CLIMATE CHANGE AND HEALTH

SET-UP OF MONITORING OF POTENTIAL EFFECTS OF CLIMATE CHANGE ON HUMAN HEALTH AND ON THE HEALTH OF ANIMALS IN BELGIUM

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1 INTRODUCTION

Over the recent years, scientific consensus has grown that human activity is the most probable cause for climate change in the past decades. In the Fourth Assessment Report (2007) [1], the Intergovernmental Panel on Climate Change (IPCC) projects that, without further action to reduce greenhouse gas emissions, the global average surface temperature is likely to rise by a further 1.8-4.0°C this century, by up to 6.4°C in the worst case scenario. The average temperature in Europe is projected to climb by 1 to 5.5°C.

Climate change is likely to affect a range of geophysical, ecological and socio-economic systems which influence human and animal health including more variable weather, stronger and longer heat waves, more frequent heavy precipitation events, more frequent and severe droughts, extreme weather events such as flooding and tropical cyclones, rises in sea level and increased air pollution. Climate change will not generate new threats, but it will cause more pronounced effects.

Socio-economic, environmental factors and determinants of vulnerability interact with the impact of climate change on human health, e.g. urbanization, housing conditions, quality of medical care and public health systems, wealth, scientific developments, individual behavior and individual vulnerability (e.g., genetic makeup, nutritional status, age, gender, economic status). The assessment of climate change related health effects is therefore complicated. However, evidence of climate change effects on human health worldwide [2-7] shows that climate change is likely to cause:

- increased heat wave-related deaths
- fewer deaths from cold
- increased number of people affected by floods, storms, fires and droughts
- altered range of some infectious disease vectors
- increased burden of diarrheal diseases
- increased aero-allergenic diseases due to altered seasonal distribution of some allergenic pollen species
- increased cardio-respiratory morbidity and mortality associated with ground-level ozone and particulate matter

The potential effects of climate change on animal health have recently been reviewed by the OIE [8]. It was subject of a work package of the Epizone [9] network of excellence and is being investigated as part of the FP6 EDEN project.

2 AIMS AND SCOPE OF THE PROJECT

To reduce the extent of the impact of climate change on public health, mitigation and adaptation strategies and actions are currently being implemented in several countries.
Data collection to monitor health status and disease occurrence is essential in order to follow up threats to public health, to implement action programs and to evaluate the effectiveness of policy measures. In 2008, the Federal Public Service Health, Food Chain Safety and Environment and Belgian Science Policy committed to the first steps towards an indicator-based assessment of the health effects of climate change in Belgium. The aim of this project is therefore to select indicators that allow monitoring of: 1/ potential effects of climate change on human health and 2/ potential effects of climate change on the health of animals. Only livestock animals (cattle , pig, goat, and poultry) are considered. Aquatic animals have not been taken into account within the scope of this project.

Indicators aim to quantify and summarize complex phenomena and are increasingly used as a decision support-tool within management frameworks of complex systems. They enable to verify the status of outcomes, changes, progress of products, and are used as reference points for monitoring, decision-making and evaluation. The process of selecting an indicator takes several steps including brainstorming ideas, assessing each one and narrowing the list (using the criteria below) and, finally, making an indicator monitoring plan. Potential indicators should be based on scientific rigor and relevance and need to be evaluated in their ability to serve as a decision-support tool [10]. Depending on the purpose, different quality criteria can be used to select relevant indicators. The transparency in the process of evaluating and selecting indicators can be enhanced by clearly documenting the qualities of the indicators as well as the scientific background and the related uncertainties. Indicators should ideally be selected in a dynamic interactive and iterative process building on consultations with stakeholders and policy-makers.

Within the framework of this project, the selection of the indicators was carried out in a three-step procedure:

(1) Inventory of health effects
In a first step, we inventoried health effects potentially related with climate change. The inventory was based on international reports and publications and on the relevance for Belgium according to the projections of IPCC. Collaboration with WHO was initiated. Both direct and indirect impacts of climate change on health were reviewed. Main topics included (a) heat waves, (b) cold spells, (c) extreme weather, (d) air quality related mortality and morbidity, (e) ultraviolet radiation, (f) food- en waterborne diseases, (g) vector-borne and zoonotic diseases, and (h) aero-allergenic diseases. For each of these topics, we summarized the health effects that may result from climate change, with a special attention on the pathways (direct/indirect) by which these effects may take place as well as on possible confounding factors and on vulnerability factors.

(2) Construction of a list of indicators
Based on the inventory of health effects, a list of indicators, allowing for the monitoring of these health effects, was constructed. This resulted in a list of indicators theoretically relevant for Belgium. The pertinence of the indicators, their associated uncertainties and their format as a decision-tool were reviewed by an audience of experts and stakeholders at an

international workshop (Brussels, March 31st 2009) and accepted as the foundation for further work.

(3) Priority analysis of indicators

In a third and last phase, a priority analysis of indicators that should be monitored or for which data should be collected was carried out. This analysis was based on:

- Scientific evidence (as described in Chapter 3)
- Policy relevance, in accordance with international reports and initiatives (as described in Chapter 4) and as agreed upon during the above-mentioned international workshop
- Aspects of data-availability. To this purpose, an inventory of the available information was made to enable the indicator-based assessment. This task consisted in the identification of the actors (institutes, administrations,…) which can deliver data, the identification of on-going initiatives that may be integrated, the assessments of aspects related to data-delivery such as costs, level at which data are available, readiness to deliver data, … In addition, missing information for indicators has been identified.

3 HEALTH IMPACT OF CLIMATE CHANGE

Climate change causes weather changes (temperature, precipitation, extreme weather) that:

- **directly** influence human and animal health: heat wave related mortality and morbidity and health effects related to extreme weather events
- **indirectly** influence human and animal health: health effects related to air pollution, aero allergenic diseases, water- and food-borne diseases and vector- and rodent-borne diseases

as illustrated in Figure 1.

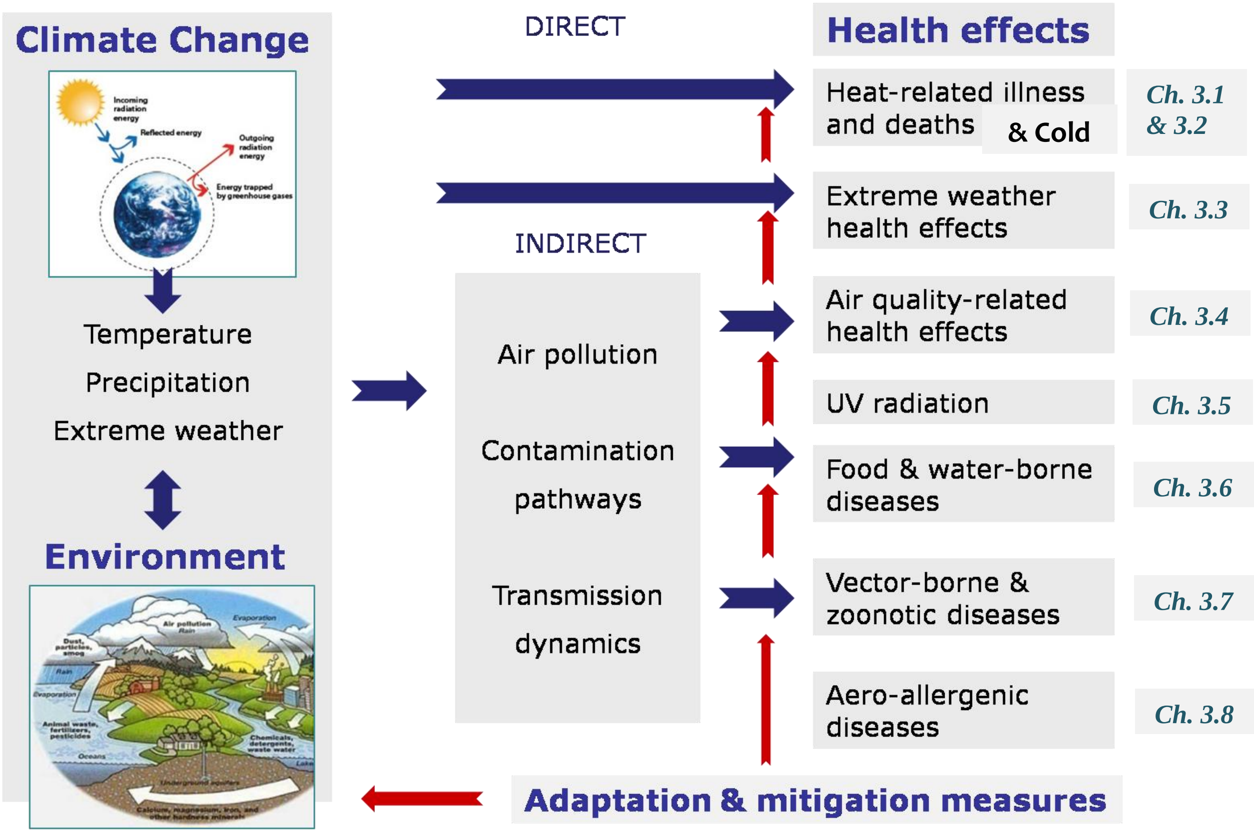

Figure 1 Direct and indirect effects of climate change on health.
Adapted from Patz et al, 2000 [11]

In order to describe the 6 health effects related to climate change adequately, the following subsections are provided:

(1) a short definition
(2) the projections for the 21st century for Europe according to IPPC [1, 2, 12]
(3) health issues
(4) environmental factors
(5) determinants of vulnerability
(6) possible indicators

Indicators are listed in tables including also the parameters needed to monitor the possible indicators. Each parameter has been given a code [P1-P14], referring to Chapter 5 where these codes are used in the files on data-availability.

The projections for climate change in the IPCC reports [12] are based on socio-economic scenarios and climate models. Estimates of the confidence levels in the assessment of the projected changes and likelihood of the impacts in climate change events are used to describe uncertainty. Uncertainty refers to situations in which the appropriate data might be fragmentary or unavailable. Dealing effectively with the communication of uncertainty is an important goal for the scientific assessment of long-term environmental policies. The degree of consensus among the available studies is a critical parameter for the quality of information. The description of uncertainties is important for decision-makers to prioritize and to create adaptation plans: e.g. priority for action will be higher for an event occurring virtually certain and with very high confidence of the model predicting the event. In this report, the IPCC terminology is adopted.

A level of confidence, as defined in Table 1, is used to describe uncertainty that is based on expert judgment with regard to the correctness of a model, an analysis or a statement.

Table 1 IPCC, level of confidence

Terminology	Degree of confidence in being correct
Very high confidence	At least 9 out of 10 chance of being correct
High confidence	About 9 out of 10 chance
Medium confidence	About 5 out of 10 chance
Low confidence	About 2 out of 10 chance
Very low confidence	Less than 1 out of 10 chance

Likelihood, as defined in Table 2, describes the probability of a defined outcome having occurred or occurring in the future.
Likelihood may be based on quantitative analysis or an elicitation of expert views.

Table 2 IPCC, likelihood scale

Terminology	Likelihood of the occurrence (probability)
Virtually certain	>99%
Very likely	>90%
Likely	>66%
About as likely as not	33 to 66%
Unlikely	<33%
Very Unlikely	<10%
Exceptionally unlikely	<1%

3.1 HEAT WAVES

Climate change can directly affect health due to projected higher temperatures [13, 14]. Hyperthermia occurs following exposure to heat, e.g. during a heat wave. Impaired thermoregulation mechanisms due to excessive environmental heat can cause heat-related illnesses and mortality (Figure 2).
The hot summers of 2003 and 2006 caused an increase of all-cause mortality in Belgium, with estimates of 1230 additional deaths during the heat periods of 2003 [15] and around 1263 excess deaths during the heat periods of 2006 [16].

Heat waves provoke stress in animals, but provided they have a shelter place, adequate ventilation and fresh water, livestock animals are rather resistant to heat [17].

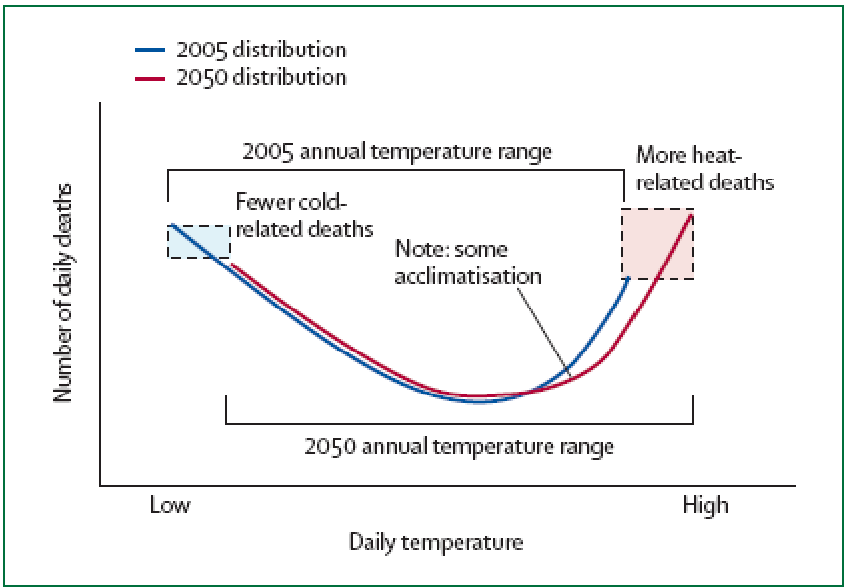

Figure 2 Distribution of temperature related mortality, McMichael et al., 2006 [7]

3.1.1 DEFINITIONS

No global definition for heat waves is available.
In Belgium, two definitions are used:

- Retrospective definition from the Royal Meteorological Institute: a period of 5 consecutive days with a maximum daily temperature of 25°C or more (summer days) AND with a 3 day-period of 30°C or higher (tropical days).
- Prospective definition used by the federal heat plan “Heat waves and Ozone peaks” [18]: a period with a predicted minimum temperature of 18.2°C or more (average for the 3 days) AND a maximum temperature of 29.6°C or higher.

3.1.2 Projections for the 21st century for Europe

Projections by the Intergovernmental Panel on Climate Change (IPCC) predict more erratic weather. By the end of this century, the average temperature in all seasons in Europe is projected to climb by 1 to 5.5°C. Heat waves will occur more often; therefore estimates are that heat-related mortality could increase in the following decades.

It is '**very likely**' (*>90% probability)* that the following changes or phenomena will occur in the 21st century [2]:

- More frequent heat waves and warm spells
- More warm and hot days and nights

3.1.3 Human Health

3.1.3.1 Health Issues

Several health outcomes [18-20] are related with heat waves as listed in Table 3. A list of possible symptoms is given for each health outcome, to describe the gradation of the illness.

Table 3 Heat wave related health outcomes

Health effects	Cause	Symptoms
Sun Stroke	exposure of the head to the sun	head ache sleepiness unconsciousness high fever sun burns
Heat Cramps	dehydration following physical activity, heavy sweating decreases electrolytes and salts	muscle spasms (abdominal, extremities)
Heat Exhaustion	after several days of exposure to high temperatures, dehydration	dizziness, sweating profusely muscle weakness nausea sleeplessness
Heat Stroke	prolonged exposure to high temperature, in case of disturbed thermoregulation following (medical) conditions and medication that impair the ability to sweat	high body temperature hart rhythm warm, red and dry skin head ache nausea spasms unconsciousness coma death

3.1.3.2 Environmental factors

Ambient concentrations of particulate matter (PM) and ozone: exposure to ozone or PM during a heat wave has been shown to cause excess mortality and therefore may confound the relationship between temperature and morbidity/mortality [21, 22].
Urban areas are significantly warmer than surrounding rural areas, a phenomenon called 'Urban heat island'[6, 23].

3.1.3.3 Determinants of Vulnerability

Vulnerability to heat depends on climate factors (such as the frequency of heat waves) and on individual risk factors, including medical, behavioral and environmental factors [18, 24]:

- age
- impaired cognition, such as dementia
- pre-existing disease
- use of certain medications
- level of hydration
- living alone
- housing conditions

3.1.3.4 Possible indicators

Based on the above-mentioned health issues related to heat waves, a set of potential indicators is formulated. Parameters needed to monitor the indicator are listed in Table 4.
Generally, to study the effects of heat, temperature is used as a measure, sometimes adjusted for humidity. In the USA and in some European studies, the effect of apparent temperature is used, which is a thermal discomfort index combining air temperature and humidity [25].

Table 4 Possible indicators to monitor heat related mortality and morbidity in humans

Indicator		Parameters
Heat related mortality	**Total mortality**	Maximum and minimum daily temperature **[P1]** Average daily temperature **[P1]** Number of deaths (age categories): daily **[P2]**
	Cause-specific mortality	Maximum and minimum daily temperature **[P1]** Average daily temperature **[P1]** Number of deaths (age categories) cause-specific: daily cardiovascular diseases, stroke, cardiac diseases, respiratory diseases, cardiopulmonary diseases **[P3]**
Heat related morbidity	**Emergency hospital admissions**	Maximum and minimum daily temperature **[P1]** Average daily temperature **[P1]** Total emergency hospital daily admissions **[P4]**
	Cause-specific emergency hospital admissions	Maximum and minimum daily temperature **[P1]** Average daily temperature **[P1]** Emergency hospital daily admissions for heat-related illnesses: cardiovascular diseases, stroke, cardiac diseases, respiratory diseases, cardiopulmonary diseases, heat stroke **[P5]**

[P] *refers to Chapter 5 where the codes are used in the files on data-availability.*

3.1.4 Animal Health and production

Relevant indicators need to be developed for both the potential effects of heat on animal health as on the effects on *animal production*.

3.1.4.1 Animal health and production issues

Table 5 Heat related health and production outcomes

Health effect	Cause
Decreased food intake	Disturbed thermoregulation, hyperthermia, dehydration
Increased water intake	
Decreased milk production	
Decreased growth (broiler)	
Decrease in meat quality	
Decreased egg production	
Decreased fertility	
Decreased reproduction performance	
Death	

3.1.4.2 Environmental factors

/

3.1.4.3 Determinants of Vulnerability

- Species (cattle, pig, poultry...)
- Race/breed
- General health condition
- Housing condition
- Dehydration level

3.1.4.4 Possible indicators

Table 6 Possible indicators to monitor heat related mortality and morbidity in animals

Indicator	Parameters
Heat-stress	Temperature (Maximum daily air temperature, minimum daily air temp, mean daily temp) Temperature humidity index (THI): indicator for potential heat stress
Heat wave related decreased production	Meat quality, carcass quality Milk production Egg production
Heat wave related mortality	Mortality: Carcass processing at RENDAC

3.2 Cold Spells

Climate change can directly affect health due to projected higher temperatures [13, 14]. Exposure to cold, e.g. during a cold spell, may cause hypothermia. Impaired thermoregulation mechanisms due to cold can cause cold-related illnesses and mortality (Figure 2). Since climate change will increase the average temperature a decrease in cold spells is expected [26].

3.2.1 Definition

The Royal Meteorological Institute of Belgium defines a cold spell as a 5 day period with:

- A minimum daily temperature below zero
- The maximum daily temperature is below zero for at least 3 days

3.2.2 Projections for the 21st century for Europe

By the end of this century, the average temperature in all seasons in Europe is projected to climb by 1 to 5.5°C [1]. Winters will be warmer and milder; therefore morbidity and mortality due to cold spells will decrease in the following decades.

It is '**very likely**' (*>90% probability)* that the following changes or phenomena will occur in the 21st century [1]:

- Higher minimum temperatures
- Fewer cold days and frost days

3.2.3 Human Health

3.2.3.1 Health Issues

Hypothermia is associated with cold-spells. A list of *possible* symptoms is given to describe the gradation of the illness in Table 7 [20].

Table 7 Cold related health outcomes

Health effects	Cause	Symptoms
Hypothermia	Exposure to cold	exhaustion confusion memory loss / slurred speech drowsiness hyperventilation low blood pressure bradycardia death

3.2.3.2 Environmental factors

The relationship between temperature and morbidity/mortality may be confounded by air pollution levels. Ambient concentrations of particulate matter (PM) has been shown to cause excess mortality and therefore may confound the relationship between temperature and morbidity/mortality [27].

3.2.3.3 Determinants of Vulnerability

Vulnerability to cold depends on climate factors and on individual risk factors, including medical, behavioral and environmental factors [28, 29].

- Age (elderly and children)
- Illnesses: heart, lung, central nerve system
- Dependency on others to get warmed (elderly or babies)
- Socio-economic: homeless, poorly insulated houses, socially isolated situation
- Influenza-epidemic

3.2.3.4 Possible Indicators

Based on the above-mentioned health issues related to cold spells, a set of potential indicators is formulated. The parameters needed to monitor the indicator are also listed in Table 8.
In the USA and in some European studies, the effect of apparent temperature is used, which is a thermal discomfort index combining air temperature and humidity [25].

Table 8 Possible indicators to monitor cold related mortality and morbidity in humans

Indicator		Parameters
Mortality	Total mortality	Maximum and minimum daily temperature **[P1]** Average daily temperature **[P1]** Number of deaths (age categories): daily **[P2]**
	Cause specific mortality	Maximum and minimum daily temperature **[P1]** Average daily temperature **[P1]** Number of deaths (age categories) cause-specific: daily **[P3]**
Morbidity	Total emergency hospital admissions	Maximum and minimum daily temperature **[P1]** Average daily temperature **[P1]** Total emergency hospital admissions **[P4]**
	Cause specific emergency hospital admissions	Maximum and minimum daily temperature **[P1]** Average daily temperature **[P1]** Emergency hospital admissions for cold-related illnesses **[P5]**

[P] *refers to Chapter 5 where the codes are used in the files on data-availability.*

3.2.4 ANIMAL HEALTH

3.2.4.1 Health Issues

Table 9 Cold related mortality and morbidity in animals

Health Effect	Health effects
Cold-related stress	Disturbed thermoregulation, hypothermia
Morbidity	Frostbite (ears, tail, udder…)
Mortality	

3.2.4.2 Environmental factors

/

3.2.4.3 Determinants of vulnerability

- Species
- Breed / race
- Age
- Health status: livestock animals are quite resistant to cold, but are more vulnerable in adverse weather condition (humidity, wind)

3.2.4.4 Indicators

Table 10 Possible indicators to monitor cold related mortality and morbidity in animals

Indicator	Parameters
Cold-wave related mortality	Temperature (Maximum daily air temperature, minimum daily air temp, mean daily temp) Mortality: Carcass admission at RENDAC
Cold-wave related morbidity	Temperature (Maximum daily air temperature, minimum daily air temp, mean daily temp) Frozen body-parts

3.3 EXTREME WEATHER

Climate change can directly affect health due to projected increase of extreme weather events. In recent decades, a global upward trend in natural disaster occurrence is reported, mainly due to an increase in hydrological (floods) and meteorological (storms) disasters. However, the Royal Meteorological Institute did not register an increase for Belgium until now [30].

3.3.1 DEFINITIONS

Extreme weather includes weather phenomena that are at the extremes of the historical distribution, especially severe or unseasonal weather.

The Emergency Events Database (EM-DAT) [31] of the WHO collaborating Centre for Research on the Epidemiology of Disaster (CRED) includes disasters from around the world, both natural and man-made, from 1900 to present that fulfill any one of the following criteria:

- 10 or more people reported killed
- 100 or more people reported affected
- a declaration of a state of emergency
- a call for international assistance

Categories of natural disasters as used by the CRED are shown in Figure 3. Only the occurrence of hydro-meteorological disasters are discussed in this chapter.

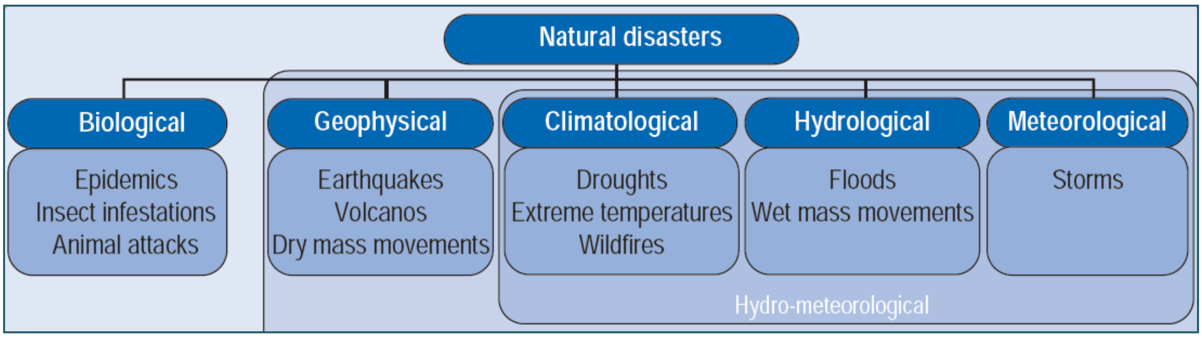

Figure 3 Categories of disasters [32]

3.3.2 PROJECTIONS FOR THE 21ST CENTURY FOR EUROPE

Projections by the Intergovernmental Panel on Climate Change (IPCC) predict more erratic weather globally. The frequency and intensity of extreme weather events are expected to change. It is '**likely**' (*>66% probability)* that the following changes or phenomena will occur in the 21st century [1, 2]:

Winter floods are likely to increase in maritime regions and flash floods are likely to increase throughout Europe. Coastal flooding related to increasing storminess and sea-level rise is likely to threaten Europe. It is likely that the seasonality of precipitation will change and the frequency of intense precipitation events will increase, especially in winter.

Fire danger due to drought is likely to increase in central, eastern and northern Europe.

Change in storm intensity and winds is '**more likely than not**' (*>50% probability*)**.**

3.3.3 Human Health

3.3.3.1 *Health Issues*

Health outcomes related with extreme weather events are listed in Table 11 [33-35]. Extreme weather events may also indirectly increase infectious diseases, toxic contamination, vector-borne diseases and water- and food-borne diseases.

Table 11 Health impact of extreme weather events

Health Effect	Cause
• **Mental health problems** • **Injuries** • **Deaths**	Heavy precipitation events, floods • general floods • flash floods • coastal flood • storm surge
	Drought, wildfires
	Storms • Tropical cyclone • Local storm • Extra tropical cyclone • Winter storm

3.3.3.2 *Environmental factors*

The relationship between extreme events and health impact may be confounded by land coverage: increase in vegetated surface increases rainwater interception and improves infiltration [36]. Extreme weather events may also interact indirectly with vector abundance [9] and the occurrence of water-borne diseases.

3.3.3.3 *Determinants of Vulnerability*

Vulnerability to extreme events depends on climate factors and on [34, 35]:

- Housing conditions
- Housing location
- Protection & adaptation measures

3.3.3.4 Possible indicators

Based on the above-mentioned health impact related to extreme events, a set of potential indicators is formulated and listed in Table 12.

Table 12 Possible indicators to monitor the health impact of extreme events in humans

Indicator	Parameters
Impact of floods on health	Flood: type & period **[P6]** • general floods • flash floods • coastal flood • storm surge Total number of people affected Number of deaths
Impact of drought on health	Drought period **[P6]** Total number of people affected
Impact of wildfires on health	Wildfire period **[P6]** Total number of people affected Number of deaths
Impact of storms on health	Storm type and period **[P6]** • Tropical cyclone • Local storm • Extra tropical cyclone • Winter storm Total number of people affected Number of deaths

[P] *refers to Chapter 5 where the codes are used in the files on data-availability.*

3.3.4 Animal Health

For Belgium, potential losses are involved due to relocation of animals to safe zones after floods, storms, lightings, drowning,... Extreme weather events may also interact indirectly with vector abundance [9] and the occurrence of water-borne diseases.

3.4 Air Quality related mortality and morbidity

Several studies documented the impact of air pollution on health. Alterations in the atmosphere determine the development, transport, dispersion, and deposition of air pollutants. Therefore, it is expected that climate change will affect the burden of morbidity and mortality associated with air pollution (cardiovascular and respiratory diseases) [37, 38].

Air quality, in return, is an important driving factor (emission of greenhouse gases) for climate change.

3.4.1 Definition

Air quality is defined by the concentrations of air pollutants such as ground-level ozone, particulate matter (PM), sulfur dioxide, carbon monoxide and nitrogen dioxide in ambient air. In this chapter, ozone and PM are discussed.

3.4.2 Projections for the 21st century for Europe

Ozone formation increases with greater sunlight and higher temperature. Climate change is likely (>66% probability) to influence air quality in Europe [1, 2]. Furthermore, climate change will increase cardio-respiratory morbidity and mortality associated with ground-level ozone with **high confidence**.

Climate change will also have an effect on PM concentrations as changes in temperature and precipitation have an impact on gas phase partitioning and deposition of particulate matter. However, in comparison with ozone, assessments of the impact of climate change on PM are few, mainly because less studies are performed [37]. Additional research is needed to better understand the possible impacts of climate change on air pollution-related health impacts.

3.4.3 Human Health

3.4.3.1 Health Issues

Health effects of exposure to particulate matter and ozone are listed in Table 13 [38-43].

Table 13 Air quality related mortality and morbidity

Health effect	Cause
Respiratory illnesses: • Coughing • Decreased lung function • Aggravated asthma • Development of chronic bronchitis **Cardiovascular diseases** **Premature death** **Prenatal exposure**: • Increased risk of low birth weight • Preterm birth • Infant mortality	Particulate Matter
Induction of respiratory symptoms **Decrements in lung function** **Inflammation of airways** **Induction of respiratory symptoms e.g.:** • Coughing • Throat irritation • Chest tightness, wheezing, or shortness of breath **Premature death**	Ozone

3.4.3.2 Environmental factors

The association between climate change and respiratory diseases is confounded by several environmental factors that are important determinants for the concentration of ambient air pollutants [40, 41]:

Particulate matter:
- Emission by transportation, industry, agriculture, energy, households

Ozone:
- Nitrogen oxides and volatile organic compounds emission by transportation, industry, agriculture, energy, households

3.4.3.3 Determinants of Vulnerability

Vulnerability to air quality related illnesses depends on [44]:

- Age (children, elderly)
- Chronic lung and heart disease
- Outdoor labor or exercise

3.4.3.4 Possible indicators

Based on the above-mentioned health impacts related to air quality, a set of potential indicators is formulated and listed in Table 14 [45].

Table 14 Possible indicators to monitor air quality related mortality and morbidity in humans

Indicator	Parameters
All causes mortality	Concentrations of PM **[P7]** and ozone **[P8]** (daily, or 8h average) Number of deaths: all causes: daily **[P2]**
Cause specific mortality	Concentrations of PM **[P7]** and ozone **[P8]** (daily, or 8h average) Number of deaths: respiratory and cardiovascular mortality: daily **[P3]**
Hospital admissions	Concentrations of PM **[P7]** and ozone **[P8]** (daily, or 8h average) Hospital admissions for respiratory and cardiovascular illnesses **[P5]**
Medication sales	Concentrations of PM **[P7]** and ozone **[P8]** (daily, or 8h average) Sales of prescribed anti-asthma & COPD and anti-cough medication **[P9]**

[P] *refers to Chapter 5 where the codes are used in the files on data-availability.*

3.4.4 Animal Health

There are few studies on the effect of air-quality on animal health. Ozone does not induce significant airway inflammation in horses.

3.5 Ultraviolet Radiation

Climate Change can indirectly affect health by the alteration of the level of Ultraviolet (UV) radiation [46]. Small amounts of UV radiation are beneficial for people and essential in the production of vitamin D. Prolonged human exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye and immune system. Ozone, cloud cover, aerosols and ground reflections influence the level of UV radiation. These factors are directly or indirectly related to climate change. Human exposure to UV may therefore be altered by climate change.

3.5.1 Definition

UV light is electromagnetic radiation with a wavelength shorter than that of visible light: UV-C (200-280nm), UV-B (280-315nm) and UV-A (315-400nm). UV light is found in sunlight. The UV spectrum has both beneficial and damaging effects on human health. UV-B light has the most damaging effects.
The UV index, as shown in Figure 4, is an international standard measurement of intensity of UV radiation from the sun, and aims the warning and prevention from harmful effects of UV radiation [47, 48].

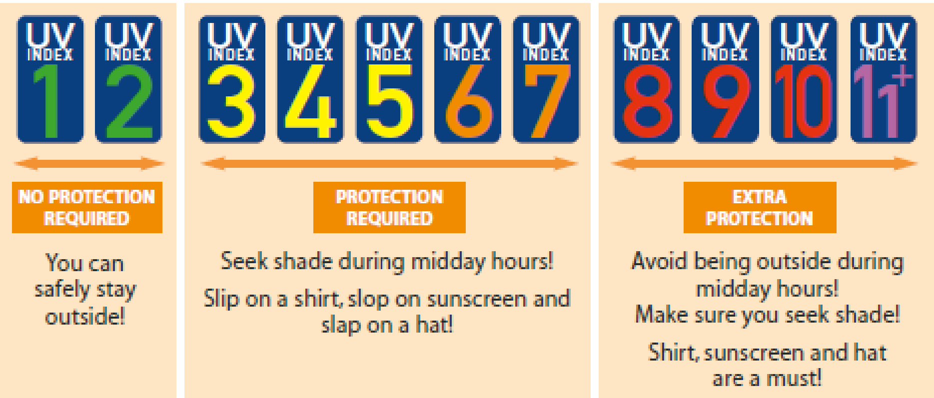

Figure 4 Global Solar UV Index [47]

3.5.2 Projections for the 21st century for Europe

Predictions on future changes of UV radiation are primarily based on the effect of ozone changes. A depleted ozone layer allows more UV radiation to reach the global surface. Ongoing reduction in the use of ozone-depleting substances will lead to the recovery of the ozone layer. However, the level of future consumption of such products is uncertain. Clouds, aerosols, and surface albedo (fraction of reflected sun light by a surface) are also very important and subject to changes in a future climate [2, 49].
Because of the numerous variables that affect UV levels, projections for the 21st century are uncertain.

3.5.3 Human Health

3.5.3.1 Health Issues

Health outcomes, associated with exposure to UV radiation, are listed in Table 15 [47, 50, 51].

Table 15 UV-radiation related health outcomes

Health effect	
On skin	Sunburn Chronic sun damage Photodermatoses Malignant melanoma Non-melanocytic skin cancer: Squamous cell carcinoma and basal cell carcinoma
On eye	Acute photo keratitis and photo conjunctivitis Pterygium (raised, wedge-shaped growth of the conjunctiva) Cortical cataract Squamous cell carcinoma of the cornea and conjunctiva
On immune system	Suppression of cell-mediated immunity Increased susceptibility to infection Activation of latent virus infection (e.g. herpes labialis)

3.5.3.2 Environmental factors

Ozone absorbs UV radiation. In the last decades ozone depletion has been observed, which has led to an increase in ground-level UV dose.
The presence of aerosols in ambient air is also an important environmental modifier of UV radiation [46, 52].

3.5.3.3 Determinants of Vulnerability

Vulnerability to UV radiation depends on climate factors and on individual risk factors [48]:

- Age (children)
- Skin type
- Genetics
- Immune deficiency
- Use of solar beds or sunbathing
- Precautionary measures (sensitization)

3.5.3.4 Possible Indicators

Based on the above-mentioned health issues related to UV-radiation, a set of potential indicators is formulated. The parameters needed to monitor the indicator are also listed in Table 16.

Table 16 Possible indicators to monitor UV-radiation related morbidityin humans

Indicator	Parameters
Malignant Melanoma of skin	Incidence ICD-10 C43 **[P10]**
Other Malignant neoplasms of skin	Incidence ICD-10 C44 **[P10]**

[P] *refers to Chapter 5 where the codes are used in the files on data-availability.*

3.5.4 ANIMAL HEALTH

Increase in UV radiation resulting from ozone depletion is potentially harmful for animals. The following diseases are likely to increase:

- Squamous cell carcinoma of exposed non-pigmented areas
- Keratoconjunctivitis
- Melanoma
- Photosensitivity [50]

3.5.4.1 Animal health and production issues

Table 17 Possible indicators to monitor UV-radiation related morbidity in animals

Impact	Cause	Species affected	Symptoms/Effects
Squamous cell carcinoma in exposed non pigmented areas		Ruminants (Bovine, caprine, ovine), horses	Eye cancer (eye and eyelids), horn cancer
Infectious keratoconjuctivitis (pinkeye)	*Moraxella bovis* (primary infectious bacteria)	Bovine Caprine/ovine	Inflammation of the cornea and conjunctiva Reduced weight gain Decreased milk production Devaluation of sale animal
Melanoma **Melanocytomas**		Porcine Horses, Ruminants	
Photosensitivity	Skin sensitive to UV light due to the presence of a chemical		Skin damage and loss on (hairless) sites exposed to direct sunlight Liver damage Economic loss

3.5.4.2 Environmental factors

UV-depletion: Thickness stratospheric ozone layer

3.5.4.3 Determinants of Vulnerability

- Species/breed (e.g. Hereford, white-faced Friesian, …)
- Genetic factors
- Nutrition
- Immunodeficiency

3.5.4.4 Possible indicators

Table 18 UV-related related indicators in animals

Indicator
Incidence squamous cell carcinoma of exposed non pigmented areas
Incidence infectious keratoconjuctivitis (New Forest disease/Pink eye) (cattle)
Incidence melanoma
Incidence photosensitivity

3.6 Food- and water-borne diseases

Climate change can indirectly affect health by projected increase of food- and water-borne diseases through alterations in temperature and precipitation [53].
Many illnesses are contracted through contaminated food and water. Climate change is likely to increase temperature and precipitation, hence influencing the risk of food– and waterborne diseases.

3.6.1 Definition

Food-borne illnesses are defined as diseases, usually either infectious or toxic in nature, caused by agents that enter the body through the ingestion of food.
Water-borne illnesses are caused by agents entering the body through ingestion of water (drinking, recreational or coastal water).

3.6.2 Projections for the 21st century for Europe

Rainfall patterns can influence the transport and dissemination of infectious agents; temperature can affect their growth and survival. Thus, pathogens that are transmitted by food or water may be susceptible to changes in persistence, survival, replication and transmission due to climate change phenomena such as temperature increase, precipitation, extreme weather events and season's length.
Climate change is expected to (indirectly) increase the burden of diarrheal diseases with **medium confidence [1, 2]**.

3.6.3 Human Health

3.6.3.1 Health Issues

Water and food-borne diseases that might increase in Europe are listed in Table 20 [53-58]. The selection is based on the inventory from a consensus report of the European Centre for Disease Prevention and Control, following an expert workshop on linking environmental and infectious diseases data (Sigtuna, 2008). From this inventory, we selected diseases influenced by climate factors e.g. water, air temperature and/or heavy rainfall as presented in Table 19 [54].

Table 19 Food and water-borne diseases

Health effect	Water/Food	Climate factor
Salmonellosis	Food	Surface water and air temperature increase; heavy rainfall
E. Coli infection	Water/Food	Surface water and air temperature increase; heavy rainfall
Campylobacteriosis	Water/Food	Heavy rainfall

Health effect	Water/Food	Climate factor
Cryptosporidiosis	Water	Heavy rainfall
S. Aureus infection	Food handling	Air temperature increase
Shigellosis	Water/Food	Air temperature increase
Giardiases	Water	Heavy rainfall
Yersiniosis	Water/Food	Air temperature increase; heavy rainfall
Amoebiasis ***(entamoeba histolytica)***	Water	Heavy rainfall
Cholera	Water	Surface water and air temperature increase
Legionellosis	Water	High temperature; humidity

3.6.3.2 Environmental factors

The incidence of water and food-borne diseases is influenced by increased mobility, namely travelling and food-import [53].
Eutrophication, an increase in the concentration of chemical nutrients in an ecosystem, has an impact on the incidence of water-and food-borne diseases.

3.6.3.3 Determinants of Vulnerability [56]

- Handling, preparation, storage of foods
- Hygiene practices
- Age
- Malnutrition
- Immune system

3.6.3.4 Possible indicators

The incidence of the above-mentioned water- and food-borne diseases (Table 19) in relation to temperature and/or precipitation **[P11]**.

3.6.4 Animal Health

3.6.4.1 Health Issues

Among the food- and water-borne diseases, helminth diseases should receive special attention since they may be influenced by climate change and often constitute a burden to animal health [8].

Table 20 Food and water-borne diseases

Health effect	Pathogen	Zoonosis	Intermediate Host (IH)/ vector	Species affected
Fasciolasis	*Fasciola hepathica*	X	Freshwater lymnaeid snail	Bovine, caprine, Ovine, (Horses)
Echinococcoses	*Echinococcus multilocularis*	X	Small rodents	Foxes
Heterakiasis	*Heterakiasis gallinarum*			Chicken, Turkey
Trichostrongy-liases	*Trichostrongylus* spp. *Haemonchus contortus*			Bovine, caprine, ovine Ovine
Salmonellosis	*Salmonella* spp.	X		Pig, cattle, poultry

3.6.4.2 Environmental factors

- Water quality
- Landscape (grassland, pastures, rivers)

3.6.4.3 Determinants of Vulnerability

- General health condition
- Species – race
- Age
- Immunological status

3.6.4.4 Possible indicators

Incidence of the above-mentioned water- and food-borne diseases.

3.7 VECTOR-BORNE AND ZOONOTIC DISEASES

Shifts in the distribution of several species are partially associated with climate change, although many non-climate change factors must be taken into account such as population changes, land use, travelling, and migration. Changes in distribution of vectors may alter transmission of infectious diseases [59, 60].

3.7.1 DEFINITION

Vector-borne diseases are infectious diseases, caused by pathogenic agents transmitted from an infected individual to another individual by an arthropod, other invertebrate or rodent. Intermediary hosts such as domesticated or wild animals often serve as a reservoir for the pathogen until susceptible animal populations are exposed.

A zoonotic disease or zoonosis is caused by pathogenic agents that are transmitted from vertebrate animals to humans.

3.7.2 PROJECTIONS FOR THE 21ST CENTURY FOR EUROPE

Important properties in the transmission of vector-borne diseases are survival and reproduction rate of the vector, time of year and level of vector activity, rate of development and reproduction of the pathogen within the vector.
Changes in season's length, precipitation, humidity and temperature may affect the distribution and survival chances of both vectors and pathogens. Therefore, climate change is expected to indirectly change the range of some infectious disease vectors with **high confidence [1, 2]**.

3.7.3 HUMAN HEALTH

3.7.3.1 Health Issues

Vector-borne diseases that might increase or be introduced in Europe/Belgium are listed in Table 21 [60-62]. The selected diseases are known to be associated with environmental changes, which alter the geographical distribution.

Table 21 Vector-borne and zoonotic diseases of importance for human health

Health effect	Pathogen	Vector	Present in Europe/Belgium
Leishmaniasis	Protozoa: *Leishmania*	*Phlebotomus species* (sand fly)	**Europe:** vector and pathogen in Southern Europe, Germany, UK **Belgium:** vector (llimited, not well known)
Malaria	Protozoa: Plasmodium falciparum, *Plasmodium vivax*, *Plasmodium malariae,* and *Plasmodium ovale.*	*Anopheles maculipennis complex: Anopheles atroparvus* (mosquito). *Anopheles plumbeus* (might be a vector of falciparum malaria)	**Europe:** Vector. Disease is eliminated (also in Belgium) since the late 40's. **Belgium:** vector
Tick borne encephalitis	Tick borne encephalitis virus - *Flaviviridae* family	*Ixodes ricinus* (ticks)	**Europe:** vector and pathogen in East and central Europe **Belgium:** vector
St Louis Encephalitis	St Louis Encephalitis virus is a *flavivirus -Flaviviridae* family	*Culex pipiens* and other mosquito species	**Europe:** vector **Belgium:** vector
West-Nile fever and encephalitis	West nile *virus* is a *flavivirus* - *Flaviviridae* family	*Culex pipiens* and other mosquito species	**Europe:** vector and pathogen in Southern and Eastern **Belgium:** vector
Dengue fever	Dengue virus is a *flavivirus* - *Flaviviridae* family	*Aedes aegypti* or more rarely the *Aedes albopictus* (mosquito)	**Europe:** vector **Belgium:** vector *(Aedes albopictus: reported in 2000, not in MODIRISK[63])*
Yellow fever	Yellow fever virus is a flavivirus - *Flaviviridae* family	*Aedes* and *Haemogogus* (South-America)	**Europe:** vector **Belgium:** vector
Crimean-Congo hemorrhagic fever	Crimean-Congo hemorrhagic fever virus is a *Nairovirus* - *Bunyaviridae* family	*Hyalomma spp.*(ticks)	**Europe:** Eastern **Belgium:** vector
Hantavirosis *(zoonosis)*	*Hantavirusses* - *Bunyaviridae* family • Puumala virus • Dobrava virus • Saaremaa virus	Small rodents: → *Clethrionomys glareolus* (bank vole) → *Apodemus flavicollis* (yellow necked mouse) → *Apodemus agrarius* (striped field mouse)	**Europe:** Puumala virus: vector and pathogen **Eastern and central Europe**: Dobrava and Saaremaa vector and pathogen **Belgium:** Puumala virus vector and pathogen: virus causing Nephropathia epidemica
Rift valley fever *(zoonosis)*	Rift valley fever virus is a *Phlebovirus- Bunyaviridae* family	*Aedes* mosquito or contact with blood/organs of infected cattle and rodents (animals are infected by mosquitoes: *Anopheles, Aedes, Culex*)	**Europe:** vector **Belgium:** vector
Chikungunya disease	Chikungunya virus is an *alphavirus* – *Togoviridae* family	*Aedes aegypti* or *Aedes albopictus* (mosquito)	**Europe:** vector **Belgium:** vector

Health effect	Pathogen	Vector	Present in Europe/Belgium
Lyme Borreliosis or Lyme disease	*Borrelia burgdorferi* bacteria	*Ixodes ricinus* or *persulcatus* (ticks)	**Europe:** vector and pathogen **Belgium:** vector and pathogen
Leptospirosis	*Leptospira spp*. (bacterial)	Rodents, dogs and other mammals	**Europe:** vector and pathogen **Belgium:** vector and pathogen
Other Japanese Encephalitis Schistosomiasis Onchocerciasis African trypanosomiasis American trypanosomiasis	 Japanese encephalitis virus *Schistosoma*, helminth *Onchocerca volvulus*,helminth *Trypanosoma brucei*, protozoa *Trypanosoma cruzei*, protozoa	 *Culex tritaeniorhynchus* (mosquito)	 **Europe:** no **Belgium:** no

3.7.3.2 Environmental factors

Land use and land coverage, deforestation, land clearance and urbanization have an important impact on the distribution patterns of vector-borne diseases [61].

3.7.3.3 Determinants of Vulnerability

Vulnerability to vector-borne diseases depends on globalization and population mobility (travelling), living conditions, human behavior [64].

3.7.3.4 Possible indicators

The incidence of the above-mentioned vector-borne and zoonotic diseases **[P12]**. The presence of the vectors of the above-mentioned vector-borne diseases in Belgium can be monitored, as performed in the MODIRISK project, studying biodiversity of mosquitoes and monitoring and predicting its changes [63]. A combination of approaches taken by specialists in the biology and ecology of vectors and diseases and those of modeling teams, may enable to understand the effects of environmental change on disease transmission, and to forecast the consequences [61] as shown in the EDEN project (see Chapter 4). Indicators are important to follow risks and guide control/preventive measures. But a change in these indicators does not directly imply a potential impact of climate change.

3.7.4 Animal Health

Many important animal diseases may be indirectly affected by climate change [9, 65, 66].

Table 22 Vector-borne and zoonotic diseases of importance for animal health

Health effect	Pathogen	Zoonosis	Vector	Species affected	Present In Europe/ Belgium
Bluetongue	Bluetongue Virus (BTV serotypes, Orbovirus)		Midges of *Culicoides* spp. (*Culicoides obsoletus* s.l.; *C. pulicaris ; C. chiopterus ; C. dewulfi*)	Ruminants	**Mediterranean Europe:** BTV 1, 2, 4, (8), 9, 16 **Temperate Europe:** BTV 1-(6)-8-(11) **Belgium:** Vector and pathogen BTV (1), 8, (11) present
Rift Valley fever	RVFV, Genus *Phlebovirus* (Bunyaviridae)	X	Mosquitoes of *Aedes* spp. Secondary *Culex* and *Anopheles* spp.	Ruminants (cattle, ovine, caprine), Humans	**Europe:** vector, no pathogen **Belgium:** Vector
West Nile Fever	West Nile Virus (Arbovirus of the Flaviridae)	X	Essentially mosquitoes of *Culex* spp.	Birds Horses Humans	**Europe:** vector, pathogen (France, UK,..) **Belgium:** Vector, no pathogen
Visceral leishmaniasis	*Leishmania Tryponosomatidae* (Protozoa,) *L. infantum*	X	Sandfly species (Phlebotominae (Diptera)	Domestic dogs, wild canids	**Europe:** vector, pathogen (Southern Europe, Germany, France, UK,..) **Belgium:** vector, no pathogen
African Horse sickness	Orbivirus		Midges *Culicoides imicola; C. obsolerus, pulicaris*	Horse (Equidae)	**Europe:** vector, no pathogen **Belgium**: vector, no pathogen High risk for animal health and huge economic risk
Crimean-Congo hemorrhagic fever (CCHF)	CCHF virus (Nairovirus, Bunyaviridae)	X	*Hyalomma* spp. ticks	Ruminants (sheep, goat,cattle) Ostriches Humans	**Europe:** vector, pathogen **Belgium**: no vector, no pathogen

Health effect	Pathogen	Zoonosis	Vector	Species affected	Present In Europe/ Belgium
Babesiosis	*Babesia divergens,* *B. microti,* *B. venotorum*	X	*Ixodes ricinus* ticks	Ruminants Humans	**Belgium:** Vector and pathogen ***B. divergens:* endemic in southern Belgium**
Anaplasmosis (previously ehrlichiosis)	*Anaplasma phagocytophilum*		*Ixodes ricinus* ticks	rodents *Apodemus sylvaticus* (reservoir), sheep, goat, horses, cattle , deer human	**Belgium:** Vector and pathogen
Lyme disease	*Borrelia* spp.	X	*Ixodes ricinus* ticks	Ruminants, dogs, humans	**Belgium:** Vector and pathogen endemic
Leptospirosis	*Leptospira* spp.	X	Rodents, dogs	Dogs, cattle, horses, pigs, sheep	**Belgium:** Vector and pathogen
Dirofilariasis	*Dirofilaria immitis/repens* (helminth)	X	*Aedes albopictus, Culex, Anopheles*	Dog, cat, human	**Belgium:** Vector

3.8 AERO-ALLERGENIC DISEASES

There is considerable evidence to suggest that climate change will have, and has already had, impacts on aeroallergens [38, 67]. These include impacts on pollen amount, pollen allergenicity, pollen season, plant and pollen distribution, and other plant attributes. There is also some evidence of impacts on other aeroallergens, such as mould spores. Health effects that may increase are allergic rhinitis and asthmatic symptoms.

3.8.1 DEFINITION

Aero-allergens are airborne allergens such as pollen or spores, which trigger an allergic reaction.

3.8.2 PROJECTIONS FOR THE 21ST CENTURY FOR EUROPE

It is '**very likely**' *(>90% probability)* that the average temperature will increase in the 21st century [1, 2]. Higher temperatures and lower rainfall at the time of pollen dispersal are **likely** *(>66% probability)* to result in higher concentrations of airborne pollen during the peak season. Distribution of plants may alter, which changes the dispersion of pollen and may allow imported plant species (e.g. ragweed) to be distributed. Spring warming is associated with earlier starting date of pollination.

3.8.3 HUMAN HEALTH

3.8.3.1 Health Issues

Important aero-allergenic plants and health effects caused by exposure to these aero-allergens are listed in Table 23 [68].
Ragweed (Ambrosia) is a widespread allergenic plant in North-America. It is introduced in Europe by import of the seed as winter food for birds. Currently, limited concentrations of ragweed are found in Belgium; however, climate change is expected to cause an increase.

Table 23 Aero-allergens and health effects

Health effect	Cause	
Allergic rhinitis: • irritation of the nose • sneezing • itching • redness of the eyes **Asthmatic symptoms**: • bronchoconstriction • shortness of breath (dyspnea) • coughing • wheezing	Aero-allergens: Trees and bushes : Hazel (*Corylus*) Alder (*Alnus*) Yew and Cypress (Taxus & cuppressaceae) Willow (*Salix*) Poplar (*Populus*) Ash (*Fraxinus*) Hornbeam (*Carpinus*) Birch (*Betula*) Plane (*Platanus*) Oak (*Quercus*) Beech (*Fagus*) Pine (*Pinaceae*) Horse chestnut (*Aesculus*) Linden (*Tilia*) Ragweed (*Ambrosia)* Sweet chestnut (*Castanea*)	Herbaceous plants Sorrels and docks (*Rumex*) Plantain (*Plantago*) Grasses (*Gramineae*) Lamb's quarter (*Chenopodium*) Nettle (*Urtica*) Mugwort (*Artemisia*)

3.8.3.2 Environmental factors

Exposure to air pollutants can also cause asthmatic symptoms and allergic rhinitis [39].

3.8.3.3 Determinants of Vulnerability

Vulnerability to aero-allergenic diseases depends on:

- Age
- Genetics
- Immune system

3.8.3.4 Possible indicators

Possible indicators for the monitoring of aero-allergen related health effects are listed in Table 24. The Belgian Aerobiological Network (Institute of Public Health, IPH) monitors the above-mentioned aero-allergens.

Table 24 Possible indicators to monitor aero-allergens for humans

Indicator	Parameters
Aeroallergen concentrations	Monitoring of pollen and spores **[P13]**
Length / Start of pollen season	Length of the season of aero-allergenic plants **[P13]**
Medication sales	Medication sales of prescribed anti-histamines and anti-asthma medication **[P14]**

[P] *refers to Chapter 5 where the codes are used in the files on data-availability.*

3.8.4 Animal Health

The potential effects of aero-allergens on animal health is unknown. No publications have been found on this topic.

4 HARMONISATION WITH INTERNATIONAL INITIATIVES

Climate Change is a global issue, therefore international cooperation is important. Harmonization with international initiatives is indispensable for selecting suitable indicators for the monitoring of climate change related health effects.
The overview of health effects and proposal of possible indicators in the AGORA project has been based mainly on international consensus reports from e.g. IPCC, EU, WHO.

WHO-Europe is currently conducting the **CEHAPIS** program: Climate, Environment and Health Action Plan and Information System. This international project, co-funded by the European Commission (EC), Directorate General for Health and Consumers (DG SANCO), aims 1/ to assess the health impact of climate change in Europe, 2/ to evaluate the impact of policy options for health adaptation to climate change and 3/ to monitor trends and policies over time by establishing a set of indicators.
The IPH (unit Environment and Health) in Belgium actively participates in the development of health relevant indicators of climate change. A first expert meeting 'Defining health relevant climate change indicators' was organized by WHO in Bonn (DE), 14-15 May, 2009. Indicators of this AGORA project have been selected in accordance with the CEHAPIS program.

EURO-MOMO, European monitoring of excess mortality for public health action, is an EU-wide project aiming to develop, strengthen and harmonize real-time mortality monitoring across Europe. This will enhance the management of serious public health risks such as pandemic influenza, heat waves and cold snaps. Belgium is an important partner in this project, as it belongs to one of the few EU countries with a functional real-time national surveillance system (BE-MOMO). Belgium also participates actively in the pilot study, which started earlier than foreseen because of the influenza epidemic and is currently implemented by 12 other countries. BE-MOMO - Belgian monitoring of all cause mortality - is carried out by the IPH on a weekly basis[69]. Next to the monitoring of deaths, also daily-level information on possible risk factors for mortality is collected each week, such as temperatures (Tmax, Tmin, Tavg), humidity, air pollution (ozone and PM10) and influenza (consultation rate for Influenza-Like Illnesses and Acute Respiratory Infections).

HIALINE, Health Impacts of Airborne Allergen Information Network, is a project funded by the European Union through the Executive Agency for Health and Consumers. The objectives of the project are 1/to evaluate the effects of climate diversity and change on airborne allergen exposure, and 2/to implement an outdoor allergen early warning network. Belgium does not participate in the project.

The fifth Framework Programs for research have provided support to a number of projects in the field of climate change. The **PHEWE** project (Assessment and Prevention of acute Health Effects of Weather Conditions in Europe) investigated the association between meteorological variables during the warm season and acute health effects (mortality, hospital admissions) in 17 large European cities, and used these results to develop preventive strategies. In the **cCASHh** program (Climate Change and Adaptation Strategies for Human Health in Europe) impact and adaptation assessment were used for health effects of heat and cold, of extreme weather events, vector-borne and rodent-borne diseases and of infectious water-borne and food-borne diseases.

In the Sixth Framework Program (FP6), the major projects relevant for the climate change effects on health are **EDEN** and **MICRODIS**.

The **EDEN** project (Emerging Diseases in a Changing European Environment) funded by the European Commission, aims at understanding and modeling the conditions for vector-borne diseases to occur and spread, depending on the regions and time of year. It aims to gain an overall picture of emergence risks and provide methods and tools to design surveillance networks and early warning systems. Currently an EDENext proposal has been submitted following an open FP7 call procedure.

The selection of indicators for vector-borne diseases in the AGORA project is partially based on the selection of diseases of the EDEN project.

The general objective of the **MICRODIS** ((Integrated Health Social and Economic Impacts of Extreme Events: Evidence, Methods and Tools) project is to strengthen preparedness, mitigation and prevention strategies in order to reduce the health, social and economic impacts of extreme events on communities. Research is conducted in disaster-affected communities to assess the health, economic and social impacts at the micro-level.

5 DATA AVAILABILITY

Data that are needed to set up an indicator based monitoring system to study the impact of climate change on health, are listed below in separate files, and grouped per health effect.

5.1 Heat Waves

Parameters for indicators on temperature and heat wave related mortality and morbidity.

Temperature	**Code P1**
Definition of indicator	Temperature
Specification of data needed	Average daily temperature Maximum and minimum daily temperature Heat wave period Cold spell period
Data source	Royal Meteorological Institute www.meteo.be
Accessibility	Freely available: monthly averages of 3 most recent years Upon payment: hourly measurements
Time coverage	Measurements since 1833 in Uccle
Geographical coverage	Main station is Uccle, 28 meteostations in Belgium
Remarks	

Mortality for all natural causes	**Code P2**
Definition of indicator	All cause mortality
Specification of data needed	Mortality for all natural causes: ICD10 A11-R99 Date of birth, date of death, sex, residence, place of death, nationality Daily data For each period, excess mortality is calculated: 1) Absolute excess mortality = N° of Observed deaths (O) – N° of Expected deaths (E) 2) Relative excess mortality (X%)=(O-E)/E*100 Expected mortality and a threshold are obtained from modeling past 5-year death counts using a log-linear regression model. Time-series methods can also be used to model daily mortality data in relation to temperature or concentrations of pollutants.
Data source	Data from the National Registry (all deaths registered by the communes during the week before) are sent on a weekly basis to BE-MOMO at IPH. www.iph.fgov.be, http://www4.iph.fgov.be/Epidemio/Be-Momo/
Accessibility	Weekly real-time data: upon payment Freely available at the SPMA database (Standardized Procedures for Mortality Analysis): annual mortality http://www.iph.fgov.be/epidemio/spma/ until 1999 and 2004 and at the FPS Economy, SMEs, Independent Professions and Energy http://statbel.fgov.be/nl/statistieken/cijfers/bevolking/sterfte_leven/index.jsp until 2005.
Time coverage	Measurements since 1987
Geographical coverage	Belgium, total population, per community
Remarks	

Cause-specific mortality	**Code P3**
Definition of indicator	Cause-specific mortality

Specification of data needed	Cause-specific mortality:
	Cardiopulmonary diseases (ICD-10 I00-I99 and J00-J98)
	• Cardiovascular diseases (ICD-10 I00-I99)
	  ○ Stroke (ICD-10 I60-I69)
	  ○ Cardiac diseases (ICD-10 I00-I09 and I20-I52)
	• Respiratory diseases (ICD-10 J00-J98)
	Date of birth, date of death, sex, residence, place of death
	Daily data
	For each period, excess mortality is calculated:
	3) Absolute excess mortality = N° of Observed deaths (O) – N° of Expected deaths (

	4) Relative excess mortality (X%)=(O-E)/E*100 Time-series regression models can also be used: daily mortality data in relation to temperature or concentrations of pollutants.
Data source	
Accessibility	Freely available: annual mortality http://www.iph.fgov.be/epidemio/spma/ until 1999
Time coverage	Measurements since 1987
Geographical coverage	Belgium, total population, per community
Remarks	For Belgium, data are available until 1999 and for 2004 because there is a delay in the coding procedure for mortality data in the French community. Data for the Flemish Community and Brussels Capital are available at http://www.zorg-en-gezondheid.be/doodsoorzaken.aspx and http://www.observatbru.be/documents/sante/source-et-flux-des-donnees/bulletins-statistiques.xml?lang=en

Total Morbidity	**Code P4**
Definition of indicator	Morbidity: temperature related morbidity: emergency hospital admissions, all causes.
Specification of data needed	Emergency hospital admissions Date of admission, age, sex Daily data Time-series regression models are used: daily data in relation to temperature or concentrations of pollutants.
Data source	Registration of Minimal Clinical Data
Accessibility	Freely available: https://portal.health.fgov.be/portal/page?_pageid=56,512876&_dad=portal&_schema=PORTAL
Time coverage	Measurements since October 1st 2003
Geographical coverage	Belgium, total population: per jurisdiction (“arrondissement”)
Remarks	Data for emergency hospital admissions (even when without a following stay at the hospital) are available since 2003.

Cause-specific Morbidity	**Code P5**
Definition of indicator	Morbidity: temperature related morbidity: emergency hospital admissions, cause-specific morbidity.
Specification of data needed	Emergency hospital admissions Date of admission, age, sex Daily data Time-series regression models are used: daily data in relation to temperature or concentrations of pollutants
Data source	Registration of Minimal Clinical Data
Accessibility	Freely available: https://portal.health.fgov.be/portal/page?_pageid=56,512876&_dad=portal&_schema=PORTAL
Time coverage	Measurements since October 1st 2003
Geographical coverage	Belgium, total population: per jurisdiction (“arrondissement”)
Remarks	Data for emergency hospital admissions (even when without a following stay at the hospital) are available since 2003. Diseases are coded in ICD-9 system.

Conclusion:
Data on temperature are available freely or more detailed upon request and payment at the Royal Meteorological Institute.
All cause mortality data are available on community-level; the Institute of Public Health receives daily-level data from the National Registry. Cause-specific mortality (ICD-9 or ICD-10 codes) are available for Belgium on community level until 1999 and for 2004.
Data on emergency hospital admissions are available per jurisdiction or “arrondissement”.
Mortality and hospital admission data are not available on sub-community level.

5.2 Cold Spells

For parameters for indicators cold related mortality and morbidity, see 6.1., **[P1 – P5]**.

Conclusion: Idem 6.1

5.3 Extreme weather

Parameters for indicators on extreme weather events are based on data in the Emergency Events Database (EM-DAT) from the WHO collaborating Centre for Research on the Epidemiology of Disaster (CRED).

Emergency Events	**Code P6**
Definition of indicator	Impact of extreme events on health: • Floods • Drought • Wildfires • Storms
Specification of data needed	Flood type and period Drought period Wildfire Period Strom type and period Total number affected people per event Number of deaths per event
Data source	Emergency events database (EM-DAT) from the WHO collaborating Centre for Research on the Epidemiology of Disaster (CRED)
Accessibility	Freely available: http://www.emdat.be/database. Raw data upon request
Time coverage	Data since 1900
Geographical coverage	Worldwide, on national level
Remarks	For Flanders a flood forecast tool is available at http://www.overstromingsvoorspeller.be/ with forecasts per (sub)community The Royal Meteorological Institute offers information for Belgium on natural disasters, freely available and for detailed information upon request and payment. http://www.kmi.be/meteo/view/nl/1102999-Gebeurtenissen.html

Conclusion:

EM-DAT contains data on the occurrence and effects of disasters in the world from 1900 to present. Data are freely available on national level, raw data upon request.
Data on extreme events are also available freely or more detailed upon request and payment at the Royal Meteorological Institute.
The Flemish region offers a free flood forecast tool with forecasts on (sub)community level.

5.4 Air Quality

Parameters for indicators to monitor air quality related mortality and morbidity.
For mortality and morbidity indicators, see 6.1., **[P2-5]**.

Particulate matter concentration	**Code P7**
Definition of indicator	Concentration of Particulate Matter
Specification of data needed	a). Daily mean PM10 concentration (intensity of episodes) b). Number of days per year with daily mean PM10 concentrations above 50 µg/m3 (frequency of episodes) c). Daily mean PM2.5 concentration (intensity of episodes) d). Number of days per year with daily mean PM2.5 concentrations above 25 µg/m3 (frequency of episodes)
Data source	Daily data are available at the Belgian Interregional Environment Agency
Accessibility	Freely available: http://www.irceline.be/ . Raw data upon request
Time coverage	Data since 1999
Geographical coverage	Belgium
Remarks	With the RIO-Corine interpolation technique: resolution of 4x4 km for Belgium

Ozone concentration	Code P8
Definition of indicator	Concentration of Ozone
Specification of data needed	a). Daily maximum 8-hour mean ozone concentration (intensity of episodes) b). Number of days per year with daily maximum 8-hour mean ozone concentrations above 100 µg/m3 (frequency of episodes)
Data source	Daily data are available at the Belgian Interregional Environment Agency
Accessibility	Freely available: http://www.irceline.be/ . Raw data upon request
Time coverage	Data since 1999
Geographical coverage	Belgium
Remarks	

Anti-asthma & COPD and anti-cough medication	Code P9
Definition of indicator	Sale of prescribed anti-cough and anti-asthma & COPD medication
Specification of data needed	Sales (per unit) of prescribed anti-cough and anti-asthma & COPD medication Time-series regression models are used: daily data on medication sales in relation to concentrations of pollutants
Data source	Data available upon request and payment at the RIZIV/INAMI, the Institute for health insurance. At the "Intermutualiteit agentschap" a request can be made for a random sample**.**
Accessibility	Available upon request and payment: http://www.riziv.fgov.be Upon request: random sample: http://www.nic-ima.be
Time coverage	Data since 2002
Geographical coverage	Belgium
Remarks	

Conclusion:
Total mortality data are available on community-level; the Institute of Public Health receives daily data from the National Registry.
Cause-specific mortality (ICD-9 or ICD-10 codes) are available for Belgium on community level until 1999 and for 2004.
Data on prescribed medication sale are available in Belgium.

5.5 Ultraviolet Radiation

Parameters for indicators on health effects of ultraviolet radiation.

Ultraviolet radiation related health effects	Code P10
Definition of indicator	Cancers related to exposure to ultraviolet radiation
Specification of data needed	Incidence of • Malignant melanoma of the skin: ICD-10 C43 • Other malignant neoplasms of the skin: ICD-10 C44
Data source	Data are available at the Belgian Cancer Registry
Accessibility	Freely available: http://www.kankerregister.org/
Time coverage	Data for Belgium (coverage of >95%) since 2004
Geographical coverage	Belgium
Remarks	A complete coverage (>95%) for Flanders since 2000

Conclusion:
Data on malignant melanoma and malignant neoplasms are available at the Belgian Cancer Registry since 1999. The long latency time of exposure to UV radiation and cancer has to be considered.

5.6 FOOD- AND WATER-BORNE DISEASES

Parameters for indicators on food- and water-borne diseases.
For temperature related diseases, time-series analysis can be performed using incidence of diseases and temperature data **[P1]**.
For rainfall related diseases, time-series analysis can be performed using incidence of diseases and extreme weather data **[P6]**.

Food- and water-borne diseases	**Code P11**
Definition of indicator	Water- and food-borne diseases
Specification of data needed	Incidence of Salmonellosis, E. Coli infection, Campylobacteriosis, Cryptosporidiosis, S. Aureus infection, Shigellosis, Giardiasis, Yersioniosis, Amoebiasis, Cholera, Legionellosis.
Data source	Data are available at the Scientific Institute of Public Health
Accessibility	Freely available: www.iph.fgov.be/epidemio/labo
Time coverage	Monthly data since 1995
Geographical coverage	Belgium
Remarks	

Conclusion:
Data on food- and water-borne diseases are available.

5.7 VECTOR-BORNE AND ZOONOTIC DISEASES

Parameters for indicators on vector-borne and zoonotic diseases.

Vector-borne and zoonotic diseases	**Code P12**
Definition of indicator	Vector-borne and zoonotic diseases
Specification of data needed	Incidence of vector-borne diseases for which the vector and pathogen are present in Europe. Leishmaniasis, Tick borne Encephalitis, West-Nile fever and encephalitis, Crimean-Congo fever, Hantavirosis, Leishmaniasis, Lyme Borreliosis
Data source	Data are available at the Scientific Institute of Public Health
Accessibility	Freely available: www.iph.fgov.be/epidemio
Time coverage	Monthly data since 1995
Geographical coverage	Belgium
Remarks	A combination of spatial data (earth observation data, GIS) with epidemiological data has recently been used for surveillance (EDEN project). The presence of vectors in Belgium has been monitored in the MODIRISK project (see 4.7.3.4).

Conclusion:
Data on vector-borne and zoonotic diseases are available.
Data on the distribution of vectors in Belgium is available via projects such as MODIRISK[63] and EDEN[61].
Recently ECDC has also established VBORNET, a European Network for Arthropod Vector Surveillance for Human Public Health which will establish Pan-EU maps at three administrative levels (NUTS1-2-3). Questionnaires regarding vector distribution and vector surveillance activities will be disseminated by the end of January.
See also: http://ecdc.europa.eu/en/activities/diseaseprogrammes/Pages/VBORNET.aspx

5.8 AERO-ALLERGENIC DISEASES

Parameters for indicators on aero-allergenic diseases.

Exposure to aero-allergens	**Code P13**
Definition of indicator	Exposure to aero-allergens
Specification of data needed	Exposure to pollen: • Length of total pollen season = (End – Start) • Annual sum of pollen, both for the four selected allergenic species.
Data source	Belgian aerobiological surveillance network
Accessibility	Freely available: http://airallergy.iph.fgov.be/sites/airallergy/nl/default.aspx
Time coverage	Data since 1974
Geographical coverage	Belgium
Remarks	

Anti-histamine, anti-asthma medication	**Code P14**
Definition of indicator	Sale of prescribed anti-histamines and anti-asthma medication
Specification of data needed	Sales (per unit) of prescribed anti-histamines and anti-asthma medication Time-series regression models are used: daily data on medication sales in relation to concentrations of pollen
Data source	Data available upon request and payment at the RIZIV/INAMI, the Institute for health insurance. At the "Intermutualiteit agentschap" a request can be made for a random sample.
Accessibility	Available upon request and payment: http://www.riziv.fgov.be Upon request: random sample: http://www.nic-ima.be
Time coverage	Data since 2002
Geographical coverage	Belgium
Remarks	

Conclusion:
Data on pollen are available.
Data on prescribed medication sales are available in Belgium.

6 PRIORITIES

To reduce the extent of the impact of climate change on public health, mitigation and adaptation strategies and actions are currently being implemented in several countries.
Data collection to monitor health status and disease occurrence is essential in order to follow up threats to public health, to implement action programs and to evaluate the effectiveness of policy measures. Internationally, several initiatives are undertaken to enable the monitoring of the effects of climate change on health, e.g. by the U.S. Environmental Protection Agency, the European Commission and the United Nations/WHO. As climate change is a transboundary matter, it is important for Belgium to participate in international initiatives.

Both the WHO and ECDC started initiatives related to health and climate change. In the WHO CEHAPIS program (Climate, Environment and Health Action Plan and Information System); co-funded by the European Commission, indicators are selected by an international team of experts. The IPH (Unit Environment and Health) has been asked as scientific advisor in this working group. In October 2009, ECDC has launched a call for tenders (OJ/2009/09/25-PROC/2009/044) to assess the ability and sustainability of a set of disease indicators of climate change in order to establish comparable data sets, in order to perform European health policies and strategies.

In this chapter, priorities for data collection and research are highlighted to ensure:

1/ **Future participation of Belgium in international initiatives**:

- Cooperate in the WHO **CEHAPIS program and feasibility studies**. Based on these studies, an optimal indicator-set will be selected.
- Ability to deliver (data-availability) and submission of data-sets within the context of WHO and ECDC. These data-sets will be used as reference points for monitoring, international comparisons, decision-making and evaluation.

2/ **An optimal indicator based monitoring in Belgium**.

In Chapter 3, both **direct and indirect effects** of climate change **on health** are described. In addition, determinants of vulnerability and environmental factors that may interact with these health effects, are listed to emphasize their influence on the health effects. Some examples are urbanization, housing conditions, quality of medical care and public health systems, wealth, scientific developments, individual behavior and individual vulnerability (e.g., genetic makeup, nutritional status, age, gender, economic status).
The interaction of these factors that all influence human health complicates the assessment of climate change related health effects. **Research** is needed to study these interactions.

Table 25 presents **priorities for data collection and research** for the climate change related health impacts as described in Chapter 3. The priorities for data collection are subdivided into:

- Priorities to enable participation in the WHO CEHAPIS feasibility studies and program. Indicators planned for the feasibility studies are summarized in Table 25.
- Priorities to enable an optimal indicator-based monitoring in Belgium.

Table 25 Priorities for data collection and research for the monitoring of climate change related health impacts

HEALTH IMPACTS	PRIORITIES FOR DATA COLLECTION		PRIORITIES FOR RESEARCH
	PARTICIPATION IN CEHAPIS	OPTIMAL INDICATORS FOR BELGIUM	
Heat waves	• All cause excess mortality: **ok** • Cause-specific mortality: update of the Belgian data (data for French community) is necessary	Mortality data on smaller geographical level: to study more local phenomena (e.g. the effect of urban heat islands); at this moment, data are only available at community-level	• Research on temperature related mortality with cause-specific mortality data • The effect in small areas, for example urban heat islands when sub-community (e.g. statistical area) mortality data should become available • The effect on mortality and morbidity in lower age groups (children) • Research on the influence of ambient concentrations of particulate matter (PM) morbidity/mortality • Research on the interaction between heat and the effects of ozone on heat-related morbidity/mortality (may differ from city to city)
Cold spells	• All cause excess mortality: **ok** • Cause-specific mortality: update of the Belgian data (data for French community) is necessary	/	• Research on temperature related mortality with cause-specific mortality data • The influence of ambient concentrations of particulate matter (PM) and ozone on temperature related morbidity/mortality
Extreme weather	• Flood and storm related mortality, number of people affected and population at risk: **ok**, data available at CRED • Elaboration of more specific methodology: planned by WHO experts → may lead to new priorities for data collection	/	
Air quality	• Concentration of ozone and PM_{10}: **ok** • Cardio- respiratory mortality: update of the Belgian data (data for French community) is necessary • Medication sales for asthma, COPD and cough: IPH has been asked by WHO-Europe to develop the methodology and lead a European feasibility study. Planning of design 2010	Mortality data on smaller geographical level: to study more local phenomena (e.g. the effect of traffic proximity); at this moment, data are only available at community-level	• Research on temperature related mortality with cause-specific mortality data • The effect of traffic-proximity when sub-community (e.g. statistical area) mortality data should become available • Development of the methodology and a feasibility study for prescribed anti-cough and anti-asthma & COPD medication as indicators for respiratory morbidity
Ultraviolet radiation	/	/	/

HEALTH IMPACTS	PRIORITIES FOR DATA COLLECTION		PRIORITIES FOR RESEARCH
	PARTICIPATION IN CEHAPIS	OPTIMAL INDICATORS FOR BELGIUM	
Food- and water-borne diseases	• Time-series of temperature related Salmonellosis incidence: ok • Time-series of heavy rainfall related Cryptosporidiosis: ok • Elaboration of more specific methodology is being planned by experts (WHO, ECDC) experts → may lead to new priorities for data collection • Animals: long-term monitoring of certain parasitary diseases (nematodes, trematodes,…) is necessary	At this moment, no priority in Belgium and in other countries with a good public health system	/
Vector-borne and zoonotic diseases	• Lyme disease: **ok** • Elaboration of the methodology is being planned by experts (WHO, ECDC) experts → may lead to new priorities for data collection	• Monitoring of vectors (MODIRISK, 3.7.3.4) is not permanently organized. • Use of data from the EDEN project and EPIZONE and collaboration with these experts • Interaction and collaboration with projects such as MOSS (Monitoring and Surveillance System), for emerging diseases having an impact on animal health	• Programs on the permanent monitoring of vectors (e.g. MODIRISK, 3.7.3.4). • Methodology (using, exchanging information) from the EDEN project (Chapter 4). • Interaction and collaboration with projects such as MOSS (Monitoring and Surveillance System), for emerging diseases having an impact on animal health
Aero-allergenic diseases	• Exposure to pollen from four plant types: 1) Alder (Alnus); 2) Birch (Betula); 3) Grasses (Poaceae) and 4) Ragweed (Ambrosia) • Distribution of Ragweed • Medication sales for allergic rhinitis and asthma: IPH has been asked by WHO-Europe to develop the methodology and lead a European feasibility study. <u>Planning of design 2010</u>	Other important aero-allergens are pollen of hazel (Corylus) and mugwort (Artemisia): **ok**	• Development of the methodology and a feasibility study for prescribed anti-histamine and anti-asthma medication as indicators for aero-allergenic diseases

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