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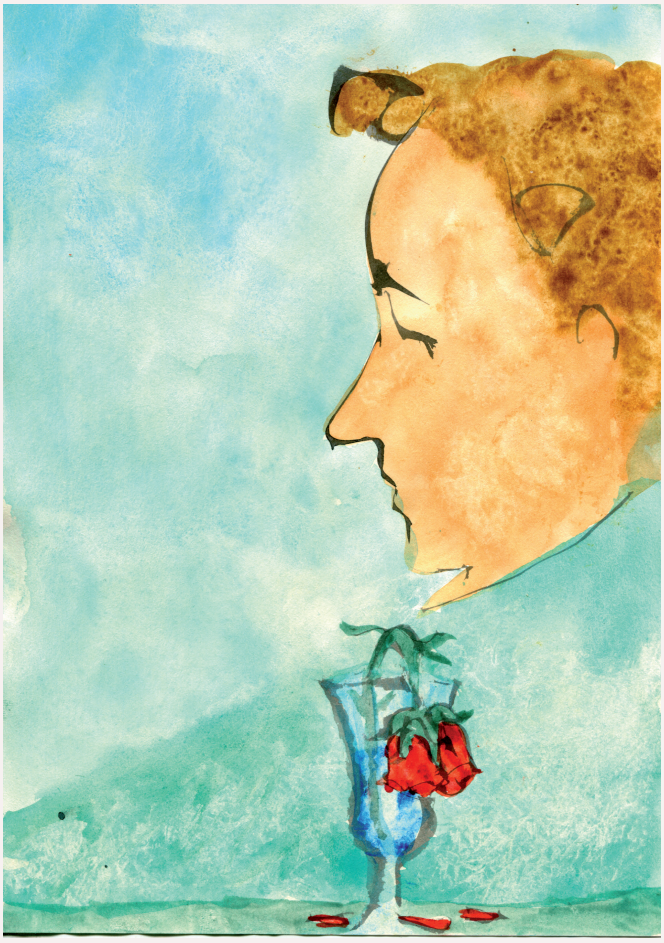
Report on climate change and health in Catalonia

A Report by the Biological Sciences Section of the Institute of Catalan Studies



Institut d'Estudis Catalans

SECCIÓ DE CIÈNCIES BIOLÒGIQUES

Report on climate change and health in Catalonia

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Informe de la Secció de Ciències Biològiques de l'Institut d'Estudis Catalans

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GENERAL CONTENTS

I. PREAMBLE

For over thirty years, there has been much talk regarding climate change, not only about its consequences, but also about our responsibility, considering that humans are highly impacting ecosystem dynamics. As early as 1988, at the initiative of the United Nations Environment Program and the World Meteorological Organization, the Intergovernmental Panel on Climate Change (IPCC) was created. The panel consists of experts on climate change and has the mission to evaluate scientific, technical and socio-economic information on the risks of climate change caused by human activity, the potential environmental and socio-economic consequences of climate change and the options for adapting to these consequences or to mitigate its effects.

Unfortunately, the political and economic powers that dominate our planet have been systematically very critical of the experts' conclusions and even more reluctant to the proposed measures. The IPCC has produced five major reports, the most recent in 2014. On the basis of these reports, various international conventions and treaties have been promoted, not without enormous difficulties. These include the Kyoto Protocol, the first international treaty to reduce greenhouse gas emissions, in force until 2020, and the subsequent Paris Agreements, which establish new measures to reduce greenhouse gas emissions after 2020. The international political community has been ratifying the treaties, with largely unequal effective measures and the systematic boycott of US governments for the consequences that the implementation of such measures would have on their economy.

In May 2019, the Generalitat de Catalunya joined the global declaration of climate and environmental emergency, an agreement that was initiated in the

United Kingdom in response to the petition of citizens and, especially, to the student movement Fridays for Future. It is, precisely, the young people who are calling for a more active position by governments to address the climate change challenge. It is necessary to move from the rhetoric commitments to the adoption of concrete measures. This is the case of environmental pollution, which severely harms life in urban areas and degrades the planet's ecosystems. To avoid this and in order to radically change the composition of the air we breathe in our cities, measures are needed aimed at mobility (traffic and circulation of vehicles, infrastructure, fuels, etc.). In our country, only a few local administrations start to be well committed to it.

More generally, however, the fact is that recent scientific information is showing that indicators of the consequences of climate change are much worse than previously thought. We are moving from a formal concern about climate change by the intellectual elite, accepted later with much reluctance by most governments in the world, to a real emergency. We need to take unavoidable measures as an ethical imperative, to which, precisely, the new generations push. "It's an emergency, science says" is one of the mottos of the student movement Fridays for Future in Spain.

With regard to human health, all available scientific information proves that climate change poses a serious threat, from the effects of changes in temperature or air pollution on mortality to diseases resulting from new epidemics of infectious origin or as a consequence of the increase in allergens to which we are exposed. In any case, there is no doubt that climate change is having a negative impact, both directly and indirectly, on the morbidity and mortality of our population, and everything seems to indicate that the current situation will worsen. Our society must therefore be aware of this, and must be concerned without delay about the multitude of direct and indirect effects that climate change has on human health.

The Biological Sciences Section of the Institut d'Estudis Catalans selected the effects of climate change on human health as the theme of the year, organizing various conferences and a workshop as well as preparing the report presented below, in which these effects are reported and evaluated always with a final view on our territory. This was done also to contribute to the awareness of the emergency. Considering the analysis carried out, it is concluded that our society must take an urgent action and it must be based on scientific knowledge.

Beyond the need to decisively face an energy transition and a substantially change in our lifestyles, as mentioned in the conclusions of this report, we must be vigilant to the problem and its evolution, we must take measures on land management and urban planning, and we need to rethink strategies in the field of public health. These are unavoidable decisions to prevent even worse conse-

quences. Not forgetting to preserve our heritage and our past, the climate change emergency and its consequences in all areas of our existence requires us to build a new future. It is about taking action in many areas, and this is an essential requirement in order to leave a reasonably livable world for future generations. It is, in short, an action of responsibility to which the Biological Sciences Section of the Institut d'Estudis Catalans wants to contribute.

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II. EXECUTIVE SUMMARY AND RECOMMENDATIONS

There is widespread consensus in the scientific community that our climate is changing and that the primary cause of these changes is the greenhouse gas emissions we pump into the atmosphere. These global and regional trends are being reproduced, and are more than evident, in Catalonia, where temperatures are increasing, precipitation levels are falling and the sea level is rising. Moreover, these changes are as equally, if not more, pronounced here than in the rest of the world.

Climate change, whether directly or indirectly through its impact on our ecosystems or socioeconomic systems, is eroding the health and well-being of Catalan society. Often what we find is the interaction of various factors attributable to climate change impacting on a patient in complex, and largely unknown, ways, undermining his or her health status. Current trends predict a worsening of the situation and an increase in health risks. The following are some of the most overt and obvious risks:

— High temperatures – especially as recorded on summer nights and as exacerbated in urban conglomerations – and heatwaves cause respiratory, cardiovascular, renal, and mental complications resulting in premature deaths.

— The precipitation regime, characterised by more droughts but also by fiercer storms, increases the risk of both wildfires and flash floods and general flooding, with their associated threats to life and health. Airborne particles from wildfires cause respiratory and cardiovascular disorders and even direct deaths. Floods increase the transmission of water-borne diseases. Rising sea levels make the coastal areas, and especially the Ebro Delta, even more vulnerable to these storms.

— Rising temperatures shift tropical species north to occupy our latitudes. Among them we find vectors of infectious disease; marine organisms that produce toxins that can provoke neurotoxic, respiratory, cutaneous and digestive disorders; and allergens from different organisms, among others.
— The interaction between levels of air pollution and the rise in temperatures increases the number of hospitalizations and premature deaths. The combination of air pollution and allergens increases respiratory disorders.
— Droughts together with rising temperatures and concentrations of atmospheric CO2 reduce agricultural and livestock yields potentially affecting human nutrition. Severe droughts elsewhere in the world can prompt major human migrations, overwhelming welfare and healthcare systems.
— The impact on health is far from uniform, being dependent on the degree of vulnerability of each sector of the population. More deaths associated with temperature rises are reported in infants and the elderly as well as in a city's poorest districts. Here, the increase in the at-risk-of-poverty rate in Catalonia is a concern, since it is a factor that increases vulnerability to the impact of climate change.

Evidence that climate change is affecting health highlights the need to take action at different levels:

— At the monitoring level to ensure the recording of all parameters of climate change in Catalonia and their effects: be they meteorological, geographical, related to public health or the appearance of new invasive species. Research into all known and possible effects of these new climate scenarios needs our full support.
— At the regional planning level so as to take into consideration the appearance of catastrophic episodes such as wildfires breaking out in places previously not at risk, storms and floods and the consequences of rising sea levels. It may eventually be necessary to relocate infrastructures affected by these phenomena.
— At the urban planning level so as to reduce episodes of high temperatures in homes during the most intense periods of heat and to introduce emergency measures to protect the most vulnerable during these episodes. The building of 'climate shelters' might be necessary.
— Within public health so as to monitor effectively the emergence of new infectious diseases and those related to food. There appears to be a need to strengthen health and food safety services to ensure they can provide accurate diagnoses and adopt appropriate measures rapidly.

These short-term measures, however, should not blind us to the need to implement those measures that have been proposed for tackling the root causes of

climate change. First and foremost, an immediate transition must be initiated towards the adoption of systems of energy production, of transportation and of industrial, agricultural, and livestock production that minimize greenhouse gas emissions. The need to reach broad social agreements that permit an energy transition to sustainable systems is a matter of considerable urgency.

Society must remain alert to technology changes that might permit new ways of producing and storing energy or of reducing carbon-rich gases in the atmosphere. We must also be aware of the lifestyle changes that might be required to face the situations that present themselves. Here, the role of the media is critical for keeping society abreast of the changing situation, its underlying causes and the measures that will have to be taken.

The Biological Sciences Section of the IEC calls on political and social agents to adopt the necessary measures to mitigate the anticipated effects of climate change and, more specifically, to reduce all types of activities responsible for them, in particular greenhouse gas emissions. The agreements reached at COP21 in Paris in 2015 are minimum objectives that must be considered unwavering. The Section also calls on Catalan society to recognize the pressing nature of the current situation and to commit to the changes that will be necessary in the near future and which will have to be implemented without delay. Ultimately, it is a matter of recognising the need to preserve the environment for future generations, one in which human life can achieve the best levels of health possible.

III. REPORT ON CLIMATE CHANGE AND HEALTH IN CATALONIA

1. Introduction

More and more studies are finding links between environmental quality, on the one hand, and health and well-being, on the other. Since the 1960s we have known that waters contaminated with chemicals can be highly toxic to health, provoking all kinds of disease, including high-mortality cancers. Likewise, every day we further our understanding of the medical problems related to the quality of the air we breathe. However, there are many factors that complicate the causal nature of these links, including the duration, intensity and frequency of exposure, our knowledge or lack of knowledge of how a specific agent behaves in a matrix of many agents and how different agents might interact, as well as just how vulnerable an individual might be to an agent or combination of agents. Despite this complexity, progress is being made and we are able to link subtle aspects of the environment, such as temperature, to health. For example, between 1980 and 2016, some 90,000 deaths were linked to climate and the weather among the countries of the European Economic Area. Most of these fatalities were associated with heatwaves that lasted for just a few days and resulted from either the direct effects of high temperature or the indirect effects of deteriorating respiratory, cardiovascular, renal, or other conditions (EEA, 2018c). In short, it has become increasingly apparent that as a society we need to concern ourselves with the multitude of direct and indirect effects that climate change has on human health.

In this report we specifically describe and evaluate these effects as they manifest themselves in Catalonia. First, we provide a brief overview of the region's meteorology and climatology and the trends observed. We then examine in detail the effects they have on health today and, based on the predicted trends, their impact

in the future. These effects are either direct or indirect via, that is, the changes undergone by the ecosystem or the socioeconomic structure.

Information in relation to these questions has been collected at a series of conferences on Climate Change and Health organized between 2018 and 2019 by the Biological Sciences Section of the Institute for Catalan Studies as well as from the scientific literature and the reports of various bodies.

2. Climate of Catalonia

In general, Catalonia's climate can be classified within what we know as the Mediterranean climate, a subtropical climate halfway between a temperate and a tropical climate. It is characterized by its relatively low rainfall of less than 800 mm per year, distributed unevenly and with significant periods of drought in summer. Its summers are hot and its winters mild, though temperatures can fall below freezing at night. Catalonia's temperature range is dominated by latitude, but its weather patterns are complex and quite varied across the region. It is influenced by cold air masses originating from higher latitudes and warm air masses from lower latitudes, while the Atlantic fronts, after crossing the Iberian Peninsula, have typically lost their strength when they reach Catalonia. The humidity and latent heat of the Mediterranean Sea that accumulates during the warmer months can generate major storms when coming into contact with cold air masses, especially in autumn. All in all, Catalonia presents a highly remarkable geographical and orographic diversity that conditions local climates, which can range from continental and oceanic to mountain or alpine in the region's highest altitudes.

3. Climate change in Catalonia

Today, there is widespread consensus that the warming of the climate system is unequivocal (IPCC, 2014) and that many of the changes observed have no precedent in millennia. At the global scale, both the atmosphere and the oceans have warmed, the amounts of snow and ice have diminished, and the sea level has risen. It seems highly probable that responsibility for these changes, above all since the middle of the 20th century, can be attributed to human actions. Among the main causes, atmospheric greenhouse gas levels stand out. Since the pre-industrial era they have increased to reach levels today that have not been recorded for at least 800,000 years. These gases trap part of the energy emitted by the earth's surface, energy which otherwise would be released into space, thus warming the globe. Atmospheric CO_2 levels have increased by 40% between 1900 and 2018. The European Union has reduced emissions since

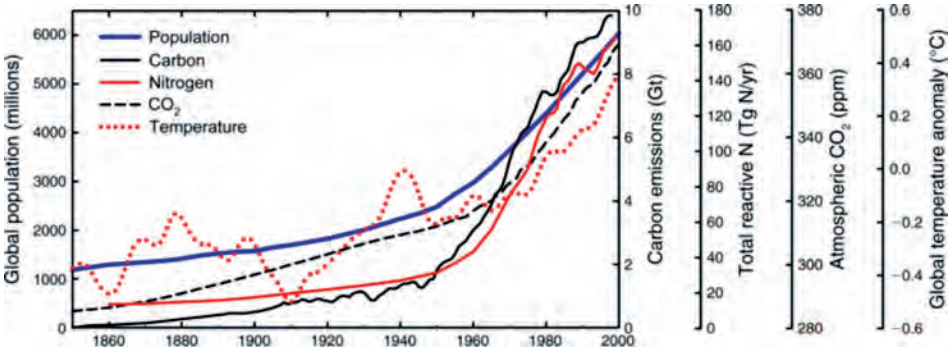

FIGURE 1. Long-term trends in the global human population, carbon emissions, reactive N produced by humans, CO_2 concentration of the atmosphere, and the global temperature anomaly. Reproduced from Smith et al. (2009), «A framework for assessing ecosystem dynamics in response to chronic resource alterations induced by global change». Ecology. 90: 3279-3289.

1990, except those related to transport, but it is still responsible for 9% of anthropogenic emissions of global CO_2 into the atmosphere, a direct cause of climate change (Fig. 1). It should be stressed this is not a problem of third-party countries but that we too continue to contribute to global warming. Within Europe, the areas most sensitive to climate change are the Mediterranean and the Arctic. We have already seen that the climate in Catalonia can be defined primarily as Mediterranean and, as such, we find ourselves in the most vulnerable area in Europe. Likewise, the high mountain climate of Catalonia, which at these altitudes presents characteristics of the Arctic climate, is also highly vulnerable to climate change trends.

3.1. Rising temperatures

Records for the average global temperature (combining, that is, land and ocean surface temperatures) between 1850 and 2012 show that the last three decades have been the hottest ever (IPCC, 2014). In fact, the decade 2008–2017 has been 0.89 to 0.93 °C warmer than the pre-industrial average, making it the hottest decade since direct records have been kept (Fig. 2). Of the 17 hottest years on record, 16 have occurred since 2000 (EEA, 2018b). In Europe, climate models project further temperature increases by the end of the 21st century relative to the 1971-2000 period of between 1.0 and 4.5 °C, depending on the atmospheric emission scenarios used (EEA, 2018b). The greatest warming is expected in northern Europe in winter and in southern Europe in summer.

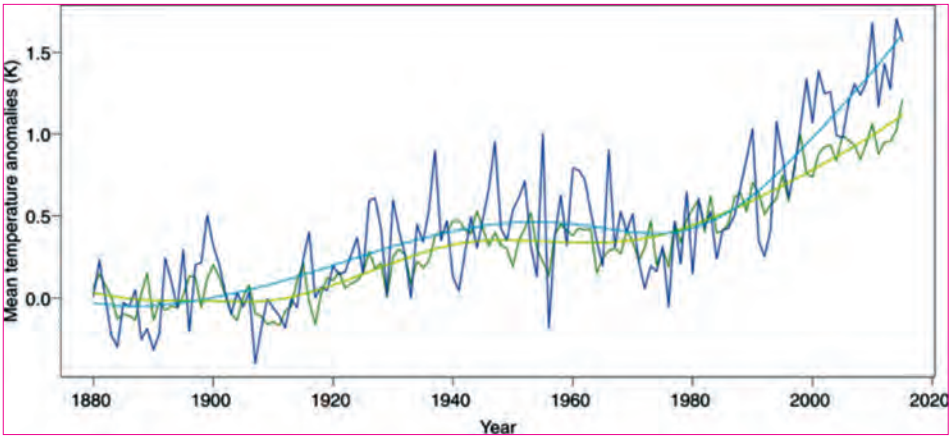

FIGURE 2. Anomalies of the average annual temperature with respect to the period 1880-1899. Curves for Mediterranean (blue) and global (green) basin data. Reproduced from Cramer *et al.* (2018).

In Catalonia, the average air temperature has increased by 0.23 degrees per decade in the period 1950–2014 (TICCC, 2016). This increase is greater than the mean global rise of between 0.18 and 0.20 °C per decade. Additionally, over the last decade, annual record temperatures have been constantly broken both globally and at home. These temperature increases are more pronounced in summer and spring and affect daily highs more than they do daily lows.

Particular mention should be made of the so-called "urban heat island". This is not a direct phenomenon of climate change but rather a consequence of human life in urban concentrations; yet, as it results in a positive temperature anomaly with respect to adjacent areas it has an additional impact on the temperature rise attributable to climate change (Moreno-Garcia, 1994). Note, however, that care needs to be taken when defining the reference area with respect to which the urban thermal anomaly is measured (Martín-Vide et al., 2015). The causes of this phenomenon are many, including the high heat capacity of building materials that store heat during the day, human population density, the decrease in evaporation due to the waterproofing of the urban land surface and the artificial channelling of water, the reduced amount of heat loss due to the reduction in wind speeds, the urban geometry that recaptures the radiation emitted by the surface into the atmosphere, and the greenhouse effect due to pollutants in the air. Above all, the urban heat island effect increases temperatures at night and on days with little wind. In the city centre of Barcelona, for example, nights are about 2 °C warmer than those 12 km away at the airport of El Prat de Llobregat.

3.2. Precipitation

A warmer global climate implies more energy – a sizeable part of which is stored in the oceans – as well as a more intense water cycle. In principle, this means a more humid climate with higher levels of precipitation; but, it does not mean that the increase in precipitation is homogeneous around the globe. In fact, what is foreseen, and what is actually being observed, is that there are regions where it rains more and others where it rains less and Catalonia and the Mediterranean Arc are among the latter.

These changes in precipitation have a lower certainty because there is considerable local variation and historical data are unreliable in this respect. In Catalonia as a whole during the period 1950 to 2014 there was a fall in precipitation of 1.2% per decade (though the data variation means this outcome is not statistically significant). Summers, however, do show a clearly statistically significant fall in precipitation of 5% per decade. There is also a reduction in winter precipitation of 1.9% per decade rising to 2.5% per decade in the Pyrenees region. If we go back to the end of the 18th century, these trends are not statistically significant, but it should be borne in mind that such analyses depend greatly on the cut-off point and the end of that century was marked by a notable number of drought episodes.

3.3. Sea level rise

As a direct result of climate change and increasing temperatures, sea levels are rising. Between 1901 and 2010, global sea levels rose by 1.7 cm per decade (IPCC, 2014). In Catalonia, between 1990 and 2017, Josep Pascual has recorded the rise in sea level in l'Estartit. He reports a significant rise of 3.1 cm per decade (Fig. 3), with a spring maximum of 3.8 cm per decade (BAIC, 2018). It should be borne in mind that part of the global temperature rise is absorbed by the oceans. With increasing temperature, water gains volume and this is the main cause of rising sea levels. To this we have to add melting glaciers and continental ice sheets. Although the ice balance in Antarctica (holding 70% of the planet's fresh water reserves) is controversial, a recent scientific study concluded that, between 1992 and 2007, the Antarctic continent lost 53 Gt of ice per year. More worrying is that between 2007 and 2017 this loss accelerated to 190 Gt per year (The IMBIE Team, 2018).

3.4. Extreme events

Since 1950, changes have been observed in extreme weather and climate conditions (IPCC, 2014). It is very likely that the number of cold days and nights has decreased and the number of warm days and nights has increased globally and

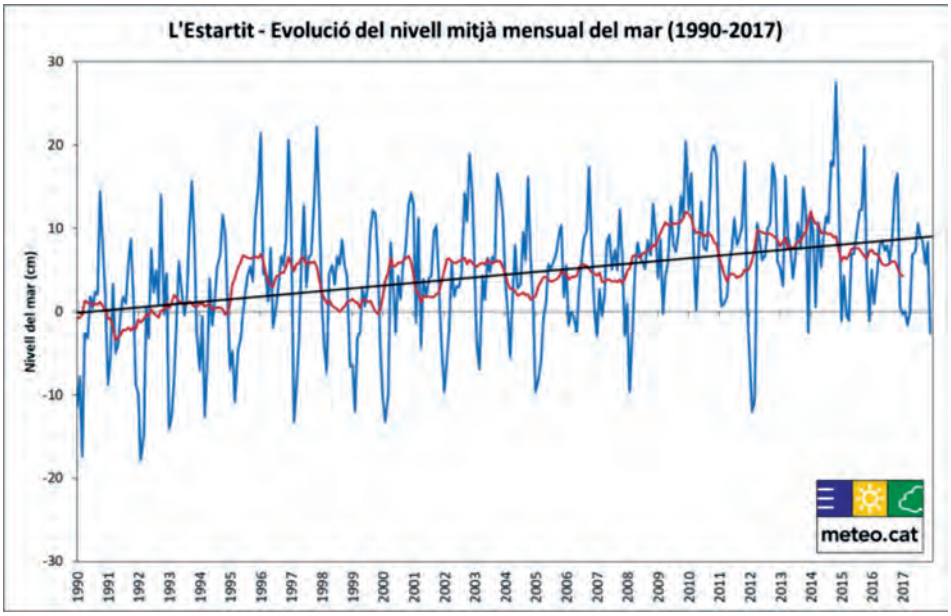

FIGURE 3. Mean sea level at l'Estartit. The red line is a 12 month mobile mean and the straight black line is the long-term trend.. Data provided by Josep Pascual. Reproduced from BAIC (2018).

Caption: L'Estartit – Monthly mean sea level over time
Vertical axis: Sea level (cm)

that these trends are all linked to climate change. The frequency of heatwaves in Europe, Asia and Australia is also increasing. Extreme events by their very nature are relatively low in frequency. This means that there are few data to analyse trends; in other words, observed trends often do not have the statistical power needed to make high probability statements. Likewise, attributing specific events to climate change trends is also complicated. However, as scientists study more cases, evidence is building up indicating that the intensity and frequency of some extreme weather events can be attributed to climate change (Otto, 2016). Thus, in 54 of 61 studies of heatwaves and forest fires, their greater intensity or frequency can be attributed to anthropogenic climate change. This high percentage falls to 54% in the case of episodes of drought and those of extreme rainfall and floods. In the case of storms, only 38% can be attributed to climate change, but it should be borne in mind that this analysis considered just eight cases (Schiermeier, 2018).

Catalonia is one of the regions of Europe in which the number of warm days – that is, those defined as being above the 90th percentile of the daily maximum tem-

perature – has increased most during the period 1960–2017 (EEA, 2018b; Fig. 4) and model projections identify it as being one of the areas where the frequency of extreme heatwaves is increasing most (EEA, 2018b, Fig. 5). For the second half of the 21st century, it is projected that extreme heatwaves in Europe will be just as intense, or even more so, than those experienced since 2000, and that their frequency will increase (EEA, 2018b). The greatest impacts are projected to be recorded in southern Europe.

4. Effects of climate change on human health

To address the effects that the different components of climate change have on human health, we first have to understand that the natural and anthropized environment have an impact on our health. We know for certain that repeated and prolonged exposure to solar radiation (because of its ultraviolet radiation component) is the primary cause of some skin cancers (especially basal and squamous cell carcinomas). Likewise, paradigmatic examples of environmental effects of anthropogenic origin are the contamination of freshwater by pesticides in the mid-20th century and air pollution, in response to which the US in-

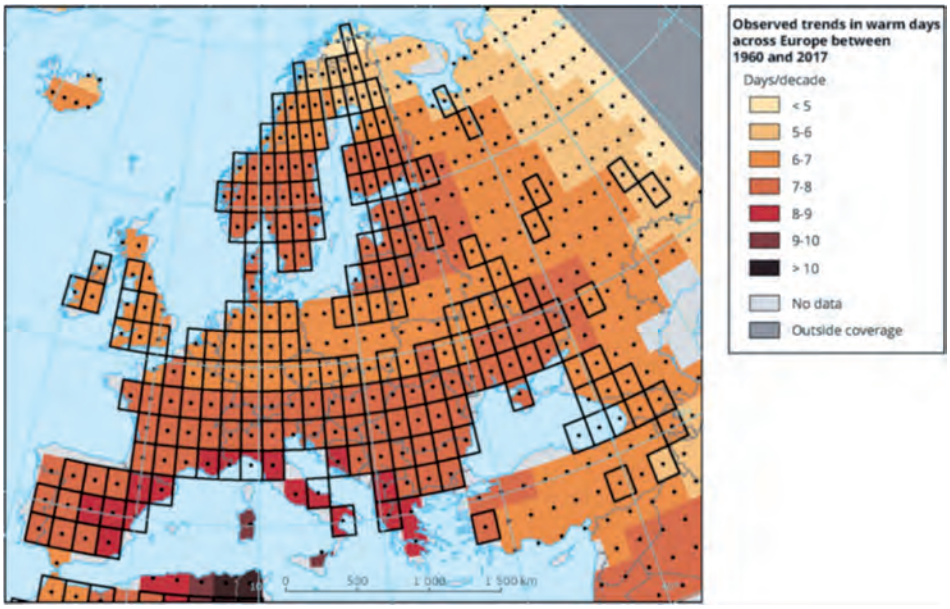

Figure 4. Observed trends in warm days across Europe between 1960 and 2018 (EEA, 2018b).

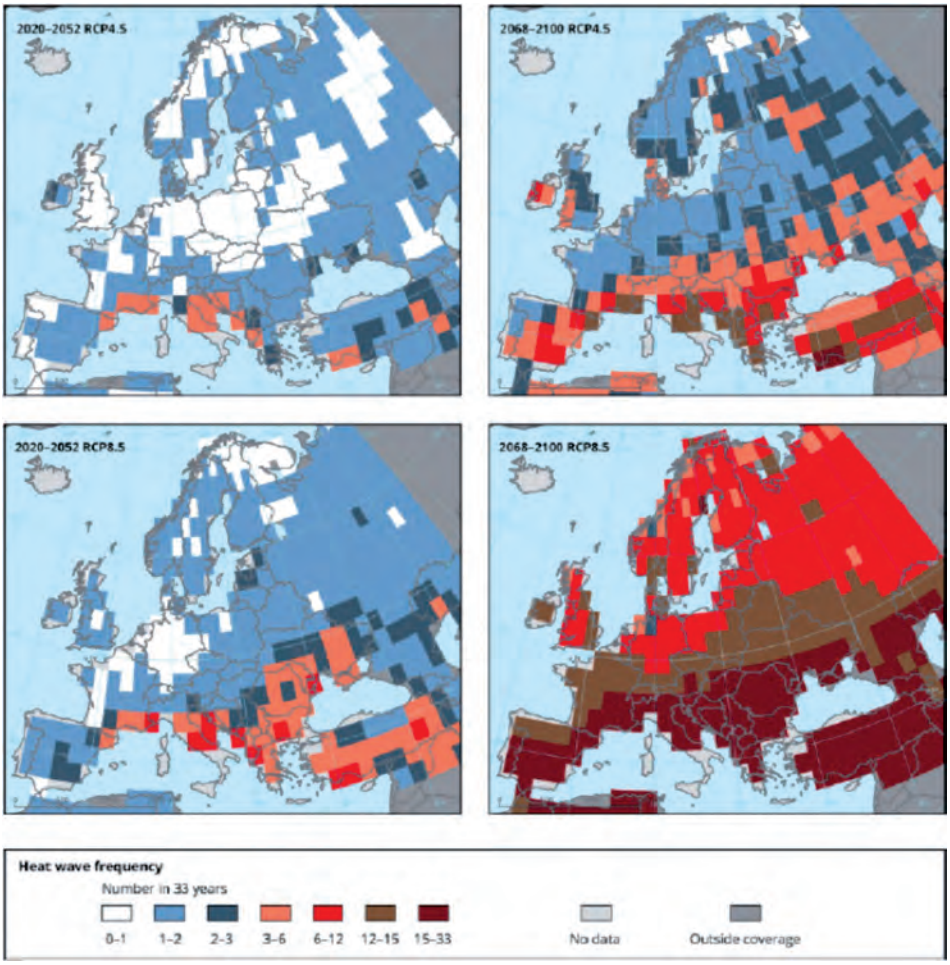

FIGURE 5. Median of the number of extreme heatwaves in future climates under two different climate forcing scenarios. Maps in top panel s under the Representative Concentration Pathway (RCP) 4.5 scenario; maps in lower panels under RCP8.5. Left-hand panels correspond to period 2020-2052; right-hand panels correspond to period 2068-2100. Extracted from EEA (2018b).

troduced, respectively, the Clean Water Act of 1972 (though the bases were enacted as early as 1948) and the Clean Air Act of 1990. This legislation requires the implementation of measures to reduce the impacts of human activity on the environment because otherwise we run the risk that they will be detrimental to our health (e.g. cancers, toxicities, infectious diseases, etc.). Wastewater treat-

ment is a direct and understandable consequence of this legislation, which has been extended to all developed countries, although much of the world remains unprotected.

Human actions have a clear impact on climate change, and, like other human-induced environmental changes, these changes also have an effect on our health. This impact can range from subtle changes in people's well-being and minor complaints to severe illnesses, the shortening of life expectancies and may even result directly in death. Here, we can distinguish between direct effects caused by the components of climate change described above and indirect effects caused by global changes to other agents, both natural or ecosystemic and socioeconomic, which in turn affect our health.

4.1. Direct effects

The direct effects of climate change on health are primarily related to the consequences of a rise in temperature on the human body, an increase in extreme weather events and rising sea levels, which can cause all kinds of fatalities.

4.1.1. Effects of temperature

Humans are endothermic organisms that regulate their body temperature within a very narrow range (between 35.5 and 37 °C). Owing to temperature differences with the environment, our body temperature regulation mechanisms can be placed under too much stress, which is when we might enter a state of hypothermia or hyperthermia – that is suffer a heat stroke – which can be fatal. In addition to this extreme effect on the body, increases in mortality have been observed with high temperatures in relation to cardiovascular and respiratory diseases, nervous system disorders, diabetes and kidney diseases (Basagaña et al., 2011). The 2003 heatwave in Europe was estimated as being directly responsible for the premature death of about 70,000 people (Robine et al., 2008). Most deaths associated with heat waves are concentrated in southern and south-western Europe. In Spain, 3,166 deaths were estimated as having been caused by the 2003 summer heatwaves (Simón et al., 2005). According to Basagaña et al. (2011), each year in Catalonia about 300 deaths can be attributed to high temperatures. About 40% of these deaths occur in periods of high temperatures that are not, however, defined as heatwaves. A more recent global study estimates that, between 2000 and 2016, 125 million adults were vulnerable to the effects of heatwaves (Watts et al., 2018). The populations most at risk are the elderly, children, pregnant women, outdoor workers and the socially marginalized.

In addition to heatwaves, the increase in mean temperatures worsens pre-existing cardiovascular and renal diseases. Tropical nights – when the minimum temperature stays above 20 °C – are also a trigger of heat-related symptoms. The Ebro and Fabra Observatories today record 26 and 23 more tropical nights, respectively, than at the beginning of the 20th century (TICCC, 2016). The urban heat island phenomenon, in a society that lives predominantly in large population centres, only accentuates the risk of high nocturnal temperatures, which, in turn, can also affect sleep patterns. Indeed, sleep disorders are a risk factor for those with cardiovascular disease (Obradovich et al. 2017).

4.1.2. Effects of torrential rain and floods

Globally, extreme weather events have accounted for about 90% of natural disasters over the last 20 years. Between 1990 and 1996, a total of 2,843 such episodes were recorded, affecting 408 million people and killing 505,013 (Watts, 2018).

If the climate is to suffer more frequent and intense weather events, this is likely to trigger a series of grave situations for human health and physical integrity. Catalonia, above all in its coastal and pre-coastal areas, is susceptible to torrential rains, often resulting in violent flash floods, albeit generally of short duration. Note that the risk of flooding is high in 40% of Catalan municipalities (Llasat et al., 2009). Each year, these episodes result in a number of deaths in addition to cause injuries, infections, poisoning, and cardiovascular and mental problems. The increasing waterproofing of the land surface and the construction of homes in river beds in areas where floods have a statistical return period of 100 years are risk factors that are likely to increase the number of affected people in a scenario marked by the increasing intensity and frequency of extreme rains.

However, globally there is no clear trend towards an increase in the number of deaths as extreme weather events increase. This is due to improved capacity for disaster control and response, especially in poor countries (Watts, 2018). Yet, the numbers of non fatal injuries look certain to increase.

4.1.3. Effect of rising sea levels

There are areas in Catalonia, such as the low-lying Ebro Delta, where the rise in sea level will represent a serious challenge to any hopes of preserving the coastline. If the sea level were to rise by 1 m, much of the Ebro Delta would be submerged (TICCC, 2016). In other places, a rise in the mean sea level will place the coast and its infrastructures, including boardwalks, promenades, houses,

ports and the like, at risk of being affected by storms (especially, by the north-easterly gales known locally as *llevantades*), which have been known to result in deaths. In January 2017, the Catalan coast, but also the Valencian coast and the Balearic Islands, suffered a particularly violent storm during which the waves reached record heights. As with other effects of climate change, the level of prevention and adaptation of our society will surely increase, so the number of accidents and deaths may not increase with rising sea levels, although the risks remain.

4.2. Indirect effects related to the ecosystem

Climate change has innumerable effects on ecosystems as a whole, and on their specific components, that in turn can have an impact on human health. In many cases, these changes are associated with the displacement of species to higher latitudes, following a rise in temperature, where they occupy regions which, precisely because of their temperatures, they could not previously tolerate. The acidification of the oceans may also affect the growth and biodiversity of marine life and, as a result, our fishing and food stocks, which in turn may again impact our health. Yet, the level of confidence of these chains of effects is relatively low, because they are dependent on many factors whose response to climate change has yet to be calibrated with any accuracy, Moreover, these causal chains are also dependent on many socioeconomic variables that can vary substantially.

4.2.1. Infectious diseases

The 2009 Greifswald (Germany) conference on "Climate change and infectious diseases" identified a series of such diseases that may affect humans and which, as a result of climate change, might have a greater impact on populations in temperate climates (EASAC, 2010). This would tend to be the case because, with the rise in temperature, primary hosts (i.e. animals that can harbour a disease which can then, secondarily, affect humans) and vectors (animals that do not have the disease but which can transmit it) move to more temperate latitudes where now they can survive during the colder seasons (António et al. 2018).

The hosts may be vertebrates, especially small rodents, while the vectors are primarily arthropods. Pathogens may be viruses, bacteria, fungi or parasites. The tiger mosquito (*Aedes aegypti*), a vector for transmitting arboviral diseases such as dengue fever, yellow fever and Zika, has already established stable populations in Madeira and in various areas of the Mediterranean. There are also organisms, especially microorganisms, that do not need other transmitters to spread their infections, as is the case of *Vibrio chlolerae*. But their association with marine or-

ganisms, such as copepods (1 mm cosmopolitan crustaceans), which are also expanding their biogeographic range, increases their presence on our shores and in our estuaries (Constantin de Magny and Colwell, 2009).

In the case of dengue fever, transmitted primarily by *A. aegypti* and *A. albopictus*, it is clear that their vector capacity increased greatly between 1950 and 2015 in countries where the disease was already present (Watts, 2018). It seems that the expansion of dengue in the Americas (Messina et al. 2014) could be related to increases in temperature and humidity. In the case of Catalonia, dengue fever, malaria and chikungunya are the main infectious diseases to take into consideration (TICCC, 2016). While dengue and chikungunya are viral infections, malaria is spread by a parasite; however, all three are transmitted by mosquito bites.

In addition to the widening of the biogeographic ranges of hosts and vectors, that include mosquitoes, rodents, ticks and the like, temperature also tends to have an effect in terms of accelerating processes. Thus, it increases the replication of microorganisms and shortens the life cycles of infectious agents, increasing transmission.

Nonetheless, human migratory movements, which usually start in tropical and subtropical zones and end in temperate zones, and which may also be conditioned by climate change, are a trigger for the appearance of these diseases in Europe. And no less important, in this regard, is the increase in the global movement of goods and people (tourism, business, and others). For example, all cases of chikungunya detected in Catalonia in recent years were found in people who had travelled to countries where the virus is present (TICCC, 2016).

As mentioned above, in the case of cholera, there are infectious diseases that do not need a host or vector – these are the so-called food- or water-borne diseases and are usually caused by bacteria. The infectivity of many of them is increased by a rise in temperature, which speeds up the metabolic and replication processes. *Legionella*, *salmonella*, and *vibrio* species, in general, are just a few examples.

It should be stressed that the improvement and adaptation of social and health systems in general counteracts the possible mortality of many of these diseases. However, the risk of an epidemic outbreak, which could cause the system to collapse, is increased by the shortening of the life cycle of infectious agents with rising temperatures. Similarly, an increase in extreme weather events, such as storms and flash floods, increases the risk of transmission.

4.2.2. Allergens

Between 20 and 25% of the Catalan population is affected by allergies, above all, by rhinitis and rhinoconjunctivitis (TICCC, 2016). Globally, the number of people affected by an allergy has increased exponentially in recent decades.

Many types of substances can cause allergic reactions in susceptible individuals. Perhaps plant pollen and fungal spores are the best-known allergen carriers. With climate change, the life cycle of organisms producing allergens may be altered and this might mean that these allergens will be present for longer periods or during different periods to those in which they are present today. The geographical distribution of plants may also be altered by climate change, so we might be exposed to pollen from species to which we were not previously exposed. The same is also true of allergens of animal origin (crustaceans and arthropods in general, molluscs, fish, etc.).

To these airborne allergens of biological origin, we should add interactions with substances and particles of air pollution, which in turn are influenced by climate and anthropogenic changes. These interactions may increase allergen concentrations as well as induce immunogenic modifications of allergenic proteins (Reinmuth-Selzle et al., 2017). The data suggest an increase in the effect of aeroallergens on allergic patients, which also implies a greater likelihood of developing an allergic respiratory disease (Cecchi et al., 2010). The increase in droughts projected in the Mediterranean area as a result of climate change will favour the suspension of particles in the atmosphere, worsening allergies (Cecchi et al., 2010). This trend, however, would reduce the prevalence of other diseases, such as asthma, whose presence tends to be greater when levels of humidity are high (Arnedo-Pena et al., 2013). Therefore, the global effects of climate change are unclear. As always in such cases, we should err on the side of caution, especially given the high percentage of the population already affected by allergies.

4.2.3. Toxins of marine origin

There are several marine organisms that produce toxic substances or irritants. Perhaps the best known examples are produced by the coelenterates, more commonly known as jellyfish, although strictly jellyfish are just the majority group in this phylum. Coelenterates contain cells known as cnidocytes that have a kind of microscopic harpoon that injects poison into their prey, typically small marine animals. In humans, these poisons, depending on the species, can have neurotoxic, cytotoxic, haemolytic or cardiotoxic effects. The severity of this effect depends on the type of poison, the dose, the area affected, and the degree of susceptibility of the individual including their age and weight and previous exposure, among other factors (ACA, 2012). Tens of thousands of jellyfish stings are reported in Catalonia each year. Although some studies link the abundance of jellyfish to climate patterns (Lynam et al., 2004), there is no clear evidence of a direct link between climate change and the presence of coelenterates. However, the warming of waters can alter both sea currents and water masses and the biogeographic distri-

bution of species, so that species with more powerful poisons reach our shores more frequently and in greater abundance, with the risk that this represents to bathers.

A further risk to human health is posed by the so-called harmful algal blooms (HABs) that result in the production of toxins by marine microorganisms. Owing to extraordinary environmental and biological circumstances, the massive growth of organisms of a given sea species can occur, resulting in the appearance of foam, scum, water stains and production of toxins. The toxins are varied and human toxicity can result from either the ingestion of contaminated fish or shellfish, coming into contact with the waterborne toxins, or by inhalation of aerosolized toxins (Berdalet et al., 2016). They tend to be primarily neurotoxins and can affect the nervous, digestive, respiratory, hepatic, dermatological or cardiac systems. As in the case of jellyfish, a direct relationship with climate change has yet to be established but warming stabilizes the water column thus promoting the development of toxin-producing HABs. At the same time, climate change is also associated with an increase in the biogeographic distribution of some species at higher latitudes, the case of the genus *Ostreopsis*, which underwent expansion in the first decade of this century (Rhodes, 2011).

4.2.4. Effect of forest fires

There is a fairly strong correlation between the number of forest fires in Catalonia and those in Spain between 2004 and 2018. This means there are underlying causes related not so much to the population's access to the forests, but rather to the weather conditions. Clearly the risk of fire is higher if humidity is low. This is the situation throughout much of the summer months (combined with high temperatures), but fires can also occur in winter. A recent study develops a robust model of the increase in burnt area due to wildfires of between 40 and 100% based on an average increase in temperatures of 1.5 to 3 °C, respectively (Turco et al., 2018).

In 2018, forest fires in California, with a Mediterranean climate similar to that of Catalonia, killed 102 people. Likewise, in July 2018, 74 people died in a fire near Athens. In addition to being a direct cause of death, forest fires produce gases and emit particulate matter into the atmosphere that cause respiratory and cardiovascular problems (Analitis et al., 2012; Faustini et al., 2015) and which impact, above all, infants and individuals already susceptible because of asthma or rhinitis (Vicedo-Cabrera et al., 2016).

4.3. Indirect effects related to socioeconomics

Humans make both extensive and intensive use of the planet's resources. The socioeconomic structure that has made this possible includes structures of global production and distribution and a series of problems related to the massive amounts of waste that are generated. Here we do not address all the environmental problems caused by the human impact on the environment and their effects on human health, rather we focus only on those that are most directly affected by climate change trends and with subsequent effects on health.

4.3.1. Atmospheric pollution

Air pollution is attributable to both gases and particulate matter and in both cases there are natural and anthropogenic components. Particles are generated naturally as mineral substances, volcanic ash and the like, which the wind entrains and transports, or anthropogenically as a result of the high temperature combustion of fossil fuels or biomass, the dust that is generated from construction aggregates, the wear of pneumatic tyres and roads, etc. These particles can be of different sizes. There is now legislation in place in the European Union (EEA, 2011) with two limit values being set on particulate matter (PM10) for the protection of human health: the PM10 daily mean value may not exceed 50 $\mu g\ m^{-3}$ more than 35 times in a year and the PM10 annual mean value may not exceed 40 $\mu g\ m^{-3}$.

As climate change makes the climates of Catalonia and North Africa more arid, it is expected that the fraction made up by these largest particles will increase and that that number of episodes of high concentration will also increase. These particles typically cause discomfort in the upper respiratory tract. However, it is the smallest particles, especially those smaller than 1 μm or PM1, produced primarily by the combustion of fossil fuels and which can pass through the alveoli and move into the bloodstream, that are the most harmful. Correlations between different PM fractions and hospitalizations in several Mediterranean cities have been described (Basagaña et al., 2015).

In principle, the tendency in Europe is for the emission of these particles to show a certain reduction (EEA, 2018a). Catalonia is no different and the Catalan Air Quality Index between 2004 and 2017 has improved (OCCC, 2019). However, more and more diseases and cases are being linked to air pollution, probably reflecting prolonged exposure not only to particles but also to gases, such as ozone (Orru et al., 2013). In 2012, the World Health Organization calculated 190,000 deaths attributable to air pollution in Europe. Most are due to ischemic heart diseases and strokes, but also to lung cancers and acute respiratory infections (WHO, 2016).

The severest effects are recorded where traffic volumes are at their densest. But it should also be borne in mind that these atmospheric particles can be trans-

ported thousands of kilometres and, therefore, not only local sources of emission need to be considered. Globally, per capita exposure to PM2.5 (particles smaller than 2.5 μm, for which we have more data than we have for PM1) increased by 11.2% between 1990 and 2018 (Watts, 2018).

Long-term exposure to PM2.5 is associated with increased mortality and morbidity from cardiovascular and respiratory diseases (Pope, 2002). In urban areas with high traffic density and during periods of considerable high pressure atmospheric stability, the cloud of air pollution does not disperse and pollutants concentrate. This is usually the case in the metropolitan area of Barcelona in summer, where this toxic effect is added to the direct effects on health attributable to high temperatures. The combination of these two factors can be highly detrimental, especially for the most vulnerable, and result in an increase in hospitalizations for cardiovascular and respiratory diseases. We have also seen that the concentration of polluting particles interacts with particles of biological origin exacerbating allergies.

4.3.2. Availability of water

The world's population continues to grow – despite the fact that since the 1970s the annual rate of global growth has slowed – and no fall is expected in the 21st century (Roser & Ortiz-Ospina, 2019). To give an idea of the stress that the world's water resources are under, global consumption – that is, the water directly used by people as well as that used for agriculture, livestock farming, industry and other uses – increased six fold between 1990 and 1995, at twice the rate of population growth (UNEP, 1999).

Water is the most essential resource for human life and survival and is now a scarce resource and a limiting factor in most parts of the world (UN, 2018). While the rise in temperatures associated with climate change should intensify the world's water cycle, we know that precipitation will tend to concentrate more in equatorial and temperate latitudes, while in the Mediterranean region, and in subtropical and tropical regions in general, precipitation will decrease and the number of droughts increase. Catalonia can expect changes in its hydrology and land use that will reduce the availability of water resources by between 10 and 22%, depending on the basin (TICCC, 2016). The change in the distribution of precipitation, with an overall reduction but an increase in heavy downpours, will be poorly exploited by the current infrastructure. Moreover, rising sea levels will increase the saline wedge in coastal areas, reducing the availability of fresh water in these zones.

Poor access to water, sanitation and hygiene (WASH to use the acronym of the collective term) causes 1.5 million deaths worldwide each year. Most of these

are infants suffering from diarrheal diseases of various origins (Prüss-Üstün et al., 2008). An advanced society such as our own expects to deal with water shortages by employing technical solutions and instigating changes in use, but what cannot be ruled out are occasional restrictions and a higher cost of access to fresh water that can impact household spending. This added pressure on spending may either reduce the use of water for maintaining personal hygiene or mean that families have to prioritize water over things that, directly or indirectly, may impact their health or well-being.

4.3.3. Availability of food

The increase in drought severity in Catalonia (TICCC, 2016) may eventually compromise the water resources used for agriculture and livestock farming. We can also expect a loss of soil organic matter and higher rates of erosion, which will lead to a fall in productivity. Cultivated plants undergo a series of changes in their gene expression and metabolism as a result of drought, rising temperatures, the increase in CO_2 concentrations, salinization, and other factors (Peñuelas et al., 2013; Scheelbeek et al., 2018; Tigchelaar et al., 2018; Zhu et al., 2018). But, at the same time, it is true that better conditions for growing crops can be expected in other regions of the planet as rainfall rates and temperatures increase. High-latitude fisheries and aquaculture are also expected to be more productive, while at low latitudes it seems that productivity will decrease (Willett et al., 2019). Therefore, it is not entirely clear that the availability of nutritious food, albeit of non-local production, will lead to problems of malnutrition in Catalonia; rather, the health problems related to eating are more likely to be associated with obesity and nutritional imbalances. Beyond these forecasts, it has still to be seen how global agriculture and livestock farming will evolve in response to climate change. It seems that, in general, decreased productivity can be expected, due in the main to a shortage of water for these activities. Therefore, if Catalonia's food self-sufficiency rate – currently standing at around 40% (Reguant, 2011) – does not rise or fall, pockets of malnutrition could emerge in areas of Catalonia. It should be borne in mind that, despite being an advanced society, Catalonia is not completely free of cases of poverty-related malnutrition in children (Síndic de Greuges de Catalunya, 2013). In Catalonia, the at-risk-of-poverty rate increased by 0.2% per year between 2004 and 2017, rising to around 20% of the population at the end of that period (OCCC, 2019). These people are more likely to suffer the effects of climate change, including malnutrition, which are associated with a number of health problems and may even lead to death. Yet, it is not clear whether these trends reflect the evidence of an increase in global malnutrition in recent years (Fig. 6).

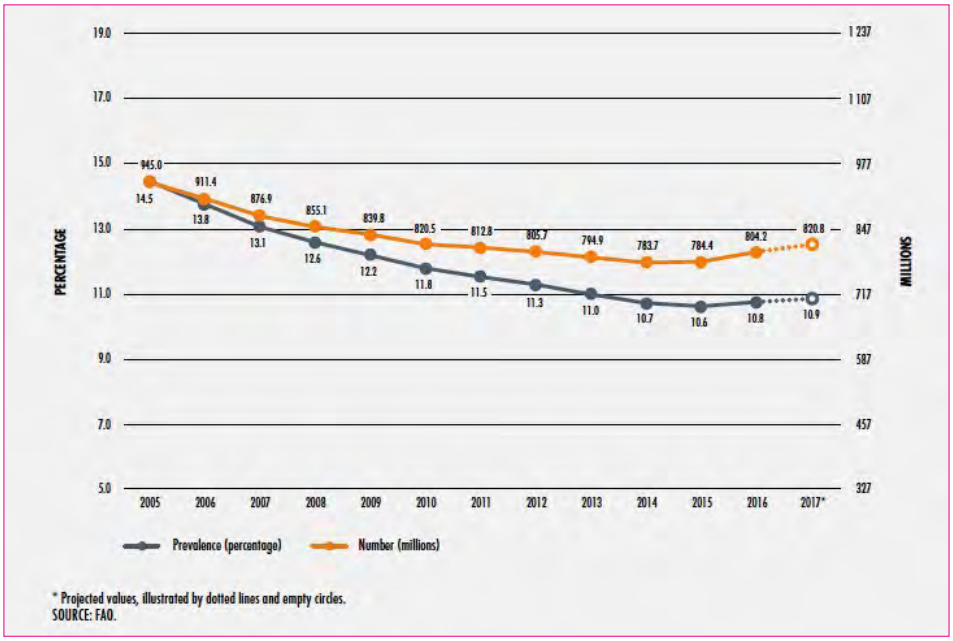

FIGURE 6. Evolution of the number of malnourished people in the world. Taken from FAO et al. (2018).

4.3.4. Migration

Climate change will lead to crop failure and water shortages, above all in tropical and subtropical zones. In conjunction with such phenomena as rising sea levels and the increasing frequency and intensity of extreme events, it is estimated that by 2050 hundreds of millions of people will have been forced to migrate in order to survive, though a significant number will be internal migrations without the need to cross frontiers (Rigaud et al., 2018). The conditions of poverty faced by most of these migrants are an obvious cause of health problems. At the same time, these human displacements may result in the reduction in wealth of host societies, while facilitating the spread of certain infectious diseases. All told, these migrations would lead to a decline in the overall health of host areas, be they cities or countries. Catalonia is located just outside the regions most affected by global warming, making it a logical gateway for migration from lower latitudes. The final impact on health is difficult to gauge because obviously as a society we have a certain capacity to respond and to adapt to these challenges. Yet, the warnings issued in specialist publications (Watts et al., 2018) concerning the need to plan and adapt our healthcare systems cannot be ignored.

4.4. Interaction of multiple effects

What emerges is that diagnosing diseases or attributing deaths directly to climate change is, in most instances, extremely complicated. The effects of temperature and other climate variables are mixed with exposure to other environmental or social agents, which in turn may be affected by climate change. Isolating them beyond all reasonable doubt is not easy, considering that the intensity and duration of exposure to these agents is a major factor to take into account, in addition to the specific vulnerability of each individual. For example, the impact and mortality risk of a given heatwave will differ depending on the population structure and the percentage of infants and elderly, the two most vulnerable demographic groups. This social factor is, in turn, regulated by many other factors. For instance, climate change forced migration would be a further indirect cause. Determining the degree to which each factor is responsible for a particular outcome is extremely complicated. The interaction of multiple factors, each with its own particular impact, may not always constitute a simple additive effect; rather, the overlapping of certain factors may have synergistic effects. Despite this, significant advances have been made in the attribution of diseases and deaths to aspects of climate change exploiting statistical analyses of healthcare provision, hospitalizations and deaths as a function of weather and climate conditions (Otto, 2016).

It should be recognised that this report has, to some degree, been restrictive in its treatment of the relations between climate change and health, ignoring many aspects with weak or less quantifiable links. For example, in the case of the pharmaceutical industries, marine biodiversity serves as a constant source of new drugs with anticancer, antimicrobial, immunomodulatory, analgesic, anti-inflammatory and other properties (Mans, 2016). Yet, at the same time, we know that we are facing a species extinction rate that is two to three orders of magnitude higher than it has ever been in the last 10 million years (IPBES, 2019), with the loss of biodiversity that this represents. In the case of the oceans, climate change, as manifest by rising water temperatures and acidification due to the absorption of part of the excess atmospheric CO_2, is inflicting additional stresses. In short, the loss of biodiversity is depriving us of the chance of discovering new drugs, opportunities that are lost with the extinction of species, and reducing our ability to fight diseases and improve health.

5. Final considerations

There is widespread consensus in the scientific community today that our climate is changing and that the primary cause of these changes is the greenhouse gas emissions we pump into the atmosphere. These global and regional

trends are being reproduced, and are more than evident, in Catalonia, where temperatures are increasing, precipitation levels are falling and the sea level is rising, and these changes are, if anything, more pronounced here than in the rest of the world.

Climate change is associated with an increase in certain risks to human health, both directly, with perhaps the most obvious being those linked to an increase in average temperature and in the number of extreme episodes of heatwaves, and indirectly via a multiplicity of other factors related to our ecosystems or socioeconomic systems, which in turn are conditioned by climate change. Cardiovascular, respiratory, renal, mental and infectious diseases are the most significant disorders known today, risks that are leading to an increase in the number of premature deaths. Often what we find is the interaction of various factors attributable to climate change impacting on a patient in complex, and largely unknown, ways, undermining his or her state of health. And this can happen despite the fact that the average life expectancy of the population continues to increase thanks to the advances made in medicine. The effects also depend on the degree of vulnerability of each sector of the population, linked to such factors as age, sex, occupation, nutrition and poverty level, among others. In Catalonia, the increase in the at-risk-of-poverty rate is a concern since it causes nutritional imbalances and increases vulnerability to the impact of climate change

Although we do not know all the direct and indirect mechanisms by which climate change impacts on health, or all the possible interactions between these mechanisms, the precautionary principle should be adopted as we begin to implement real and effective measures that seek both to address climate change and environmental sustainability in general and to adapt to their effects, including efforts to reduce our overall vulnerability.

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IV. ABSTRACTS FROM THE LECTURE SERIES (2018–2019)

Health, climate and the planet
Josep M. Antó, ISGlobal
20 September 2018

The importance of environmental quality for human health is the major paradigm that underpins modern public health services. In recent decades, our knowledge of the influence of environmental degradation on health has improved substantially. In determining this influence, the disability-adjusted life year (DALY) has been developed as a measure of the overall reduction in health, expressed as the total number of years of life lost to illness or premature death. The World Health Organization's latest assessment estimates that environmental factors were responsible for the loss of 21% (596 million) of DALYs in 2012, owing to cancer, depression, cardiovascular disease, respiratory disease and musculoskeletal diseases. Yet, this systematic assessment includes neither climate change nor related factors, such as rising temperatures. Temperature rises resulting from climate change affect health directly, indirectly and in a complex interrelated fashion. The changes humans are triggering in the environment are so great that the Holocene can be said to have given way to the Anthropocene Age. Yet, despite the deterioration of the environment, life expectancy is increasing. This paradox can be explained in part by the fact that rich countries are outsourcing environmental deterioration to other regions and by the fact that there is a delayed effect of the environment on health. These hypotheses, and others, continue to be the object of much study. If human health has improved at the expense of environmental dete-

rioration, ultimately the latter will impact health too, which is why it is increasingly being argued that human health and planetary health need to be considered as one and the same. Planetary health, a relatively new concept, is concerned with achieving the highest attainable standards of world health, well-being and equity by paying judicious attention to the human systems – political, economic and social – that shape the Earth's natural boundaries within which humanity might flourish.

Climate change, heat islands and health in Catalonia

Javier Martín-Vide, University of Barcelona

10 December 2018

More than 90% of the Catalan population can be considered urban and, therefore, subject to climate conditions that have been modified by the city. The main climate change attributable to urban settlements is the heat island effect, resulting in a positive night-time heat anomaly in city centres compared to temperatures recorded in their peripheries, and which in the case of Barcelona reaches quite considerable values. The heat island phenomenon can be attributed to many causes: storage of heat by building materials during the day (and its release at night); anthropogenic heat production; reduced rates of evaporation due to paved over, impermeable surfaces and drainage systems; less heat loss due to reduced wind speed; increased absorption of solar radiation energy due to complex geometry of urban surfaces; decreased night-time radiation; and re-emission of radiation to the surface because of the polluted atmosphere. This last effect is more significant in big cities.

Today, climate change is a reality and the fact that human activity is the cause cannot be questioned, above all as regards the emission of greenhouse gases into the atmosphere. Global warming is becoming more and more marked and the last three decades have been the hottest since instrumental records were first kept. Temperatures in Catalonia are largely in line with global patterns, while its rates of precipitation are more variable, there being mounting evidence that precipitation is falling and increasingly subject to changes in seasonality. City dwellers, however, in addition to global warming, are subject to the heat island's thermal plus which, during increasingly more frequent heatwaves, results in a manifest increase in morbidity and mortality.

Food systems and climate change

Marta G. Rivera Ferre, University of Vic

11 March 2019

Food systems, encompassing all the activities, actors and institutions that participate in the production, processing, transportation, preparation and consumption of food, are complex systems resulting from the interaction of our economic, social and environmental domains. Today, food systems fail to fulfil their primary function of feeding the world's population in a nutritious way while conserving the environment, and so are neither socially nor environmentally sustainable. Indeed, half the population suffers from some form of malnutrition (undernutrition, obesity or 'hidden hunger'). It is paradoxical that while 820 million people go hungry, 65% of the world's population lives in countries where there are more deaths attributable to obesity than famine, and 30% of food production is either lost or wasted. What stands out at the environmental level is the contribution made by food systems to the emission of greenhouse gases, accounting for 30-50% of total emissions. At the same time, food systems are themselves impacted by climate change, so that the four dimensions of food and nutrition security (that is, availability, accessibility, utilization and stability) are threatened. In the light of this evidence, food systems need to be reformed so as to reduce the associated greenhouse gas emissions, while increasing their adaptability to climate change.

V. CLIMATE CHANGE AND HEALTH CONFERENCE. INSTITUTE OF CATALAN STUDIES.

Introduction

After decades of confusion and misinformation, we have known now for some years that climate change is real, that it impacts our lives in many ways, and that the outlook for the rest of the 21st century is bleak. To the more general changes – increasing temperatures, melting ice, rising sea levels, desynchronization of basic biological processes, changes in the distribution of species, etc. – we need to incorporate the more specific impacts, at both the regional and global level. One of these impacts, characterised by a multiplicity of effects, concerns the consequences of climate change for human health, and it is for this reason that I welcome the fact that the Biological Sciences Section of the Institute has organized this series of conferences so that experts in this field can shed greater light on the question. It is true that the media frequently draw our attention to these effects, but hearing first hand about the impact that climate change is already having on our physiology, psychology, reproduction, well-being, etc., and the impact it can have in the immediate future is of interest for two reasons: first, the human motives (we are the ones that suffer its effects and will continue to be exposed to its impact) and, second, the academic (as science allows us to identify these effects and determine whether we can do anything to mitigate or eliminate them).

In my role as Professor of Ecology, I have been explaining the rudiments of climate change to my students for years, including its effects on human health. Perhaps one of the most obvious, because they have caused numerous deaths and the media have given them great coverage, are heat strokes, which, on specific

occasions, have affected the most vulnerable in our society. But there are many other effects and, here, I wish to identify those that concern me most.

Rising temperatures mean that bodies of water that previously froze in the winter, and which were too cold for mosquito larvae to survive, may now be the right temperature for these insects to transmit diseases we believed to have been long eradicated from our country (such as malaria) or which until recently were limited to warmer climates (yellow fever, dengue, Zika and chikungunya).

The thawing of the ice caps and high mountain areas is exposing corpses, whole cemeteries even, of sailors and mountaineers; some of these people died from illnesses that are today rare (such as scurvy) or which have been eradicated (such as smallpox or Spanish flu). But the germs of these and, perhaps, other diseases may come back into circulation as a result of this thaw.

Other diseases, some of them quite serious, would see their incidence increase as a result of rising temperatures, the reduced intake of food due to declining agricultural production (another consequence of climate change, which generates droughts and desertification) and other effects. It has been claimed that this is already happening, or may well happen soon, with cholera, tuberculosis, Lyme disease, avian flu, etc.).

Prolonged episodes of drought, but also extreme weather events (precipitation, hurricanes, etc.), which have clearly increased as a result of climate change, have led to a reduction in food production, at a time when the world's population is continuing to grow. Diseases associated with malnutrition are once again becoming significant and are a source of concern insofar as they affect the most vulnerable age groups: infants and the elderly.

The warming of Mediterranean waters, among others, is resulting in the redistribution of marine species: today, off our own coasts, we are now seeing fish and other organisms native to warmer waters ("tropicalisation") while cold-water fish are moving north or perishing in their efforts to seek out cooler temperatures. This has had negative repercussions for the fishing industry, already suffering the effects of overexploitation: far fewer fish are being caught today in the Mediterranean than in the past. Among the new species that have appeared thanks to this rise in sea temperatures, some are toxic and dangerous, such as blowfish (tetraodontiformes) and certain jellyfish (which are already more abundant thanks to the higher temperatures and the reduction in river waters reaching the coast), and it would not be surprising if other more undesirable species (such as sea snakes) followed suit. The rise in temperature, together with the greater influx of nutrients into salt waters and closed seas (such as the bays of the Ebro Delta), promote the proliferation of plankton giving rise to massive population growth (the so-called 'red tides'). These toxic algal proliferations contaminate mussels and oysters and can cause episodes of mild, severe, or lethal illnesses in those that consume them.

As for terrestrial species, the loss of synchrony between predator-prey population dynamics – over the last half century, summers have been lengthened by approximately a month, at the expense of two-week reductions in spring and autumn – is already reducing controls on certain pest species (for example, insects), undermining the beneficial role birds and other animals played in our fields and countryside. Some of these pest species not only damage crops and forest vegetation, they also cause harmful reactions in humans (processionary caterpillars, for example). Changes in the characteristics of oil, wine, and other foods as a result of global warming and drought result in alterations to our diet and, consequently, to the physiology of consumers, about which little is yet known.

The mass death of marine communities, from the coral reefs to the Mediterranean's coastal ecosystems, due primarily to the increase in the temperature of the oceans and the prolongation of warming into months in which previously the seasonal cycle returned them to more favourable thermal conditions, are having a huge impact on the populations of these ecosystems, many of which are exploited for their fish and shellfish and which, as a result, have seen their production fall greatly.

Today, when it is accepted that the quiet contemplation of nature as we hike through the woods or across a beautiful landscape serves to boost our state of mind (the well-documented therapeutic value, for both body and soul, of enjoying nature), we are witnessing the very degradation of these natural landscapes, whether they be mature forests, coastal wetlands, mountain or coastal landscapes, largely as a result of climate change. These and other more interesting (albeit often more distressing) subjects have been discussed during this conference, resulting in this report on Climate Change and Health in Catalonia. Many thanks to the speakers and congratulations to the Section for leading this initiative.

Joandomènec Ros
President de l'Institut d'Estudis Catalans

Presentations

Re-evaluating the role of climate variability and change in the occurrence and magnitude of epidemic outbreaks

Xavier Rodó, ISGlobal
11 April 2019

While it is well known that the climate plays a central role in the initial outbreak of an epidemic in vector-borne diseases, it is also clear that once a critical threshold of infected people has been reached, the epidemic progresses inde-

pendently even when climate conditions are not favourable (as in the case of the transmission of dengue or chikungunya). However, the progression of the epidemic is heavily dependent on local socioeconomic and demographic factors, which, if not properly understood or integrated, inevitably lead to an underestimation of the incidence of, or a poor prediction of, the epidemic. Socioeconomic factors, such as the limited hygiene or poor infrastructure of a developing country, can favour the outbreak of an epidemic, from where it will subsequently spread due to the movement of infected people, for example, within a city. All these pre-conditions have to be evaluated and correctly included at various points within the predictive models experts build. In this regard, and in order to generate accurate information about the potential (re)-emergence of climate-mediated diseases in Europe and other places that have not been previously exposed to them, it is essential attention be focused on studying and simulating how this (re)-emergence occurs in similar situations be they in endemic or epidemic areas.

How does climate change affect human health and what can scientists do to mitigate its effects?
Elisa Berdalet, Institute of Marine Sciences (CSIC)
11 April 2019

The paper begins by reviewing scientific evidence for climate change and the role played in it by human activities, before focusing specifically on the marine environment. Mention is made of specific climate change effects such as the acidification of the oceans and the impact this might have on fisheries, already affected by overexploitation. As recognized in the latest report issued by the Intergovernmental Panel on Climate Change, the changes occurring around the world that directly or indirectly affect ecosystems will also have an effect on the health and well-being of humanity. Following on from this introduction, Dr Berdalet turns her attention to harmful algal blooms and their associated risks of food poisoning and respiratory and skin disorders in humans. While these phenomena are natural, anthropic pressure on the marine environment and global warming can increase their frequency and the intensity of their negative effects. Local and international multidisciplinary scientific research, coordinated with political and socioeconomic agents, is essential if we hope to continue providing tools to prevent and mitigate these effects.

Sustainability and climate change
Humberto Llavador, Pompeu Fabra University and Barcelona Graduate School of Economics
11 April 2019

The paper begins with a reminder of the very close ties between anthropogenic emissions of CO_2 into the atmosphere and climate change, recalling that, according to expert publications and reports, a) the whole world is at risk, b) there is a tendency for health inequalities to become exacerbated, and c) that humanity's adaptation to change has it limits. Climate change and inequality are the two main challenges we face today and both are characterized by their being products of human action or inaction, and only the decisions that we take can hope to address them. The effects of climate change will exacerbate health inequalities because the former have a greater impact on the disadvantaged who, moreover, are the ones least able to adapt to these changes. We should not only concern ourselves with those who emit the most CO_2, but also with those who, because of their consumption, are indirectly emitting these gases. From a global perspective, we should be asking ourselves whether the solutions to these problems are compatible with the sustainable progress of human well-being. The answer requires a broad vision of the concept of human well-being, precision in the definition of sustainability, and an awareness of the close link between growth, inequality and climate change. The countries of the world have to adapt to a slower growth rate, but to one that is not incompatible with enhanced living standards and a fairer distribution of growth.

Climate change in Barcelona. Projected effects and actions
Irma Ventayol, Coordinator of Barcelona City Hall's Climate Plan
11 April 2019

The paper begins by recalling the Paris agreements and, in particular, the commitment to keeping the increase in the global average temperature to well below 2 °C above pre-industrial levels. By 2050, it is forecast that 85% of the world's population will live in cities, making them the biggest contributors to the economy and CO_2. They are, as such, part of the climate change problem, but they can also be an important part of the solution. The city of Barcelona has studied the impacts of climate change in a comprehensive manner. Based on regional climate projections, analyses have been made of how changes in temperature and precipitation impact health, water supply, flood risks and biodiversity, among others. Studies have looked at the increase in the number of warm nights and days

and of heatwaves, phenomena exacerbated by the city's heat island effect. Water supply needs have also been analysed. The mortality associated with the increase in heat affects the elderly and women most and life expectancy in the city of Barcelona is linked to the economic situation in the city's different districts, while these social inequalities can be further exacerbated by climate change. This information has served as the basis for drawing up the Barcelona Climate Plan, a holistic plan, based on scientific studies and in line with the Paris objectives, and which includes measures of mitigation, adaptation and resilience, climate justice and initiatives promoting citizen action.


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