation actions reported by the signatories to the Covenant of Mayors for Climate and Energy.

[vii] Based on the reporting of 163 European cities to CDP.

BOX 2. EXAMPLES OF LOCAL ACTIONS PROTECTING VULNERABLE GROUPS FROM THE IMPACTS OF HIGH TEMPERATURES.

Supporting climate-vulnerable population groups is an overarching goal of the climate adaptation strategy of the city of **Athens, Greece**. The strategy considers socio-economic and demographic aspects in assessing the impacts of climate change. For example, it assesses the adequacy of the networks of public cooling centres and public drinking water spots by overlaying them with maps of low-income households and areas with high proportion of elderly people.

In collaboration with local authorities in **Trnava and Košice, Slovakia**, the Carpathian Development Institute assessed the residential areas' vulnerability to high temperatures, considering the presence of older people and children and the location of facilities catering for these groups. Based on the results, adaptation strategies are being implemented in vulnerable locations, including provision of trees for shading, construction and restoration of water features and actions aiming at behaviour change.

In **Paris, France**, a register called Chalex was created where vulnerable people can self-register with a free phone call. During heatwaves, they receive a phone check-up and cooling advice, with a medical professional dispatched to their home if necessary. The city made air-conditioned spaces in 20 city halls accessible to vulnerable people, and in summer 2019, the city also introduced 922 'cool islands' (parks, museums, swimming areas, public libraries and places of worship) that are free for public use. Moreover, a community of climate volunteers, set up in 2018 during the adoption of the Paris climate action plan, involves almost 27 000 people.

In **Dresden, Germany**, a housing association participating in the HeatResilientCity project upgraded three 1980s apartment blocks accommodating lower-income residents. Based on the survey results with their residents, the following measures were implemented: external shutters and new windows, roof insulation and improved night ventilation in bathrooms.

Source: European Environment Agency 2020.[132]

Climate Change Adaptation and Health Policy in Europe

POLICY OPPORTUNITIES

During the development of the 2013 EU Adaptation Strategy, the WHO Regional Office for Europe identified three policy priority areas to protect health from climate change in the EU: integrating health into policies for climate change adaptation and mitigation in other sectors, integrating climate change into policies and action for public health, and increasing awareness of and intelligence on climate change and health. Eight years on, these policy calls have not been fully achieved. Currently, there is no EU policy focused on the nexus of climate change and health. Although climate change adaptation and health policies address this nexus to an extent, there is a need for mainstreaming the interactions between health and climate change more systematically. Opportunities lie in the emerging EU policies, but also in research and action under the EU Missions, whereby health is a central topic.[122]

In 2020, the EC Group of Chief Scientific Advisors examined which adaptation measures can strengthen the European health sector in response to climate change to inform the 2021 EU Adaptation Strategy and the European Climate and Health Observatory- focusing on vulnerable groups, impact of vector-borne diseases, urban environment and impact of heat and heatwaves. They made three key recommendations: integrate human health into all climate change adaptation policies, support resilience in the health sector and design policies to support the most vulnerable social groups and geographical areas.[100]

The COVID-19 pandemic has exposed the fragility of our health systems, provided a glimpse of the profound impacts that global health crises can have on lives and livelihoods, and demonstrated the critical need for global collaborative action in protecting health and well-being of world populations. The health impacts of climate change, already being felt in Europe, will worsen in the future unless action is accelerated. While climate change acts over longer timeframes, its impacts are likely to be more profound and irreversible.[7] As with COVID-19, global collaborative action is paramount to enable a response to climate change that improves planetary health and human well-being[133]. With significant economic resources being deployed for post-COVID-19 economic recovery, and with world governments critically engaged in reducing the financial impacts of the pandemic, efforts should be focused in ensuring resources are deployed in a way that support the transition towards sustainable and inclusive societies. Climate, health, and economic objectives are not only mutually reinforcing but mutually dependent and should be considered in the next phases of COVID-19 recovery planning. Indeed, the *Lancet COVID-19 Commission* has identified "rebuilding the world economy in an inclusive, resilient, and sustainable way that is aligned with the Sustainable Development Goals (SDGs) and the Paris Climate Agreement" as one of the four main global challenges posed by the pandemic.[134] We have an opportunity to come out of this stronger and more resilient. An opportunity to unite on an evidence-based path to a zero carbon, resilient and inclusive global economy – building back greener and healthier from COVID-19.[91]

Drawing on the scientific evidence, the EU policy context, and previous recommendations of established bodies, this report concludes by identifying further opportunities for increased policy ambition, with a specific focus on adaptation aimed to reduce risks of climate related health effects.

[viii] The advisers provide independent scientific advice to the EC to inform policy making and recommendations to improve the interaction between policy-making and scientific advice. Each adviser is appointed in their personal capacity, acts independently and in the public interest.

GENERAL OPPORTUNITIES FOR ADAPTATION POLICY

- Integrate health into all European climate change adaptation policies and integrate climate change adaptation into public and global health policies.
- Integrate policy strategies with relevant governmental sectors - including housing, urban planning and transport - to leverage on the opportunity to deliver adaptation and mitigation interventions that maximise health benefits across all sectors.
- Recognise and act on health and climate change by improving the knowledge base and access to European data, collecting evidence for policy change, pooling expertise, and tools, facilitating learning across European countries and bringing the climate and health communities together - leveraging non the European Observatory on Climate Change and Health to achieve this goal.
- Further develop a knowledge base on how climate change impacts health and to what extent corresponding adaptation measures are captured in national policies, with the aim of understanding the state of implementation of relevant EU Adaptation regulations and informing priority actions.
- At the national and subnational level, facilitate the shift from climate risk and vulnerability assessments and adaptation planning to the implementation of adaptation actions through capacity building and appropriate funding with the engagement of appropriate actors.
- Strengthen the role and funding of research as the driver for problem recognition and adaptation policy innovation.

INFECTIOUS DISEASES AND EXTREME EVENTS OPPORTUNITIES

- Strengthen prevention, preparedness, and control of infectious diseases by implementing holistic policies in a European coordinated response that modernise surveillance, early warning systems and data collection.[135]
- Strengthen health system resilience by improving WHO's International Health Regulations (IHR) core capacities and taking into account the changing climatic conditions influencing infectious disease transmission.[136]
- Protect human health from the adverse impacts of heatwaves and high temperatures by adopting appropriate adaptation strategies and heat-health action plans. These should include heat–health warnings based on the temperature–health association[41], the implementation of meteorological early warning systems[137], improvement in the urban and built environment, improvement of health system preparedness and resilience, ensuring timely public and medical advice, and further measures as outlined by the EuroHEAT project.[138]
- Improve resilience and preparedness to extreme events by strengthening and maintaining disaster risk management systems, utilising climate-resilient green infrastructure, integrating projections of more intense and frequent extreme weather events in emergency planning, and continued outreach and engagement processes with citizens to ensure disaster preparedness.

COVID-19 RECOVERY OPPORTUNITIES

In the course of addressing the COVID-19 pandemic, implement 'triple win' policies and investments which stabilise the climate, protect public health, and promote economic sustainability.

REFERENCES

1. Robine JM, Cheung SLK, Le Roy S, *et al.* Death toll exceeded 70,000 in Europe during the summer of 2003. Comptes Rendus - Biol. 2008;331(2):171-178. doi:10.1016/j.crvi.2007.12.001

2. Watts N, Amann M, Arnell N, *et al.* The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises. Lancet. 2020;0(0). doi:10.1016/S0140-6736(20)32290-X

3. Watts N, Adger WN, Agnolucci P, *et al.* Health and climate change: policy responses to protect public health. Lancet. 2015;386(10006):1861-1914. doi:10.1016/S0140-6736(15)60854-6

4. Copernicus. Copernicus: 2020 warmest year on record for Europe; globally, 2020 ties with 2016 for warmest year recorded. https://climate.copernicus.eu/2020-warmest-year-record-europe-globally-2020-ties-2016-warmest-year-recorded. Accessed January 21, 2021.

5. European Environment Agency. Atmospheric greenhouse gas concentrations. https://www.eea.europa.eu/data-and-maps/indicators/atmospheric-greenhouse-gas-concentrations-7/assessment. Accessed February 13, 2021.

6. European Academies Science Advisory Council. The Imperative of Climate Action to Protect Human Health in Europe | EASAC- Science Advice for the Benefit of Europe.; 2019. https://easac.eu/publications/details/the-imperative-of-climate-action-to-protect-human-health-in-europe/. Accessed January 21, 2021.

7. Kristie Ebi, Diarmid Campbell-Lendrum, Arthur Wyns. The 1.5 Health Report: Synthesis on Health & Climate Science in the IPCC SR1.5.; 2018. https://www.who.int/globalchange/181008_the_1_5_healthreport.pdf. Accessed February 13, 2021.

8. European Commission. Progress made in cutting emissions | Climate Action. https://ec.europa.eu/clima/policies/strategies/progress_en. Accessed February 1, 2021.

9. European Parliament. The European Parliament declares climate emergency | News. https://www.europarl.europa.eu/news/en/headlines/priorities/climate-change/20191121IPR67110/the-european-parliament-declares-climate-emergency. Accessed September 9, 2020.

10. 2030 Climate Target Plan | Climate Action. https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en. Accessed January 21, 2021.

11. Europäisches Parlament [European Parliament). EU-Klimagesetz: Parlament will Emissionen bis 2030 um 60% reduzieren [EU-Climate law: parliament aims to reduce emissions by 60% by 2030]. Pressemitteilung [press release].

12. European Parliament. EU responses to climate change | News. https://www.europarl.europa.eu/news/en/headlines/society/20180703STO07129/eu-responses-to-climate-change. Accessed September 9, 2020.

13. Copernicus Climate Change Service. European State of the Climate in 2018 - Surface temperature. https://climate.copernicus.eu/surface-temperature.

14. Haylock MR, Hofstra N, Klein Tank AMG, Klok EJ, Jones PD, New M. A European daily high-resolution gridded data set of surface temperature and precipitation for 1950-2006. J Geophys Res Atmos. 2008;113(20). doi:10.1029/2008JD010201

15. European Environment Agency. Global and European temperatures. https://www.eea.europa.eu/data-and-maps/indicators/global-and-european-temperature-10/assessment. Accessed January 13, 2021.

16. van der Schrier G, van den Besselaar EJM, Klein Tank AMG, Verver G. Monitoring European average temperature based on the E-OBS gridded data set. J Geophys Res Atmos. 2013;118(11):5120-5135. doi:10.1002/jgrd.50444

17. Stocker TF, Qin D, Plattner G-K, *et al.* Climate Change 2013 The Physical Science Basis Summary for Policymakers Technical Summary Frequently Asked Questions Part of the Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. 2013.

18. Jacob D, Petersen J, Eggert B, *et al.* EURO-CORDEX: New high-resolution climate change projections for European impact research. Reg Environ Chang. 2014;14(2):563-578. doi:10.1007/s10113-013-0499-2

19. Zhang R, Sun C, Zhu J, Zhang R, Li W. Increased European heat waves in recent decades in response to shrinking Arctic sea ice and Eurasian snow cover. npj Clim Atmos Sci. 2020;3(1):1-9. doi:10.1038/s41612-020-0110-8

20. World Health Organization. Health Effects of Extreme Weather Events: WHO's Early Findings to Be Presented at the World Climate Change Conference.; 2003. http://www.euro.who.int/mediacentre/PR/2003/20030929_1.

21. Barriopedro D, Fischer EM, Luterbacher J, Trigo RM, García-Herrera R. The hot summer of 2010: Redrawing the temperature record map of Europe. Science (80-). 2011;332(6026):220-224. doi:10.1126/science.1201224

22. World Weather Attribution. Heatwave in northern Europe, summer 2018. https://www.worldweatherattribution.org/attribution-of-the-2018-heat-in-northern-europe/. Accessed January 7, 2021.

23. World Weather Attribution. Human contribution to the record-breaking July 2019 heatwave in Western Europe. https://www.worldweatherattribution.org/human-contribution-to-the-record-breaking-july-2019-heat-wave-in-western-europe/. Accessed January 7, 2021.

24. King AD, Black MT, Min S, *et al.* Emergence of heat extremes attributable to anthropogenic influences. Geophys Res Lett. 2016;43(7):3438-3443. doi:10.1002/2015GL067448

25. World Weather Attribution. Siberian heatwave of 2020 almost impossible without climate change. https://www.worldweatherattribution.org/siberian-heatwave-of-2020-almost-impossible-without-climate-change/. Accessed February 1, 2021.

26. Russo S, Dosio A, Graversen RG, *et al.* Magnitude of extreme heat waves in present climate and their projection in a warming world. J Geophys Res Atmos. 2014;119(22):12,500-12,512. doi:10.1002/2014JD022098

27. Smid M, Russo S, Costa AC, Granell C, Pebesma E. Ranking European capitals by exposure to heat waves and cold waves. Urban Clim. 2019;27:388-402. doi:10.1016/j.uclim.2018.12.010

28. Székely M, Carletto L, Garami A. The pathophysiology of heat exposure. Temperature. 2015;2(4):452. doi:10.1080/23328940.2015.1051207

29. Xu Z, FitzGerald G, Guo Y, Jalaludin B, Tong S. Impact of heatwave on mortality under different heatwave definitions: A systematic review and meta-analysis. Environ Int. 2016;89-90:193-203. doi:10.1016/j.envint.2016.02.007

30. Mullins JT, White C. Temperature and mental health: Evidence from the spectrum of mental health outcomes. J Health Econ. 2019;68:102240. doi:10.1016/j.jhealeco.2019.102240

31. Burke M, Hsiang SM, Miguel E. Climate and Conflict. Annu Rev Econom. 2015;7(1):577-617. doi:10.1146/annurev-economics-080614-115430

32. Tiihonen J, Halonen P, Tiihonen L, Kautiainen H, Storvik M, Callaway J. The Association of Ambient Temperature and Violent Crime. Sci Rep. 2017;7(1):1-7. doi:10.1038/s41598-017-06720-z

33. Konkel L. Hot Days in Early Pregnancy: A Potential Risk Factor for Congenital Heart Defects. Environ Health Perspect. 2017;125(1):A25. doi:10.1289/ehp.125-A25

34. Chersich MF, Pham MD, Areal A, *et al.* Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: Systematic review and meta-analysis. BMJ. 2020;371. doi:10.1136/bmj.m3811

35. De Sario M, Katsouyanni K, Michelozzi P. Climate change, extreme weather events, air pollution and respiratory health in Europe. Eur Respir J. 2013;42(3):826-843. doi:10.1183/09031936.00074712

36. Bouchama A, Dehbi M, Mohamed G, Matthies F, Shoukri M, Menne B. Prognostic factors in heat wave-related deaths: A meta-analysis. Arch Intern Med. 2007;167(20):2170-2176. doi:10.1001/archinte.167.20.ira70009

37. Kovats RS, Hajat S. Heat stress and public health: A critical review. In: Annual Review of Public Health. Vol 29. Annu Rev Public Health; 2008:41-55. doi:10.1146/annurev.publhealth.29.020907.090843

38. Li H, Meier F, Lee X, *et al.* Interaction between urban heat island and urban pollution island during summer in Berlin. Sci Total Environ. 2018;636:818-828. doi:10.1016/j.scitotenv.2018.04.254

39. ReliefWeb. Cred Crunch Newsletter, Issue No. 41 (February 2016)- Natural Disasters in 2015- World. https://reliefweb.int/report/world/cred-crunch-newsletter-issue-no-41-february-2016-natural-disasters-2015. Accessed January 7, 2021.

40. Martinez GS, Linares C, Ayuso A, Kendrovski V, Boeckmann M, Diaz J. Heat-health action plans in Europe: Challenges ahead and how to tackle them. Environ Res. 2019;176. doi:10.1016/j.envres.2019.108548

41. Sanchez MG, de'Donato F K V. Heat and health in the WHO European Region: updated evidence for effective prevention. WHO Reg Off Eur. 2021.

42. International Labour Orgnisation. Working on a Warmer Planet: The Impact of Heat Stress on Labour Productivity and Decent Work.; 2019. www.ilo.org/publns. Accessed January 13, 2021.

43. Kenny GP, Flouris AD, Yagouti A, Notley SR. Towards establishing evidence-based guidelines on maximum indoor temperatures during hot weather in temperate continental climates. Temperature. 2019;6(1):11-36. doi:10.1080/23328940.2018.1456257

44. Liu Y, Stanturf J, Goodrick S. Trends in global wildfire potential in a changing climate. For Ecol Manage. 2010;259(4):685-697. doi:10.1016/j.foreco.2009.09.002

45. Pechony O, Shindell DT. Driving forces of global wildfires over the past millennium and the forthcoming century. Proc Natl Acad Sci U S A. 2010;107(45):19167-19170. doi:10.1073/pnas.1003669107

46. Xu R, Yu P, Abramson MJ, Wildfires, Global Climate Change, and Human Health. N Engl J Med. 2020;383(22):2173-2181. doi:10.1056/nejmsr2028985

47. Finlay SE, Moffat A, Gazzard R, Baker D, Murray V. Health impacts of wildfires. PLoS Curr. 2012;4(NOVEMBER 2012). doi:10.1371/4f959951cce2c

48. Avaliação dos Incêndios ocorridos entre 14 e 16 de outubro de 2017 em Portugal Continental - XXI Governo - República Portuguesa. https://www.portugal.gov.pt/pt/gc21/comunicacao/documento?i=avaliacao-dos-incendios-ocorridos-entre-14-e-16-de-outubro-de-2017-em-portugal-continental. Accessed February 1, 2021.

49. Reid CE, Brauer M, Johnston FH, Jerrett M, Balmes JR, Elliott CT. Critical Review of Health Impacts of Wildfire Smoke Exposure. Environ Health Perspect. 2016;124(9):1334-1343. doi:10.1289/ehp.1409277

50. Belleville G, Ouellet MC, Morin CM. Post-traumatic stress among evacuees from the 2016 fort mcmurray wildfires: Exploration of psychological and sleep symptoms three months after the evacuation. Int J Environ Res Public Health. 2019;16(9). doi:10.3390/ijerph16091604

51. European Commission. The largest EU civil protection operation helps Sweden fight forest fires | European Civil Protection and Humanitarian Aid Operations. https://ec.europa.eu/echo/news/largest-eu-civil-protection-operation-helps-sweden-fight-forest-fires_en. Accessed January 9, 2021.

52. Europoean Commission. Forest Fires in Europe, Middle East and North Africa 2019 | EU Science Hub. https://ec.europa.eu/jrc/en/publication/forest-fires-europe-middle-east-and-north-africa-2019. Accessed January 9, 2021.

53. European Environment Agency.Forest fires. https://www.eea.europa.eu/data-and-maps/indicators/forest-fire-danger-3/assessment. Accessed October 26, 2020.

54. Wagner CE Van, Van Wagner CE, Forest P, *et al.* Development and Structure of the Canadian Forest FireWeather Index System. CAN FOR SERV, For TECH REP. 1987. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.460.3231. Accessed January 9, 2021.

55. Wu M, Knorr W, Thonicke K, Schurgers G, Camia A, Arneth A. Sensitivity of burned area in Europe to climate change, atmospheric CO levels, and demography: A comparison of two fire-vegetation models. J Geophys Res Biogeosciences. 2015;120(11):2256-2272. doi:10.1002/2015JG003036

56. European Commission. Meteorological Droughts in Europe: Events and Impacts: Past Trends and Future Projections | EU Science Hub. https://ec.europa.eu/jrc/en/publication/meteorological-droughts-europe-events-and-impacts-past-trends-and-future-projections. Accessed January 8, 2021.

57. Stanke C, Kerac M, Prudhomme C, Medlock J, Murray V. Health Effects of Drought: A Systematic Review of the Evidence. PLoS Curr. 2013;5(JUNE). doi:10.1371/currents.dis.7a2cee9e980f91ad7697b570bcc4b004

58. Vins H, Bell J, Saha S, Hess JJ. The mental health outcomes of drought: A systematic review and causal process diagram. Int J Environ Res Public Health. 2015;12(10):13251-13275. doi:10.3390/ijerph121013251

59. European Environment Agency. Meteorological and hydrological droughts in Europe. https://www.eea.europa.eu/data-and-maps/indicators/river-flow-drought-3/assessment. Accessed January 7, 2021.

60. European Commission. Science for Disaster Risk Management 2017: Knowing better and losing less | EU Science Hub. https://ec.europa.eu/jrc/en/publication/science-disaster-risk-management-2017-knowing-better-and-losing-less. Accessed January 8, 2021.

61. Spinoni J, Vogt J V., Naumann G, Barbosa P, Dosio A. Will drought events become more frequent and severe in Europe? Int J Climatol. 2018;38(4):1718-1736. doi:10.1002/joc.5291

62. Roudier P, Andersson JCM, Donnelly C, Feyen L, Greuell W, Ludwig F. Projections of future floods and hydrological droughts in Europe under a +2°C global warming. Clim Change. 2016;135(2):341-355. doi:10.1007/s10584-015-1570-4

63. Lindgren E, Andersson Y, Suk JE, Sudre B, Semenza JC. Public health: Monitoring EU emerging infectious disease risk due to climate change. Science (80-). 2012;336(6080):418-419. doi:10.1126/science.1215735

64. Semenza JC, Rocklöv J, Penttinen P, Lindgren E. Observed and projected drivers of emerging infectious diseases in Europe. Ann N Y Acad Sci. 2016;1382(1):73-83. doi:10.1111/nyas.13132

65. World Health Organisation. Global Strategy for Dengue Prevention and Control 2012–2020. World Heal Organiszation. 2012. doi:/entity/denguecontrol/9789241504034/en/index.html

66. Messina JP, Brady OJ, Golding N, *et al.* The current and future global distribution and population at risk of dengue. Nat Microbiol. 2019;4(9):1508-1515. doi:10.1038/s41564-019-0476-8

67. Reiter P. Yellow fever and dengue: A threat to Europe? Eurosurveillance. 2010;15(10):11-17. doi:10.2807/ese.15.10.19509-en

68. Schmidt-Chanasit J, Haditsch M, Schöneberg I, Günther S, Stark K, Frank C. Dengue virus infection in a traveller returning from croatia to Germany. Eurosurveillance. 2010;15(40):2-3. doi:10.2807/ese.15.40.19677-en

69. La Ruche G, Souarès Y, Armengaud A, *et al.* First two autochthonous dengue virus infections in metropolitan France, september 2010. Eurosurveillance. 2010;15(39):1-5. doi:10.2807/ese.15.39.19676-en

70. Medlock JM, Hansford KM, Schaffner F, *et al.* A review of the invasive mosquitoes in Europe: Ecology, public health risks, and control options. Vector-Borne Zoonotic Dis. 2012;12(6):435-447. doi:10.1089/vbz.2011.0814

71. Ryan SJ, Carlson CJ, Mordecai EA, Johnson LR. Global expansion and redistribution of Aedes-borne virus transmission risk with climate change. Han BA, ed. PLoS Negl Trop Dis. 2019;13(3):e0007213. doi:10.1371/journal.pntd.0007213

72. Lillepold K, Rocklöv J, Liu-Helmersson J, Sewe M, Semenza JC. More arboviral disease outbreaks in continental Europe due to the warming climate? J Travel Med. 2019;26(5). doi:10.1093/jtm/taz017

73. Suk J, Semenza J, Zeller H, Rogers DJ. The climatic suitability for dengue transmission in continental Europe. doi:10.2900/62095

74. Baker-Austin C, Trinanes JA, Taylor NGH, Hartnell R, Siitonen A, Martinez-Urtaza J. Emerging Vibrio risk at high latitudes in response to ocean warming. Nat Clim Chang. 2013;3(1):73-77. doi:10.1038/nclimate1628

75. Sterk A, Schets FM, de Roda Husman AM, de Nijs T, Schijven JF. Effect of Climate Change on the Concentration and Associated Risks of Vibrio Spp. in Dutch Recreational Waters. Risk Anal. 2015;35(9):1717-1729. doi:10.1111/risa.12365

76. Semenza JC, Trinanes J, Lohr W, *et al.* Environmental suitability of vibrio infections in a warming climate: An early warning system. Environ Health Perspect. 2017;125(10). doi:10.1289/EHP2198

77. Semenza JC, Suk JE. Vector-borne diseases and climate change: A European perspective. FEMS Microbiol Lett. 2018;365(2):244. doi:10.1093/femsle/fnx244

78. Fischer D, Thomas SM, Suk JE, *et al.* Climate change effects on chikungunya transmission in europe: Geospatial analysis of vector's climatic suitability and virus' temperature requirements. Int J Health Geogr. 2013;12. doi:10.1186/1476-072X-12-51

79. Paz S. Climate change impacts on West Nile virus transmission in a global context. Philos Trans R Soc B Biol Sci. 2015;370(1665):1-11. doi:10.1098/rstb.2013.0561

80. Paz S, Semenza JC. Environmental drivers of West Nile fever epidemiology in Europe and Western Asia- a review. Int J Environ Res Public Health. 2013;10(8):3543-3562. doi:10.3390/ijerph10083543

81. Semenza JC, Tran A, Espinosa L, Sudre B, Domanovic D, Paz S. Climate change projections of West Nile virus infections in Europe: Implications for blood safety practices. Environ Heal A Glob Access Sci Source. 2016;15(Suppl 1). doi:10.1186/s12940-016-0105-4

82. Koch LK, Kochmann J, Klimpel S, Cunze S. Modeling the climatic suitability of leishmaniasis vector species in Europe. Sci Rep. 2017;7(1):1-10. doi:10.1038/s41598-017-13822-1

83. Suk JE, Semenza JC. Future infectious disease threats to Europe. Am J Public Health. 2011;101(11):2068-2079. doi:10.2105/AJPH.2011.300181

84. Weiss RA, McMichael AJ. Social and environmental risk factors in the emergence of infectious diseases. Nat Med. 2004;10(12S):S70-S76. doi:10.1038/nm1150

85. Murray KA, Escobar LE, Lowe R, Rocklöv J, Semenza JC, Watts N. Tracking infectious diseases in a warming world. BMJ. 2020;371. doi:10.1136/bmj.m3086

86. World Health Organization. Regional Office for Europe. Europe European Programme of Work, 2020-2025-"United Action for Better Health".; 2021 (https://apps.who.int/iris/handle/10665/339209)

87. World Health Organization Europe. European Environment and Health Process (EHP) Secretariat Better Health. Better Environment. Sustainable Choices. Sixth Ministerial Conference on Environment and Health Annex 1. Compendium of Possible Action to Advance the Implementation of the Ostrava Declaration.; 2017.

88. World Health Organization. Progress in the Development of National Portfolios of Actions on Environment and Health Summary Report of Survey Results. Ninth Meeting of the European Environment and Health Task Force.

89. Rijksoverheid. National Portfolio for Action on the Environment and Health in the Netherlands 2018.; 2018. https://www.rijksoverheid.nl/documenten/rapporten/2019/01/25/national-portfolio-for-action-on-the-environment-and-health-in-the-netherlands-2018.

90. World Health Organization. Report of the Ninth Meeting of the European Environment and Health Task Force (EHTF).; 2020. http://apps.who.int/bookorders. Accessed February 3, 2021.

91. World Health Organization. WHO Manifesto for a Healthy Recovery from COVID-19- prescriptions and actionables for a healthy and green recovery. https://www.who.int/docs/default-source/climate-change/who-manifesto-for-a-healthy-and-green-post-covid-recovery.pdf?sfvrsn=f32ecfa7_8. Accessed February 14, 2021.

92. European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An EU Strategy on Adaptation to Climate Change.; 2013. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013DC0216&from=EN. Accessed January 12, 2021.

93. European Commission. Commision Staff Working Document - Evaluation of the EU Strategy on Adaptation to Climate Change.; 2018. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=SWD:2018:461:FIN&from=EN. Accessed January 12, 2021.

94. European Commission. Report from the Commission to the European Parliament and the Council on the Implementation of the EU Strategy on Adaptation to Climate Change. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2018:738:FIN. Accessed February 1, 2021.

95. European Commission. Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. Forging a Climate-Resilient Union – the New EU Strategy on Adaptation to Climate Change.; 2021.

96. European Environment Agency. European Observatory for Climate Change and Health. https://climate-adapt.eea.europa.eu/observatory. Accessed January 12, 2021.

97. European Environment Agency. Climate-ADAPT- Sharing Adaptation Information Across Europe. https://climate-

adapt.eea.europa.eu/. Accessed January 12, 2021.

98. European Commission. EU Health Policy. https://ec.europa.eu/health/policies/overview_en. Accessed January 12, 2021.

99. European Commission. Regulation (EU) No 282/2014 of the European Parliament and the Council of 11 March 2014 on the establishment of a third Programme for the Union's action in the field of health (2014-2020) and repealing Decision No 1350/2007/EC. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014R0282&from=EN. Published 2014. Accessed January 12, 2021.

100. Group of Chief Scientific Advisors. Adaptation to Health Effects of Climate Change in Europe.; 2020. https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/e885e150-c258-11ea-b3a4-01aa75ed71a1. Accessed January 12, 2021.

101. European Commission. Council Decision of 23 October 2001 establishing a Community mechanism to facilitate reinforced cooperation in civil protection assistance interventions. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32001D0792. Published 2001. Accessed February 14, 2021.

102. European Commission. RescEU | European Civil Protection and Humanitarian Aid Operations. https://ec.europa.eu/echo/what/civil-protection/resceu_en. Accessed January 12, 2021.

103. European Commission. Decision No 1313/2013/EU of the European Parliament and of the Council of 17 December 2013 on a Union Civil Protection Mechanism. Off J Eur Union. 2013. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013D1313. Accessed January 12, 2021.

104. European Commission. EU Civil Protection Mechanism | European Civil Protection and Humanitarian Aid Operations. https://ec.europa.eu/echo/what/civil-protection/mechanism_en. Accessed January 21, 2021.

105. ICF. Interim Evaluation of the Union Civil Protection Mechanism, 2014-2016.; 2017. doi:10.2795/157863

106. European Commission. Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks. Off J Eur Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32007L0060. Accessed January 12, 2021.

107. European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, The European Economic and Social Committee and the Committee of the Regions COM/2019/640. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52019DC0640. Accessed January 12, 2021.

108. European Commission. Recovery plan for Europe . https://ec.europa.eu/info/strategy/recovery-plan-europe_en#nextgenerationeu. Accessed February 24, 2021.

109. European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions- The EU Budget Powering the Recovery Plan for Europe.; 2020. https://ec.europa.eu/info/sites/info/files/about_the_european_commission/eu_budget/1_en_act_part1_v9.pdf. Accessed January 12, 2021.

110. European Commission. Environment action programme to 2030. https://ec.europa.eu/environment/strategy/environment-action-programme-2030_en. Accessed January 12, 2021.

111. European Commission. EU4Health 2021-2027 – a vision for a healthier European Union | Public Health. https://ec.europa.eu/health/funding/eu4health_en. Accessed January 12, 2021.

112. European Commission. Proposal for a Regulation of the European Parliament and of the council on on the establishment of a Programme for the Union's action in the field of health –for the period 2021-2027 and repealing Regulation (EU) No 282/2014 ("EU4Health Programme"). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020PC0405. Published 2020. Accessed January 12, 2021.

113. European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions - The EU budget powering the recovery plan for Europe - Building a European Health Union: Reinforcing the EU's resilience for cross-broder health threats. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0724&qid=1605690513438. Published 2020. Accessed January 12, 2021.

114. European Commission. Proposal for a Regulation of the European Parliament and of the Council on serious cross-border threats to health and repealing Decision No 1082/2013/EU. https://ec.europa.eu/info/sites/info/files/proposal-regulation-cross-border-threats-health_en.pdf. Published 2020. Accessed January 12, 2021.

115. European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the EU Biodiversity Strategy for 2030.; 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0380&from=EN. Accessed January 21, 2021.

116. European Commission. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on A Renovation Wave Communication Greening Our Buildings, Creating Jobs, Improving Lives.; 2020. https://ec.europa.eu/energy/sites/ener/files/eu_renovation_wave_strategy.pdf. Accessed January 21, 2021.

117. Sustainable finance – EU classification system for green investments. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12302-Climate-change-mitigation-and-adaptation-taxonomy#ISC_WORKFLOW. Accessed January 21, 2021.

118. European Commission. A Climate Resilient Europe - Prepare Europe for Climate Disruptions and Accelerate the Transformation to a Climate Resilient and Just Europe by 2030.; 2020. https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/2bac8dae-fc85-11ea-b44f-01aa75ed71a1. Accessed January 12, 2021.

119. European Commission. 100 Climate-Neutral Cities by 2030- by and for the Citizens- Publications Office of the EU.; 2020. https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/82f1df57-b68b-11ea-bb7a-01aa75ed71a1. Accessed February 1, 2021.

120. European Environment Agency. Monitoring and Evaluation of National Adaptation Policies throughout the Policy Cycle.; 2020. https://www.eea.europa.eu/publications/national-adaptation-policies. Accessed January 12, 2021.

121. European Environment Agency. National Climate Change Vulnerability and Risk Assessments in Europe 2018.; 2018. https://www.eea.europa.eu/publications/national-climate-change-vulnerability-2018. Accessed January 12, 2021.

122. World Health Organization Europe. Public Health and Climate Change Adaptation Policies in the European Union . World Health Organization; 2018. https://www.euro.who.int/en/health-topics/environment-and-health/Climate-change/publications/2018/public-health-and-climate-change-adaptation-policies-in-the-european-union-2018. Accessed January 12, 2021.

123. European Commission. Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC Text with EEA relevance. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1417431825480&uri=CELEX:32013R0525. Accessed February 14, 2021.

124. World Health Organization Europe. Public Health and Climate Change Adaptation Policies in the European Union Final Report.; 2018. http://www.euro.who.int/pubrequest. Accessed February 1, 2021.

125. European Union and OECD. Health at a Glance: Europe 2020 State of Health in the EU Cycle. 2020. doi:10.1787/82129230-en

126. Climate ADAPT. Implementation of the Heat-Health Action Plan of North Macedonia. https://climate-adapt.eea.europa.eu/metadata/case-studies/implementation-of-the-heat-health-action-plan-of-the-former-yugoslav-republic-of-macedonia. Accessed January 12, 2021.

127. Climate-ADAPT. Operation of the Portuguese Contingency Heatwaves Plan. https://climate-adapt.eea.europa.eu/metadata/case-studies/operation-of-the-portuguese-contingency-heatwaves-plan. Accessed January 12, 2021.

128. Climate-ADAPT. Operation of the Austrian Heat Protection Plan. https://climate-adapt.eea.europa.eu/metadata/case-studies/operation-of-the-austrian-heat-protection-plan. Accessed January 12, 2021.

129. Climate-ADAPT. Heat Hotline Parasol – Kassel region. https://climate-adapt.eea.europa.eu/metadata/case-studies/heat-hotline-parasol-2013-kassel-region. Accessed January 12, 2021.

130. Climate-ADAPT. Tatabánya, Hungary, addressing the impacts of urban heat waves and forest fires with alert measures. https://climate-adapt.eea.europa.eu/metadata/case-studies/tatabanya-hungary-addressing-the-impacts-of-urban-heat-waves-and-forest-fires-with-alert-measures. Accessed January 12, 2021.

131. Kendrovski V, Schmoll O. Priorities for protecting health from climate change in the WHO European Region: recent regional activities. Bundesgesundheitsblatt - Gesundheitsforsch- Gesundheitsschutz. 2019;62(5):537-545. doi:10.1007/s00103-019-02943-9

132. European Environment Agency. Urban adaptation in Europe: how cities and towns respond to climate change. 2020. https://www.eea.europa.eu/publications/urban-adaptation-in-europe. Accessed January 12, 2021.

133. Nilsson M, Ebi KL, Campbell-Lendrum D, Kone B, Friberg P. Covid-19—a rehearsal to build a greener and healthier society. BMJ. 2021;372:n127. doi:10.1136/bmj.n127

134. Sachs JD, Horton R, Bagenal J, Ben Amor Y, Karadag Caman O, Lafortune G. The Lancet COVID-19 Commission. Lancet. 2020;396(10249):454-455. doi:10.1016/S0140-6736(20)31494-X

135. Semenza JC. Cascading risks of waterborne diseases from climate change. Nat Immunol. 2020;21(5):484-487. doi:10.1038/s41590-020-0631-7

136. World Health Organization. (2016). International Health Regulations (2005), 3rd ed. World Health Organization. https://apps.who.int/iris/handle/10665/246107

137. Establishment of early warning systems — Climate-ADAPT. https://climate-adapt.eea.europa.eu/metadata/adaptation-options/establishment-of-early-warning-systems. Accessed January 10, 2021.

138. EuroHEAT. Improving public health responses to extreme weather/heat-waves – summary for policy-makers — Climate-ADAPT. https://climate-adapt.eea.europa.eu/metadata/publications/euroheat-improving-public-health-responses-to-extreme-weather-heat-waves-2013-summary-for-policy-makers. Accessed January 10, 2021.

139. Van Loon AF. Hydrological drought explained. Wiley Interdiscip Rev Water. 2015;2(4):359-392. doi:10.1002/wat2.1085