Hessian Agency for Nature Conservation, Environment and Geology
Centre on Climate Change and Adaptation

HESSEN

Impacts of Climate Change on Human Health

Climate Change in Hesse

FACHZENTRUM KLIMAWANDEL UND ANPASSUNG

Imprint

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Cover photo: Thermometer at the Frankfurt Hauptwache. © picture alliance, dpa, Frank Rumpenhorst

Foreword

Prof. Dr. Thomas Schmid
President of the Hessian Agency for Nature Conservation, Environment and Geology

Climate change with its various impacts on practically all areas of life has already become apparent in Hesse. The changing climatic conditions will also affect human health. The possible impacts on our own health are a major issue, both for the Hessian population and for each and every one of us.

Humans have no organ that can perceive the climate, which is affected by gradual changes in meteorological variables over longer periods of time. And yet our bodies react to weather and meteorological phenomena. There will be an increase in heatwaves and torrential rains in the wake of climate change, which can impact health directly as demonstrated by the significant increase in mortality during the heatwaves in the summer of 2003. Furthermore, climate change can also impact health indirectly: new animal and plant species that were previously never or only rarely found here could establish themselves and propagate; for example, 'new' pathogens or disease carriers such as specific mosquito species. Pollen counts could change due to changes in flowering seasons or in the propagating plant species, affecting people with pollen allergies.

A changed climate affects human health. Hence, we have to safeguard ourselves. This brochure outlines the impacts pertinent to Hesse.

Further information on climate change in Hesse is available on the website of the Hessian Agency for Nature Conservation, Environment and Geology (HLNUG).

Introduction

We all feel the effects of the weather on our well-being and health differently: some of us strongly, others perhaps hardly at all. We can assume that in Hesse too the impacts of climate change will affect people's health and well-being in a variety of manners.

- Extreme weather events such as heatwaves, storms or floods can directly affect health, as can greater exposure to UV radiation, possibly due to lower cloud cover.

- Changes in climatic conditions can affect the incidence, behaviour or development of plants and animals that could constitute health risks. These are the indirect impacts of climate change on human health.

Only the impacts of climate change that are relevant to health in Hessen will be described here.

There is not always a clear correlation between climate change and the observed impacts on health. In some cases, the influencing factors are cumulative: new disease carriers can be introduced to Hesse through international freight transport or inadvertently, with other species; climate change then creates the necessary conditions for the respective species to establish itself. It is these complex interactions between the influencing factors that this brochure will explain with examples.

Direct impacts of climate change on health

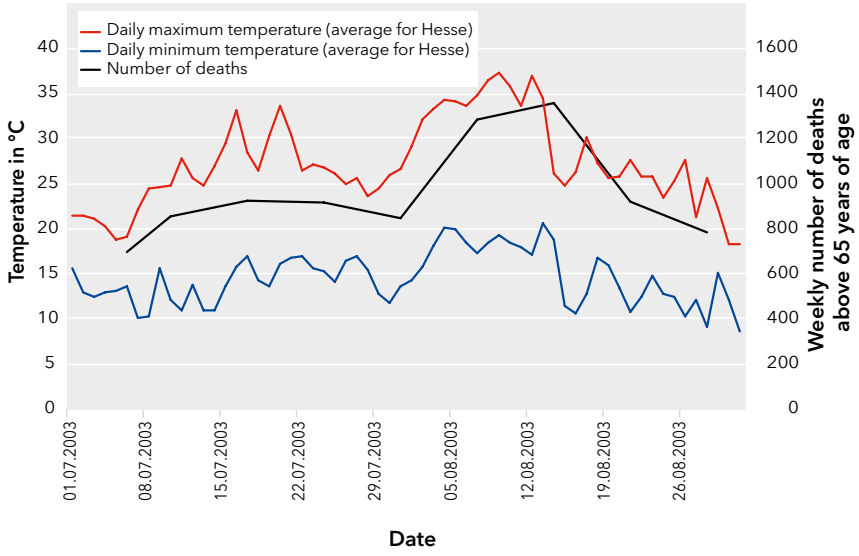
Heat and cold – effect on well-being and health

We can perceive temperature in our environment very clearly. It has a significant impact on our well-being: we feel uncomfortable when it's too cold or too hot. However, our perception of temperature is not just affected by air temperature but also by humidity, wind speed and solar radiation. Besides, we each perceive things very differently, depending on physical activity and age, as well as external factors such as clothing, for example.

But heat and cold do not only cause discomfort, they can also adversely impact health. This could be fatal in extreme cases (extremely high as well as extremely low temperatures) if humans fail to protect themselves adequately in such conditions. The elderly, the chronically ill (such as those with cardiovascular disease), infants, small children and people who work outdoors are at particular risk during heatwaves.

Summer 2003 was particularly hot throughout Europe. This resulted in many deaths, especially in France. According to estimates by the Hessian State Health Office (HLPUG), up to 1,000 additional deaths in Hesse can be attributed to the two-week heatwave in August (see graph).

In summer 2003, daily maximum temperatures (red curve) had already exceeded 30°C by mid July. However, the number of deaths (weekly) only increased significantly with the incidence of the longer heatwave that lasted from the beginning to mid August, during which the nightly minimum temperatures (blue curve) dropped only slightly below 20°C.

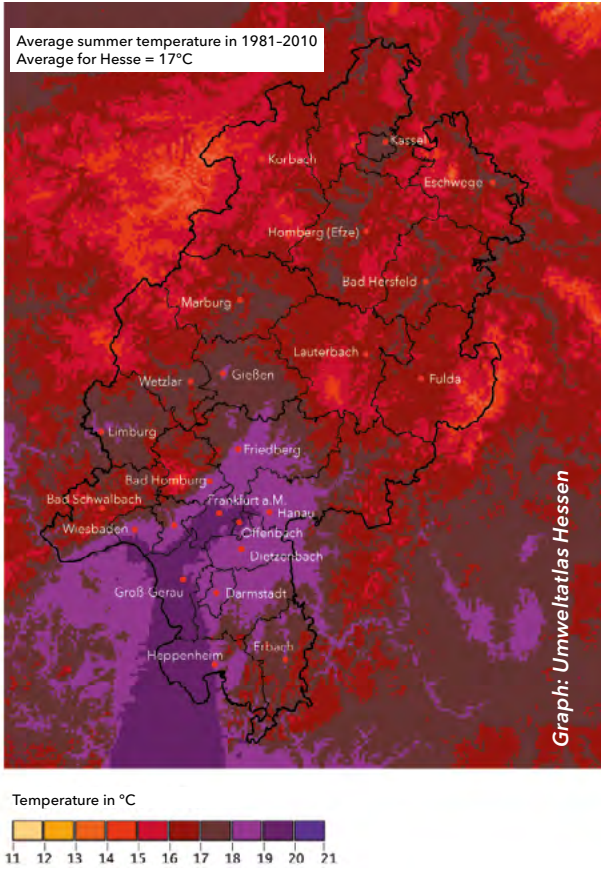


Average daily maximum and minimum temperatures (average of Hessian stations) and number of deaths among elderly people in Hesse, July to August 2003.
Graph: Helmut Uphoff, HLPUG

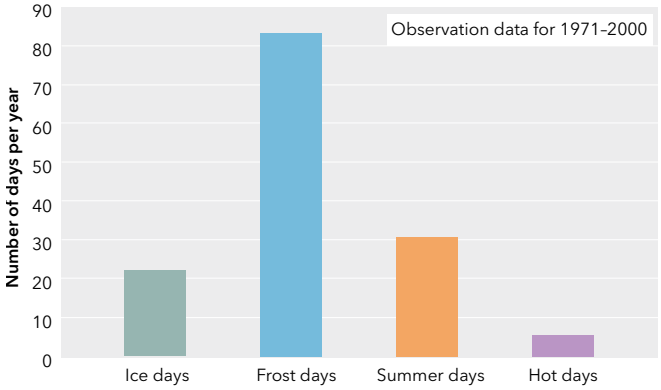
Summer and ‘hot days’ in Hesse – present and future

The average temperature during the meteorological summer (June, July and August) in Hesse has increased over the last century: it was 15.8°C in 1901–1930, 16.1°C in 1961–1990 and 17.0 °C in 1981–2010. Although the increase in average temperature is evidence of climate change, this in itself is not a cause of concern from a health perspective.

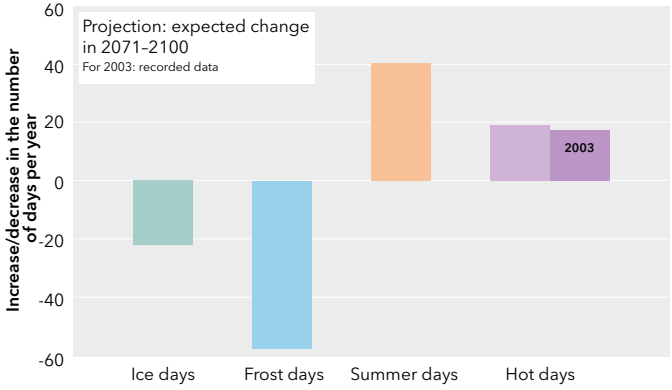
It is hot days with a maximum above 30°C and tropical nights in which temperatures do not drop below 20°C that affect the human organism in particular. Thus, we must take these particularly hot days and nights into consideration in order to draw conclusions on the relevance of climate-change-induced temperature increases to health.



The map shows the average summer temperature in 1981–2010. Regional differences are evident: the Hessian Ried and Maintal (Main valley) are the warmest regions, while the higher altitudes of the Mittelgebirge (Central Uplands) have the lowest temperatures, as expected. Regional peculiarities must also be taken into account when considering thermal stress.



Recorded number *of threshold days (climate indices) in Hesse in 1971–2000. (Ice day: daily maximum temperature < 0°C; frost day: daily minimum temperature < 0°C; summer day: daily maximum temperature > 25°C; hot day: daily maximum temperature > 30°C.) Data: DWD*



Expected change *in the number of threshold days in 2071–2100 compared to 1971–2000 (average of 30 regional climate model combinations, RCP8.5 scenario) and recorded increase in hot days in Hesse in 2003. Data: HLNUG/ReKliEs-De project. Observation data: DWD*

Regional climate projections suggest that there will be a significant decrease in the number of cold threshold days in future: should the CO_2 concentration trend remain unchanged (as in the 'business-as-usual' baseline case of RCP8.5) the number of frost days is expected to decrease by more than half, while there will hardly be any ice days at all.

In contrast, the number of summer days and hot days is expected to increase significantly: the number of hot days that particularly affect health could increase by 20 days by the end of the century (RCP8.5; see graph on the right). This would make the summer of 2003 an average summer in future.

In Hesse, the **heat extremes of the past** could well become the **norm** or even be surpassed in future. This would have an immense impact on human health!

Who is Klima Michel?

Temperature indices (combined quantities) are used to describe perceived heat and cold. Apart from the temperature, these indices take humidity, wind speed and solar radiation into account. Germany's National Meteorological Service (Deutscher Wetterdienst, DWD) uses the 'apparent temperature', which determines the heat transfer between the human body and the environment in order to estimate the health-related effect.

In warm and sunny weather with little wind and high humidity, the apparent temperature increases faster than the air temperature; in cool weather with strong winds and overcast skies, the apparent temperature rapidly drops below the air temperature. An apparent temperature between 0 and 20°C is considered comfortable when wearing suitable clothing, one below 0°C is perceived as cold and one above 20°C is perceived as warm.

The apparent temperature is vicariously determined for 'Klima Michel': he is male, 35 years old, 1.75 m tall, weighs 75 kg, is suitably dressed and moves with moderate effort. Since older people are more vulnerable to heat, the apparent temperature is also determined for 'Klima Michel senior' (75 years old).

Apparent temperature in °C	Thermal perception	Health risk
above 38	very hot	very high
32 to 38	hot	high
26 to 32	warm	medium
20 to 26	slightly warm	low
0 to 20	comfortable	none
-13 to 0	slightly cool	low
-26 to -13	cool	medium
-39 to -26	cold	high
below -39	very cold	very high

Apparent temperature, thermal perception and effect on the human organism in accordance with the guideline VDI 3787 Part 2: Environmental meteorology – Methods for the human biometeorological evaluation of climate and air quality for urban and regional planning at regional level – Part I: Climate. Source: DWD.

Heat warning system

The DWD's heat warnings are based on the apparent temperature. If the apparent temperature is expected to exceed the threshold of about 32°C on two consecutive days with the night being only slightly cooler, a severe heat warning is issued. An apparent temperature in excess of 38°C is considered extreme heat. The human organism is able to adapt to an extent, which is why the threshold for severe heat throughout the summer is constantly adjusted in accordance with the weather conditions of the previous 30 days.

Welcome cooling in the heat: fountains in Frankfurt
© Stadt Frankfurt am Main, Grünflächenamt

Heat: What can I do?

The DWD issues heat warnings both for the individual German federal states and for their respective administrative districts. Healthcare facilities, hospitals and other institutions, as well as private individuals can subscribe to the electronic heat warnings newsletter:

https://www.dwd.de → Newsletter → Hitzewarnungen

Five tips for hot days

- Ensure you consume enough liquids and electrolytes.
- Avoid the midday heat and direct sunlight.
- Schedule your outdoor physical activities (both sport and recreational) for the mornings and evenings.
- Wear light, airy clothing.
- Ventilate indoor spaces at night; shade them as much as possible and keep windows closed during the day.

Heatwaves: How can we adapt successfully?

Due to climate change, heatwaves in Hesse are expected to occur more frequently and to occasionally last longer. This makes it all the more important for particularly vulnerable sections of the population to be protected from the negative impacts in future.

For this purpose, some structures within the health sector must be extended and some newly created. Heat warnings must reach the high-risk groups: facilities such as care homes, hospitals and children's nurseries, which care for vulnerable people, should be included.

© Argus / Fotolia

Care provision for those in need should be guaranteed – this is often difficult in practice, especially in the case of elderly people living alone. The objective should be to establish a heat action plan that addresses all vulnerable people and implements the necessary measures to protect them.

The World Health Organization (WHO) has issued recommendations on how to deal with heat, upon which the Federal Ministry for the Environment has based its own recommendations for the preparation of heat-health action plans in Germany:

https://www.bmu.de/en → Topics → Energie → Climate Energy → Adaptation to climate change.

A heat action plan for Hesse is being developed. On behalf of the HLNUG, the Fulda University of Applied Sciences and the HLPUG have already developed the basic principles for its successful implementation in Hesse.

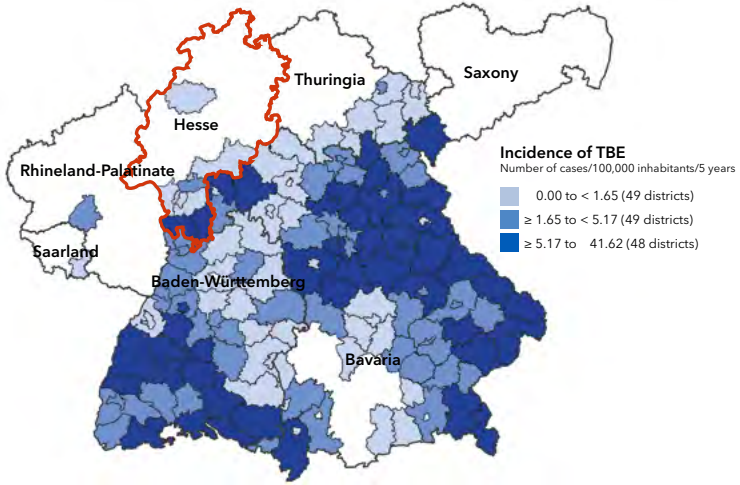
Indirect impacts of climate change on health

Animals as disease carriers

Changing climatic conditions can contribute to the propagation or establishment of disease carriers (vectors) and pathogens that are not indigenous to our regions or that are very rarely found here. Numerous other factors such as globalisation, an increase in the transport of goods and changes to existing transport routes are also to blame for the migration of many 'new' species. However, the actual risk of vector-borne diseases only exists if animals that can transmit a disease, such as ticks or mosquitoes, inhabit the region and if the pathogen exists locally. However, not every vector is capable of transmitting every pathogen. In addition, the pathogen needs suitable climatic conditions to survive and proliferate in the vector organism.

Ticks

Amongst the most significant vector-borne diseases are borreliosis and tick-borne encephalitis (TBE). The main vector of both diseases is the castor bean tick *(Ixodes ricinus)*, the most common indigenous tick species. TBE occurs primarily in southern Germany – in Hesse too, the southern parts are predominantly affected – while borreliosis occurs nationwide.

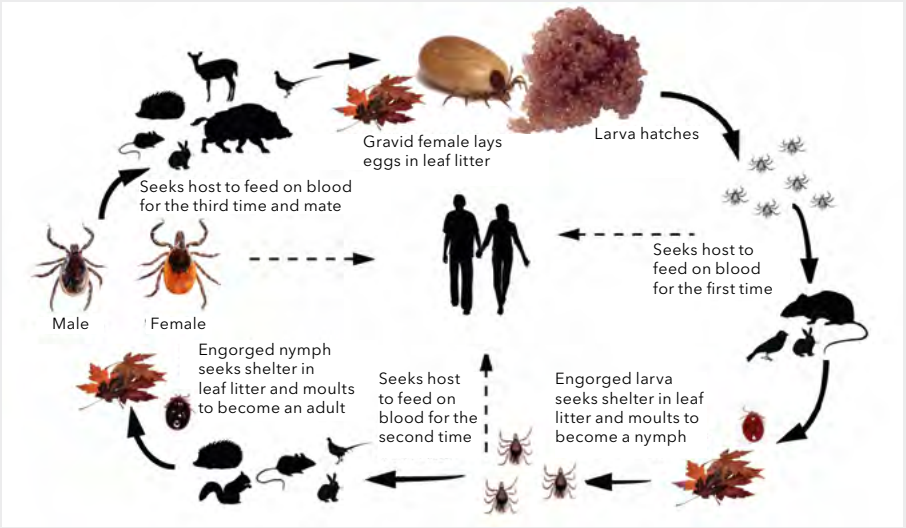


TBE risk areas in 2016 (n = 146) colour-coded by incidence (number of new infections) in 2012–2016. Graph: Robert Koch Institute; the border around Hesse has been added.

Higher temperatures, milder winters in particular, shorten the perennial life cycle of ticks. However, sufficient humidity is also essential for their development. Therefore, the expected warming could cause tick proliferation; however, longer periods of drought in summer could hinder this.

Since vegetation and land use are also relevant factors, it is difficult to assess changes in tick activity under climate-change conditions.

In recent decades, both an increased infection rate of ticks with Borrelia *(Borrelia burgdorferi)* and the propagation of TBE further north have been recorded.



Life cycle of hard ticks, which also include the castor bean tick.

Larvae, nymphs and adults seek a host to feed on blood – this can be a human in all three stages. Wearing long clothing when walking in the forest reduces the risk of a tick bite.

Illustration: Nina Littwin

Mosquitoes

Two invasive mosquito species, originally indigenous to Asia, are currently of concern in Hesse.

The Asian bush mosquito *(Aedes japonicus)* has established itself in neighbouring German states and first sightings have been confirmed in Hesse. This species is relatively tolerant to cold temperatures and can successfully breed in small bodies of water in our latitudes, such as cemetery vases. It is still unclear whether local populations can transmit diseases. However, they were successfully infected with the Japanese encephalitis virus and the West Nile virus in laboratory trials.

Asian bush mosquito feeding on blood. © James Gathany, CDC

Asian tiger mosquito. © James Gathany, CDC

From a medical point of view, the Asian tiger mosquito *(Aedes albopictus)* is far more critical: it is a vector of the dengue and chikungunya viruses. It was introduced to Genoa (Italy) in 1990 and favours similar breeding grounds to those of the bush mosquito. It has meanwhile established itself almost throughout the Mediterranean and in parts of Switzerland. Adult specimens of the tiger mosquito have been recorded annually in southern Germany since 2011. Meanwhile, the species is considered to be established in a few places in Germany.

On behalf of the HLNUG, the Senckenberg Biodiversity and Climate Research Centre (SBiK-F) is investigating applicable ecologically sensible and sustainable control measures. The ability of mosquitoes to transmit diseases is to be investigated and their propagation recorded, both nationwide.

Old car tyres, which are traded worldwide, are high-risk goods in terms of the global propagation of tiger mosquito eggs and larvae. Rainwater that collects in the old tyres, which are black and hence warm up rapidly, provides optimal breeding conditions for the mosquitoes.

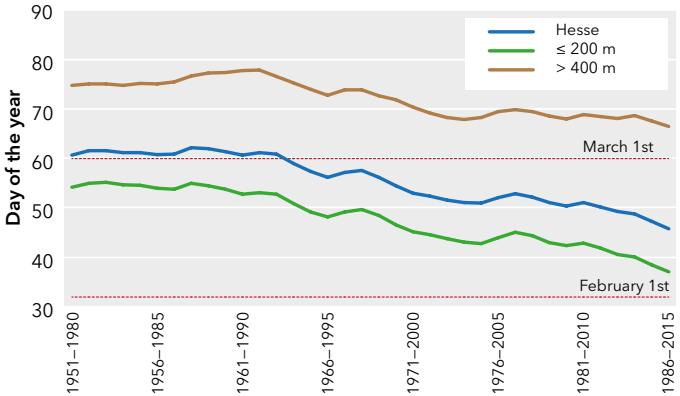
The mosquitoes also travel by road, as 'stowaways' in cars or lorries. For this reason, the HLNUG monitored motorway service stations on the A5 motorway in southern Hesse (from the Bergstrasse – the mountain route – to Frankfurt), which is a gateway for tiger mosquitoes coming from the regions south of the Alps.

In the summers of 2009–2011, the SBiK-F set up ovitraps (see photos) for pregnant females and CO_2 traps for adult males. Neither tiger nor bush mosquitoes were found.

Ovitraps for Asian tiger mosquitoes and Asian bush mosquitoes that resemble small bodies of water. Due to its rough surface, the wooden spatula is the favoured substrate on which the female mosquitoes deposit their eggs.

Pollen count and allergies

The incidence of allergies and asthma in many Western European countries has increased significantly in the last few decades. The expected climate changes will impact the beginning and duration of the pollen season, thus affecting people with allergies too. Rising temperatures cause an earlier flowering season and a longer growing season. Additionally, increased CO_2 concentrations can lead to an increase in pollen production.



Data: DWD. Graph: Ludger Grünhage, JLU Giessen; modified

Graph (left):
Beginning of the flowering season of the hazel (30-year moving average) at Hessian stations at an altitude of ≤ 200 m and > 400 m, and as the average for Hesse. A difference in altitude of 100 m can result in a deviation of 10 days in the beginning of the flowering season.

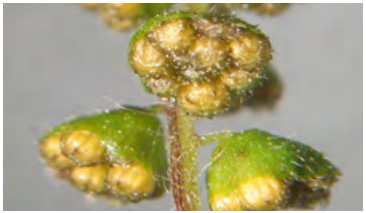
Male catkins and female flowers of the common hazel *(Corylus avellana)*. Their early flowering season marks the beginning of the pollen season here.

© Frank Hecker

The proliferation of some non-indigenous species that can propagate as a result of climate change is considered particularly relevant. A case in point is the invasive common ragweed *(Ambrosia artemisiifolia)*: it can be a strong allergen, produces large quantities of seeds and pollen, and blooms very late (around July to October).

Consequently, the pollen season does not only start earlier in the year, it also lasts well into the autumn. Recent evidence also shows that higher ozone concentrations in the air exacerbate the health problems of people with pollen allergies (see next page).

Above: Common ragweed (also known as annual ragweed) on the edge of a forest



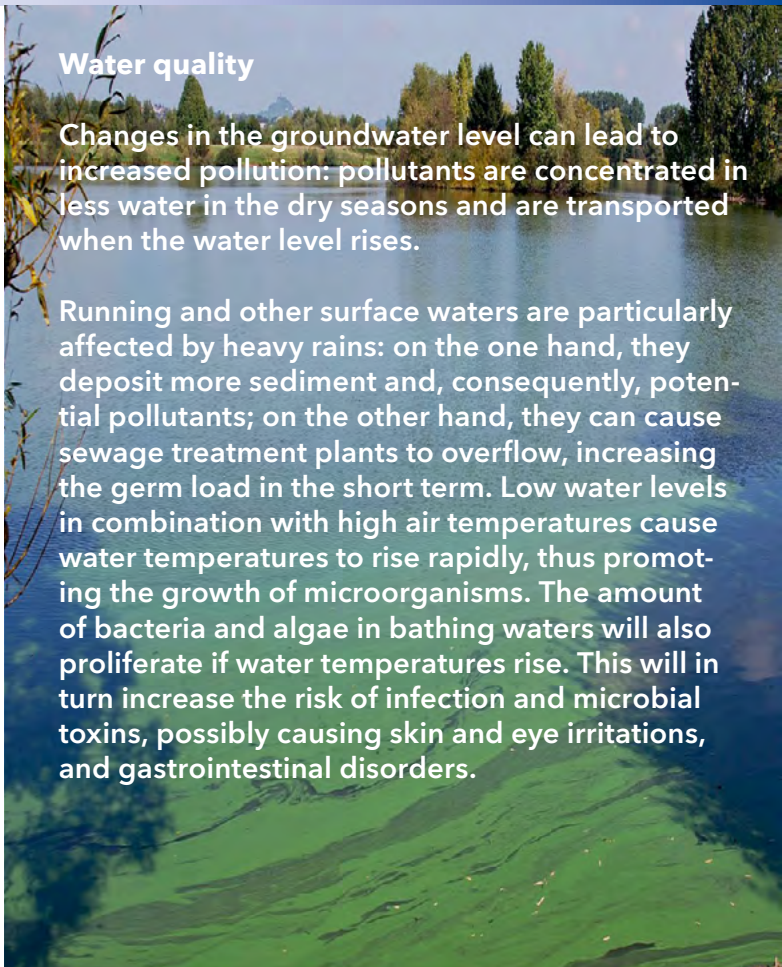
Far left: Inflorescence with male and female flowers
Left top: Female flower heads
Left bottom: Male flower heads
© Beate Alberternst, Stefan Nawrath

Further indirect impacts of climate change

Air quality

Longer periods of fine weather with high temperatures, which can be expected due to climate change, can lead to increased ozone concentration. About 10 % of the population is sensitive to ozone: it irritates the respiratory tract, causes respiratory problems and inflammation, and reduces lung function; it may also cause nausea, dizziness and headaches.

The formation of ground-level ozone depends on precursor chemicals, in particular nitrogen oxides and non-methane volatile organic compounds (NMVOCs) whose emission is largely caused by humans. Admittedly, measures to reduce emissions are having an impact: the incidence and levels of summer ozone peak concentrations have declined significantly, while annual averages have stagnated at an elevated level for about 10 years. However, NMVOC emissions from natural sources (forests) could increase with higher temperatures.



Water quality

Changes in the groundwater level can lead to increased pollution: pollutants are concentrated in less water in the dry seasons and are transported when the water level rises.

Running and other surface waters are particularly affected by heavy rains: on the one hand, they deposit more sediment and, consequently, potential pollutants; on the other hand, they can cause sewage treatment plants to overflow, increasing the germ load in the short term. Low water levels in combination with high air temperatures cause water temperatures to rise rapidly, thus promoting the growth of microorganisms. The amount of bacteria and algae in bathing waters will also proliferate if water temperatures rise. This will in turn increase the risk of infection and microbial toxins, possibly causing skin and eye irritations, and gastrointestinal disorders.

Oak processionary moth

The oak processionary moth is one of the insect pests that prefer higher temperatures and can propagate as temperatures rise. From the third larval stage onwards, this moth's caterpillars are covered with toxic bristles, which can cause skin and eye irritations, respiratory problems and even asthma attacks upon contact or inhalation.

In the last few years, the oak processionary moth has propagated tremendously, primarily in the northeast and southwest of Germany, and meanwhile also in Hesse.

A procession of oak processionary caterpillars. © Nordwestdeutsche Forstliche Versuchsanstalt, Abteilung Waldschutz

Food safety

In principle, food-borne diseases can increase as a result of climate change. Influencing factors are food storage and preparation, sanitary conditions immediately before consumption and also animal husbandry and slaughter.

Higher temperatures favour the proliferation of microorganisms in food and possibly higher infection rates among animals. Consequently, sufficient and uninterrupted refrigeration is becoming increasingly important, particularly in the summer months.

Overall, the extent of food-borne diseases largely depends on prevention and control measures.

Climate change and health in Hesse: Conclusion

We must become aware of and adapt to the impacts of climate change on health. Summers will become warmer; extreme heat will be a more frequent occurrence and probably last longer. The elderly, people with pre-existing conditions and infants are particularly at risk during heatwaves. Potentially elevated levels of UV radiation, floods, storms and lightning in thunderstorms are also direct threats.

A further risk is the establishment and propagation of disease carriers and pathogens. Warm and humid weather is expected to increase tick activity, while long periods of drought hinder it. Tropical mosquitoes, which can transmit new diseases, could establish themselves in our regions. Future developments depend not only on climate change, but also on many other factors.

The pollen season will be longer and the pollen count will probably increase, raising the risk of contact with specific allergens. Consequently, allergic respiratory diseases are expected to increase.

Extreme weather events can reduce the quality of raw water, necessitating further treatment in the production of drinking water. The quality of bathing water can also be affected by rising temperatures.

Diverse and complex interdependencies between climate change and air quality can affect the respiratory tract and lung function.

Some of the impacts of climate change on health can also be reduced by individual behaviour changes.

Further information on the climate in Hesse is available on our websites:

https://www.hlnug.de/index.php?id=10335

http://atlas.umwelt.hessen.de (only available in German)

The following information brochures in the **'Climate Change in Hesse'** series have been published.

- Observed Climate Change
- Climate Change in the Future
- Extreme Weather Events in Hesse
- Climate Change and Water
- Impacts of Climate Change on Human Health
- Agriculture, Forestry and Climate Change
- Observing the Effects of Climate Change – Climate Impact Monitoring
- Hessian Soils under Climate Change

An information brochure for schoolchildren is available in German:

- Have you heard …? The Climate is changing!

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Hessisches Landesamt für
Naturschutz, Umwelt und Geologie

Für eine lebenswerte Zukunft