EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL

MEETING REPORT

WORKSHOP

Environmental change and infectious disease

Stockholm, 29–30 March 2007

JRC
EUROPEAN COMMISSION

European Environment Agency

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Regional Office for Europe

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ABOUT THIS REPORT

This report presents the key findings and discussions from a meeting organised by the European Centre for Disease Prevention and Control (ECDC), in collaboration with the WHO Regional Office for Europe (WHO EURO), the European Environment Agency (EEA), and the Joint Research Centre (JRC) at Ispra. The aim of the meeting was to review evidence related to the implications of global climate and ecological change on the communicable disease burden of Europe, assess the preparedness of health systems, develop scientific advice, identify research needs, and make recommendations to Member States.

The meeting brought together key scientists, researchers, public health practitioners, public health advocates, environment advocates and representatives from relevant European Union institutions and other international organisations.

This report is divided into three sections, roughly corresponding to the structure of the meeting. Section I (Chapters 1 and 2) introduces the European context for addressing climate change and health and reviews some of the more pertinent scientific evidence related to climate change in Europe. Section II (Chapters 3 and 4) explores the links between climate change and the spread of infectious disease in greater detail. Section III (Chapters 5 and 6) points out research gaps, recommends further public health research and proposes action based on the essential roles of public health.

Where data and figures have been taken from presentations given during the meeting, they have been referenced accordingly.

Occasionally, names in footnotes are given without organisational affiliation. These names refer to meeting participants. Their institutional affiliations and addresses are listed in Annex 1.

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EXECUTIVE SUMMARY

Aim of the meeting

The aim of the meeting was

- to review evidence related to the implications of global climate and ecological change on the communicable disease burden of Europe;
- to discuss public health competences needed in order to deal with climate change and infectious disease threats; and
- to identify research needs.

Climate change

The Intergovernmental Panel on Climate Change (IPCC) states that the climate is changing; higher temperatures, sea-level rise and more extreme weather events are expected. These changes affect ecosystem, water, agriculture, socio-economic development and thus — directly or indirectly — the health of the population. Climate change and other ecological changes can affect infectious disease distribution in various ways. While there is much debate about the potential impacts of the various climate scenarios, all participants agreed that the 'constant composition commitment' — the kind of climate change to which we have already committed — calls for immediate action.

Disease threats

The meeting participants discussed the implications of climate change and other related environmental changes for vector-, rodent-, water-, food- and air borne diseases. Although evidence is scarce, the following conclusions were reached:

Several vector- and rodent-borne diseases have been identified as being potentially able to change their range of distribution based on climate change (temperature, extreme weather events, seasonality) and environmental factors (land-use, ecosystems, deforestation, hydrology, biodiversity). This includes arboviral diseases such as dengue, chikungunya, West Nile, and, potentially, malaria. Rodent population density and distribution is also affected by weather conditions.

Europe should be prepared for imported water-related diseases, such as cholera, localised outbreaks from extreme precipitation events, and health problems associated with the overflow of waste and waste-waters. Potential changes in diarrhoeal disease frequency were also identified as important. The groups most at risk included the poor, the elderly, the very young, marginalised groups, travellers exposed abroad, and those who are immuno-compromised or suffer from a pre-existing medical condition.

Food-borne diseases were reviewed in relation to changing human behaviours and changing contact patterns between wild and domestic animals, especially during drought conditions.

The exacerbation of asthma and chronic obstructive pulmonary diseases was identified as the most significant climate-change influence on respiratory health. The high prevalence of these conditions was thought to make them good sentinel markers for tracking the impact of climate change.

Public health competencies

There was a consensus amongst participants that the required skills are core public health competencies and represent values that exist — or should exist — in all countries. Strengthening capacities to deal with new climate change-related infectious disease threats can be seen as a way of strengthening public health more broadly. Of particular importance was the need for the coordination of intersectoral and interagency work.

The four areas of public health competencies addressed were surveillance, research, assurance and policy. Surveillance strategies for some climate change problems already exist, but gaps remain in the area of infectious diseases.

Participants pointed out that a necessary first step would be to perform a risk assessment that would identify risk factors and vulnerable groups. This would lay out the evidential platform for public health/clinical guidelines and policy recommendations. The group of experts acknowledged that a lot of work had already been done in this area, and that the main challenge was to tie loose ends together.

The group identified gaps in entomological knowledge as a major obstacle and recommended making entomological training more extensive to rectify this problem.

The lack of a comprehensive monitoring system was noted, but the group agreed that there was no need to set up a system that covered all of Europe because many of the potentially threatening diseases are rare in most areas. Concerns were raised about stressing or overtaxing existing reporting systems with additional tasks.

The consensus was for a 'respond when needed' approach. This approach focuses on being flexible and makes it possible to respond quickly to problems as they emerge. It is based on the assumption that so far only very few of these infectious diseases — when viewed in connection with climate change or other environmental issues — have posed major problems: Many problems are merely theoretical or only point in the direction of possible emerging issues rather than requiring immediate attention.

The participants expressed the need to raise public (and perhaps even professional) awareness about some of the general issues in order to improve understanding of some of the impending changes.

Finally, the group expressed that the new Green Paper on climate change offers a unique opportunity to strengthen the EU Commission's capacity in health policies. The Commission's regulatory capacity in this area could be developed if health aspects were strengthened.

Research needs, challenges and obstacles

The meeting identified a variety of research issues, including the need for indicators and the identification of vulnerable groups. Participants noted that there are clearly different capacities in different Member States in respect to carrying out climate change-related monitoring and research. They suggested that the use of sentinel sites in all countries might be a quick solution for gathering Europe-wide data until all public health and monitoring systems are fully functional.

The group identified access to long-term data as another need. It is a challenge to link these data to those gathered from satellites and arrive at useful conclusions and predictions related to human health. Attributing long-term processes to climate change is another research challenge.

Recommendations for action

The meeting concluded with recommendations for ECDC, the WHO Regional Office for Europe and other international agencies on how to assist Member States in the development of strategic action frameworks. In developing work programmes and subsequent public health policies focussing on climate change and infectious disease, there is a need to:

- build on existing initiatives and capacities;
- develop a 'win-win' culture related to intersectoral and interagency work;
- acknowledge that different parts of the region will experience the impacts of climate change in different ways;
- acknowledge the different capacities for response in different Member States;
- explore a variety of possible surveillance approaches;
- address surveillance obstacles;
- collaborate and develop a comprehensive horizon-scanning risk strategy;
- facilitate the development and implementation of professional educational programmes; and
- strengthen communication capacities.

LIST OF ABBREVIATIONS

BBQ	barbecue
BTV	Bluetongue virus
CC	climate change
cCASHh	Climate Change and Adaptation Strategies for Human Health
CCHF	Crimean-Congo haemorrhagic fever
CDC	Centers for Disease Prevention and Control (USA)
CE	Central Europe
CMCC	Centro Euro-Mediterraneo per i Cambiamenti Climatici
CO_2	carbon dioxide
COPD	chronic obstructive pulmonary disease
CSOs	combined sewage overflow events
DALYS	Disability Adjusted Life Years
EC	European Community
ECDC	European Centre for Disease Prevention and Control
EEA	European Environment Agency
EFSA	European Food Safety Agency
EMEA	European Medicines Agency
ERS	European Respiratory Society
ETH	Swiss Federal Institute of Technology
EU	European Union
FAO	Food and Agriculture Organisation (UN)
FSA	Food Safety Agency (UK)
GIS	Geographic Information System
GOARN	Global Outbreak and Response Network
GPs	general practitioners
HABs	harmful algal blooms
IFRC	International Federation of Red Cross and Red Crescent Societies
IHR	International Health Regulations
IPCC	International Panel on Climate Change
JRC	Joint Research Council
LB	Lyme disease *or* borreliosis
MRSA	multidrug-resistant *Staphylococcus aureus*
MS	Member State/s
NE	Northern Europe
NGOs	non-governmental organisations
OT	overseas territories
PCMDI	Programme for Climate Model Diagnosis and Intercomparison
PCR	polymerase chain reaction

ppm	parts per million
ppb	parts per billion
SARS	Severe Acute Respiratory Syndrome
SES	socioeconomic status
SST	sea surface temperature(s)
SE	Southern Europe
spp	species
TB	tuberculosis
TBE	tick-borne encephalitis
TSE	transmissible spongiform encephalopathies
UNEP	United Nations Environment Programme
VBD	vector-borne diseases
VRE	vancomycin-resistant enterococci
WE	Western Europe
WG2	Working Group 2
WHO	World Health Organization
WHO EURO	World Health Organization, Regional Office for Europe
WMO	World Meteorological Organisation
WNF/WNV	West Nile (flavi)virus

Chapter I

CLIMATE CHANGE IN CONTEXT

This section contextualises the need for public health and environmental agencies to address climate change as a significant potential issue. Several of the meeting's participants have worked with the International Panel on Climate Change (IPCC) in developing its latest reports.

INTRODUCTION

The European Centre for Disease Prevention and Control (ECDC), in collaboration with the World Health Organization's Regional Office for Europe (WHO EURO), the European Environment Agency (EEA), and the Joint Research Centre (JRC) at Ispra, organised this meeting to initiate a risk assessment/management process aimed at:

- reviewing evidence related to the implications of global climate and ecological changes on the air-, vector-, water- and food-borne communicable disease burden of Europe;
- assessing the preparedness of public health systems, including infrastructures, epidemic intelligence, surveillance, response and communication capacities, in order to respond effectively to current and potential changes;
- developing scientific advice and making recommendations on how to strengthen the Member State's infectious disease detection and control capacities with respect to environmental changes; and
- identifying research needs.

The workshop brought together key scientists, researchers, public health practitioners and advocates with representatives from relevant European Union institutions and other international organisations (see Annex 1). Emphasised throughout the meeting was the need to build on existing activities. Participants also emphasised the need to strengthen collaboration between the competent services of the Commission of the European Communities (see Box 1) and other relevant international organisations like WHO EURO.

Box 1: The competent services of the Commission of the European Communities[1]

- Environment
- Civil Protection
- Trade
- Humanitarian Operations
- Enterprise
- Transport
- Justice and Home Affairs
- Research
- External Relations
- Information Society
- Worker's Health
- Consumer Protection
- Joint Research Centre
- ECDC
- EFSA
- EEA

Experience gained in areas like coping with heatwaves, where challenges are dealt with by cooperatively developing warning systems, are seen as potential models of collaboration. In particular, experience gained in areas such as extreme events/heatwaves — with the cooperative development of heat health warning systems and action plans involving health and meteorological services[2] — was seen as a potential model of collaboration. The workshop was challenged to identify whether a similar process of awareness raising, research, analysis, policy action and collaborative work could be developed that would anticipate the risk of communicable diseases in connection with climate change. This type of system could provide guidance for Member States in developing (and participating in) efficient and effective surveillance and response activities.

Recent events point to growing political momentum and an unprecedented opportunity for climate change and health-related action[3]. The 4th IPCC report was noted, as well as the most recent G8 Ministers of Environment meeting where it was agreed that climate change should be a priority in the G8 framework. In March 2007, the European Union (EU) Summit agreed upon new targets for CO_2 reduction.

The group saw these political changes as a sign that the public at large favours urgent action to reduce threats from climate change[4].

[1] From Stefan Schreck's presentation.
[2] The WHO/EU Euroheat project workshop in Bonn (22–23 March 2007) reported findings of various related projects and informed EC communication on heat preparedness planning and response.
[3] Many participants noted that attitudes towards climate change have shifted significantly over the last few years at the European level and in many MS. Discussions are no longer focused on proving that climate change is happening, but rather on ways of mitigating and adapting to its effects. Politically, this is the 'flavour of the month.' DG Sanco now has three units dealing with climate change effects. At the global level, the EU is one of the key driving forces in addressing climate change, as articulated in the ECCPs (European Climate Change Policies). The first policy was released in June 2005; the second one was strengthened in October 2005.
[4] Adapted from a presentation by Merylyn McKenzie-Hedger.

Why climate change demands action

The meeting participants identified two reasons for this change of perception. Society is directly experiencing the social, health and economic impacts of extreme weather events. The chart below shows river flooding events with specific socio-economic impacts and indicates the associated economic costs.

Secondly, a significantly wider range of impacts is foreseeable (discussed below) in Europe. There are great differences in the capacities of individual countries to cope with these predicted changes, but all countries will have to take action.

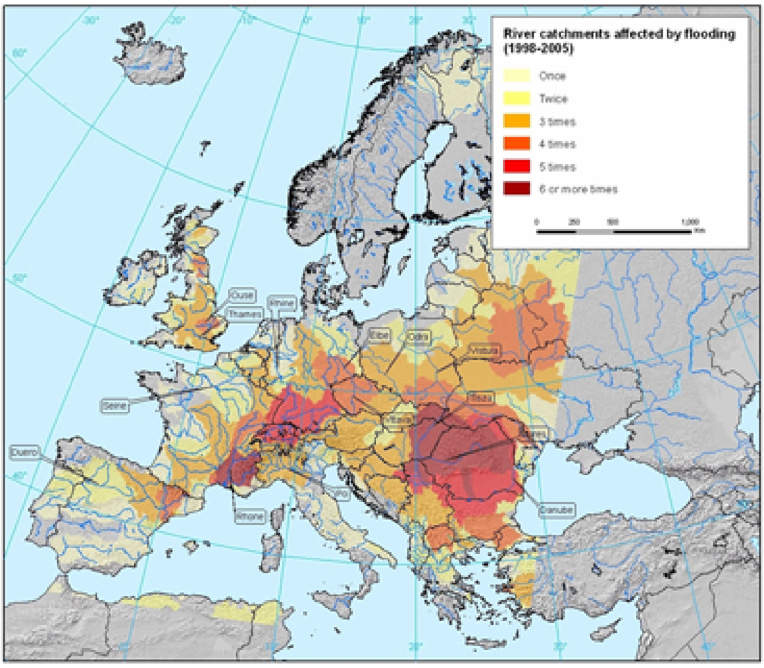

Figure 1: River flooding events 1998–2005[5]

About 100 (river) floods: more than 700 fatalities, a million people affected and €25 billion in insured economic losses (Data source: EEA, 2006, unpublished).

5 From a presentation by Merylyn McKenzie-Hedger.

Background

The European Environment and Health Ministerial process[6]

The political momentum was rather low in 1999 when the first European Environment and Health Ministerial Declaration, addressing — among other issues — climate change and health, was adopted at the 3rd European Ministerial Conference on Health and Environment held in London. The ministers of health and environment gathered in London recognised the relevant role of human activities in changing the climate. At that time there were many knowledge gaps, and the main call was for further assessment and monitoring of health impacts related to climate change. All in all, it was too early for the conference's statement of concern to become a policy driver.

By the time the 4th Ministerial Conference came around, this time held in Budapest in 2004, things had changed. After the deadly heatwave in 2003[7] that hit many European countries, commitments were made regarding climate change and health, particularly in relation to extreme weather events. This development is also reflected in the strengthening of the EU's Climate Change Policies between 2000 and 2005.

The European Climate Change Programme (ECCP), adopted in 2000, was designed to identify concrete measures that would help Member States reduce their greenhouse gas emissions. In 2005, the Commission published the communication 'Winning the Battle Against Global Climate Change'. This report highlighted the need to address adaptation because of the increasing risk that climate change would pose adverse effects on the environment[8]. Following expert discussions held in 2006, the Directorate-General for the Environment put together a Green paper on adaptation[9] (29 June 2007, see http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52007DC0354:EN:NOT).

Regional and Member State actions have been focused on risk assessment and risk management. Risk assessments have included a number of evaluations, addressing both the direct and indirect effects of climate change, especially extreme climate events.

[6] This process has been coordinated through the European Environment and Health Committee (EEHC), a unique coalition that brings together representatives from:

- health ministries;
- environment ministries;
- intergovernmental organisations; and
- civil-society organisations.

Non-member European countries and international organisations may also attend EEHC meetings by special invitation. For more information see: http://www.euro.who.int/eehc.

[7] Excess deaths from the 2003 heatwave in Europe exceeded 70 000.

[8] A specific workgroup on impacts and adaptation was set up in October 2005 when the second phase started. As the problem with adaptation in climate change affects so many individual sectors, ten individual sectors were created to engage with experts and stakeholders in order to try to take a snapshot of what was currently happening in MS. In addition, attempts were made to identify shortcomings with regard to research and knowledge, and to come up with solution strategies that eventually could be developed into Community policies.

[9] 2007 Jun 29. Available from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52007DC0354:EN:NOT.

WHO developed guidelines on how to assess the health impact of climate change[10]. So far, a number of European countries have carried out these types of studies. Table 1 presents a brief summary of their findings and recommended adaptation actions.

Country	Key findings	Adaptation recommendations
Finland (Hassi and Rytkonen, 2005)	Small increase in heat-related mortality; changes in phenological phases and increased risk of allergic disorders; small reduction in winter mortality.	Awareness building and training of medical doctors.
Germany (Zebisch et al., 2005)	Observed excess deaths from heatwaves; changing ranges in tick-borne encephalitis; impacts on healthcare.	Increase information to the population; early warning; emergency planning and cooling of buildings; insurance and reserve funds.
The Netherlands (Bresser, 2006)	Increase in heat-related mortality; increase of air pollutants; risk of Lyme disease; food poisoning and allergic disorders.	Not considered.
Portugal (Calheiros and Casimiro, 2006)	Increase in heat-related deaths and malaria, food- and water-borne diseases; West Nile fever, Lyme disease and Mediterranean spotted fever; a reduction in leishmaniasis risk in some areas.	Address thermal comfort; education and information as well as early warning for hot periods; early detection of infectious diseases.
Spain (Moreno, 2005)	Increase in heat-related mortality; air pollutants; potential change of ranges of vector- and rodent-borne diseases.	Awareness raising; early warning systems for heatwaves; surveillance and monitoring; review of health policies.
Italy (Wolf and Menne, 2007)	Increase in heat-related mortality; air pollutants; potential changes in the types of vector and rodent-borne diseases; changes in ranges of cyan bacteria; potential outbreaks of algal blooms in summer.	Strengthening of early warning systems monitoring diseases; health system preparedness planning; systematic information exchange

Table 1: National health impact assessments of climate change.

Adapted from: Confalonieri U, Menne B, Akhtar R, Ebi KL, Hauengue M, Kovats S, et al. 2007.

[10] Methods of assessing human health vulnerability and public health adaptation to climate change. Available from: http://www.euro.who.int/document/e81923.pdf.

Figure 2: Activities of WHO Euro, from London to Budapest, 1999–2004[11].

Relevant EC projects have included Euroheat[12], PHEWE[13], EUROSUN[14], Canicule[15], and the Emerging Diseases in a changing European Environment (EDEN) project[16], as well as projects

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[11] From a presentation by Bettina Menne, WHO.

[12] Euroheat — Improving public health responses to weather extremes, in particular to heatwaves. Coordinated by WHO EURO and funded by the European Commission (DG SANCO), EuroHEAT:

- carried out epidemiological assessment of the health impacts of heat-waves from 1990 to 2003;
- identified synergies with air pollution, determinants of risk, and systems for rapid detection of health impacts;
- developed a climate information tool, measures for indoor heat protection;
- assessed the health system response capacity; and
- carried out health promotion activities in particular in the ageing population.

For more information see: http://www.euro.who.int/globalchange/Topics/20050524.

[13] PHEWE: Prevention of acute Health Effects of Weather conditions in Europe.
This is a three-year EU-funded project concerning the study of weather and its impact on health. The overall aim is to assess the acute health effects of weather in various European countries characterised by widely differing climatic conditions. The information collected will be used in the development of preventive strategies to minimise adverse health effects in Europe, and to develop guidelines for public health interventions. At the end of the three-year project, a heat/health watch warning system will be in place in selected cities to predict and alert about potentially health-threatening weather.

[14] Quantification of sun exposure in Europe and its effects on health.

[15] The EU project 'Etude de l'impact de la canicule d'août 2003 sur la population européenne' (Study of the impact of the August 2003 heatwave on the European population) was coordinated by the INSERM, Montpellier, France. The study looked at the severity of the heatwave by calculating the number of excess deaths at the European level; this was achieved by looking at the spatial situation (the situation across borders and at the regional levels);

such as Phenology[17], which looks at allergens and how these could be influenced by climate change.

Risk management activities have focused mostly on adaptation. When risk management activities were first started, environmentalists raised many concerns about focusing on adaptation. The word 'adaptation' was taboo, just as the term 'harm reduction' in HIV/AIDS drug work several years ago. Many environmentalists said it meant accepting climate change. All of their previous efforts had been focused on mitigation, and they did not want to consider the need for this alternative approach. The cCASHh project was created to make the case for adaptation[18]. This project (Menne B, Ebi KL, editors; 2006) identified a variety of adaptation strategies, including climate change-related scenarios regarding vector-, rodent-, food- and water-borne diseases[19].

The workshop was also informed of other conceptual and analytical advances over the last ten years. These include modelling methods and geographical surveillance technologies[20] that can assist current risk assessment and management efforts such as advanced earth observation techniques that have been used to improve the understanding of different change processes by measuring land surface temperature, rainfall, atmospheric humidity, vegetation growth, etc. Also noted was the development of predictive models in climate change involving both mitigation and adaptation.

The European Flood Alert System is an example of an early warning system where all of these approaches have been linked successfully. This flood warning system combines information from a variety of relevant sources, including precipitation forecasts, land use maps and soil moisture tracking systems.

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the temporal situation in summer 2003; the impact on older people and on mortality trajectories for the aged; delayed impacts on mortality rates; and mortality trajectories in relation to environmental conditions.

[16] EDEN's aims are to identify, evaluate and catalogue European ecosystems and environmental conditions linked to global change, which can influence the spatial and temporal distribution and dynamics of human pathogenic agents. The project will develop and co-coordinate at the European level a set of generic methods, tools and skills such as predictive emergence and spread models, early warning, surveillance and monitoring tools and scenarios, which can be used by decision makers for risk assessment, decision support for intervention and public health policies both at the EU and at the national or regional level. Part of EDEN's innovation will be to combine spatial data (earth observation data, GIS, etc.) with epidemiological data.

[17] Phenology is the study of cyclic and seasonal natural phenomena, especially in relation to climate as well as plant and animal life.

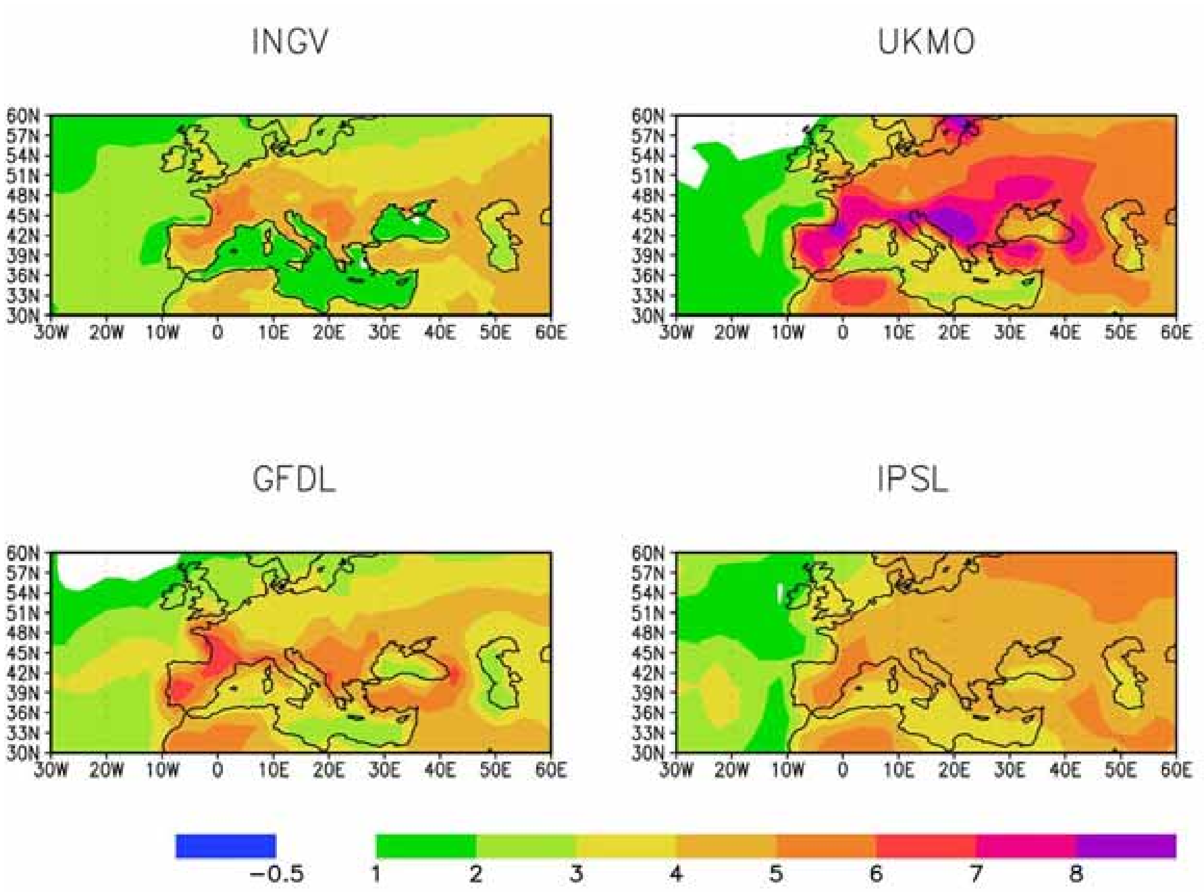
[18] The cCASHh project is a combination of impact and adaptation assessment for four climate-related health outcomes:

- health effects of heat and cold;
- health effects of extreme weather events;
- infectious diseases transmitted by insects and ticks, e.g. tick-borne encephalitis, malaria (vector-borne and rodent-borne diseases); and
- infectious diseases transmitted in the water supply or through food (water-borne and food-borne diseases).

For more information see: http://www.euro.who.int/ccashh.

[19] Findings from the cCASHh study have been used and cited throughout this report.

[20] Reviewed in presentations by Xavier Rodó and David Rodgers.



Surface Temperature Differences JAS
(2061–2090 minus 1961–1990)

Figure 3: Surface temperature differences JAS[21].

[21] From a presentation by Antonio Navarra.

Chapter II

CLIMATE AND ECOLOGICAL CHANGE

Before initiating discussions regarding the health effects of climate change, the meeting reviewed some of the findings of the 4th IPCC report[22] and other evidence regarding climate and ecological change. This chapter presents data on climate change in order to provide the foundation for subsequent chapters which will discuss the links between climate change and the spread of infectious disease[23,24].

Tracking and explaining changes

Climates are complicated structures made up of components that cannot be studied separately. The atmosphere and the oceans must be studied together when one is looking at the characteristics of a climate. Climate is also complex from a geographical point of view. What is happening in a specific area of the globe may be affecting climate variability elsewhere. This means, for example, that if we want to understand how much precipitation there is in Brazil, it is necessary to look at sea surface temperatures in the Pacific and Indian Oceans. A whole web of such 'teleconnections' has been identified covering the globe (see Figure 4). They connect several areas of the earth and several climate systems. 'Teleconnection' in atmospheric science refers to climate anomalies being related to each other at large distances (typically thousands of kilometres).

[22] Several participants have been involved in writing sections of this report, which was released just after the ECDC workshop.
[23] Adapted from presentations by Antonio Navarra and Andreas Fischlin.
[24] A glossary of terms is included in Annex 8.

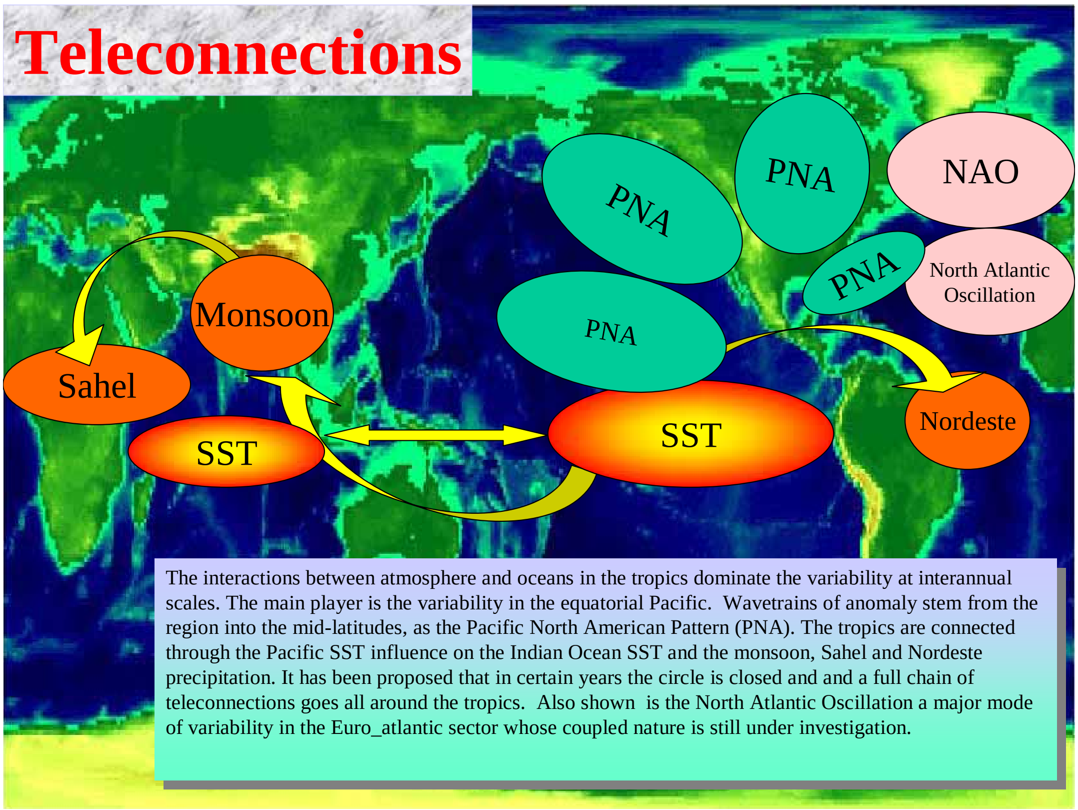


Figure 4: Teleconnections[25].
Surface Temperature Differences JAS (2061–2090 minus 1961–1990) developed by different institutions in Europe.

Carbon dioxide, methane, temperature and attribution

The latest IPCC reports[26] identify carbon dioxide as the most important anthropogenic greenhouse gas. The global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005.

'The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1732 ppb in the early 1990s, and was 1774 ppb in 2005. The atmospheric concentration of methane in 2005 exceeds by far the natural range of the last 650 000 years (320 to 790 ppb) as determined from ice cores.'

(IPCC WG1. 2007; p. 3)

[25] From a presentation by Antonio Navarra.
[26] http://www.ipcc-wg2.org/.

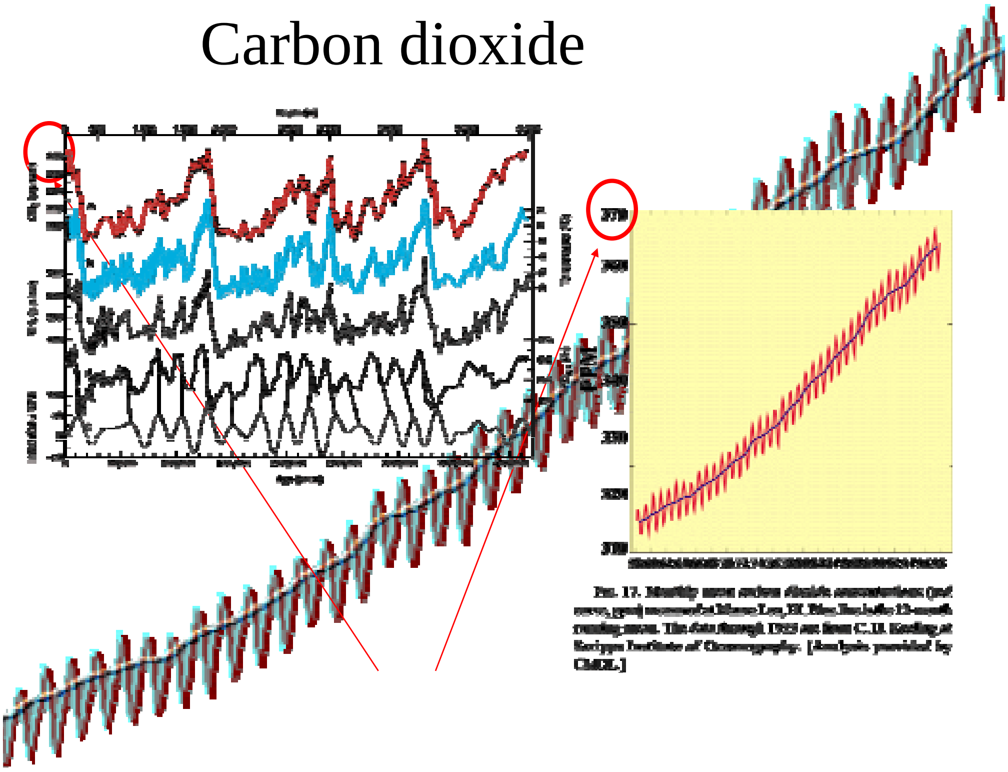


Figure 5: Carbon dioxide[27].
Comparisons between carbon dioxide concentrations in Mauna Lua and deep ice core measurements.

Temperature

Global temperature has been rising. However, there is an attribution problem, as climate is very capricious. How can we really be sure that the increase in temperature we are witnessing is the result of the changes in the greenhouse gases and not a result of natural fluctuation? While variability in the reconstruction of temperature models has not yet made it possible for the IPCC to conclusively say that increased greenhouse gases have caused the most recent temperature rise, IPCC still stated that:

'Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century.'

(IPCC WG1. 2007; p. 13)

[27] From a presentation by Antonio Navarra.

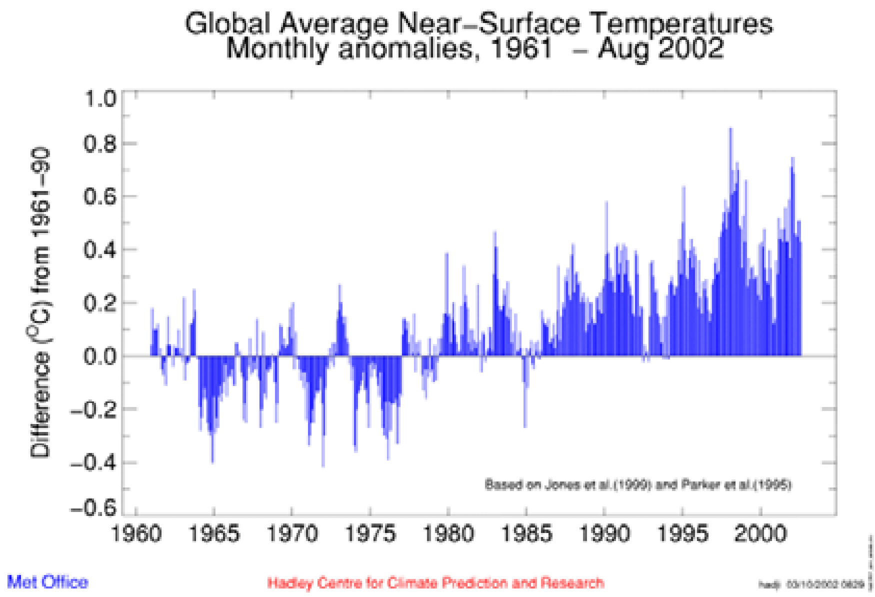


Figure 6: Global temperature[28]

Predicting future change

The only way to complete climate experiments is to produce a virtual earth in which to conduct simulations. We are very fortunate in that the basic physics and mechanics of the earth's climate are known and have led to various numerical General Circulation models. These models are our only tools for trying to make a quantitative scientific assessment on the state of the planet’s climate.

With such virtual models, we can conduct simulations. If someone were to give us expected concentrations of greenhouse gases over the next few thousand years, we could simulate the planet’s future climate. This is the basis of the IPCC scenarios, for example when tracking global surface warming. Figure 7 shows surface temperature scenarios starting in 1900 and continuing until 2300. Different lines mark different scenarios:

[28] Source: Hadley Centre for Climate Prediction and Research. From presentation by Antonio Navarra.

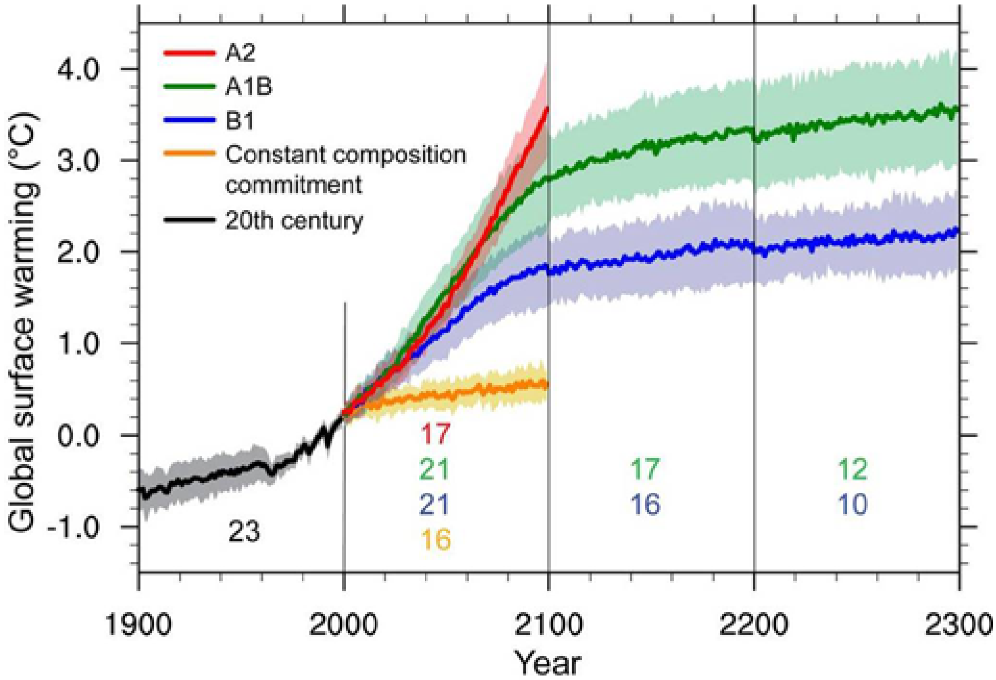


Figure 7: Surface temperature scenarios

Unprecedented coordinated climate change experiments from 16 groups (11 countries) and 23 models collected at the Programme for Climate Model Diagnosis and Intercomparison (PCMDI) (31 terabytes of model data); openly available, accessed by over 950 scientists; nearly 200 research papers.

Committed warming averages 0.1 °C per decade for the first two decades of the 21st century; across all scenarios, the average warming is 0.2 °C per decade for that time period (recent observed trend 0.2 °C per decade)[29].

The range we are facing is between a warming until 2300 of slightly less than 2° with a warming of more than 3.4° globally. In a more optimistic scenario, the planet would warm up less than 3°.

While there is much debate about the impacts of the different predicted future scenarios, one point to emphasise is the implications of the multi-model results for the 'constant composition commitment' — the kind of climate change to which we have already committed.

Box 2: Climate change commitment

Due to the thermal inertia of the ocean and slow processes in the biosphere, the cryosphere and land surfaces, the climate would continue to change even if the atmospheric composition was fixed at today's values. Past change in atmospheric composition leads to a 'committed' climate change which continues for as long as a radiative imbalance persists and until all components of the climate system have adjusted to a new state. The further change in temperature after the composition of the atmosphere is held constant is referred to as the

[29] IPCC WG1. 2007; p. 762.

committed warming or warming commitment. Climate change commitment includes other future changes, for example in the hydrological cycle, in extreme weather events, and in sea level rise.

(IPCC WG2 2007; p. 871-2)

This clearly calls for adaptation. Mitigation is important as well, but we must not forget that we are already committed to significant climate change.

Box 3: Mitigation and adaptation

In the terminology of climate change, 'mitigation' refers to actions that limit the amount and rate of climate change (the exposure) by constraining the emissions of greenhouse gases or enhancing their sinks. Adaptation refers to any actions undertaken to avoid, prepare for or respond to the detrimental impacts of observed or anticipated climate change. Mitigation and adaptation vary significantly in their scope, types of actions, characteristic spatiotemporal scales and principal actors. Mitigation is the only strategy that can reduce impacts of climate change on all systems and on a global scale but it requires international cooperation and takes a long time to become fully effective because of the inherent inertia of the climate system. Adaptation is limited to specific climate-related risks in human systems on a local or regional level and over a shorter time. Adaptation also refers to the process by which adaptive measures are implemented. It can be immediate and intuitive, but it can also involve a long process of information collection, planning, implementation and monitoring.The terms 'autonomous adaptation' and 'planned adaptation' are generally used to distinguish between these two types, even though the distinction is not always sharp (Fuessel et al 2006).

(WHO 2005; p. 14)

Box 4: Summary for policymakers — IPCC WG2 Fourth Assessment Report, Europe

For the first time, the wide-ranging impacts of changes in current climate have been documented: retreating glaciers, longer growing seasons, shift of species ranges, and health impacts due to a heatwave of unprecedented magnitude. The observed changes described above are consistent with those projected for future climate change.

Nearly all European regions will be negatively affected by some future consequences of climate change and these changes will pose challenges to many economic sectors. Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include an increased risk of inland flash floods, and more frequent coastal flooding and increased erosion (due to storminess and sea-level rise). The great majority of organisms and ecosystems will have difficulty adapting to climate change. Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60% under high emission scenarios by 2080).

In Southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. It is also projected that it will increase health risks due to heatwaves and the frequency of wildfires.

In Central and Eastern Europe, summer precipitation is projected to decrease, causing higher water stress. Health risks due to heatwaves are projected to increase. Forest productivity is expected to decline and the frequency of peatland fires to increase.

In Northern Europe, climate change is initially projected to bring mixed effects, including some benefits such as reduced demand for heating, increased crop yields and increased forest growth. However, as climate change continues, its negative impacts (including more frequent winter floods, endangered ecosystems and increasing ground instability) are likely to outweigh its benefits.

Adaptation to climate change is likely to benefit from experience gained while reacting to extreme climate events, by specifically implementing proactive climate change risk management adaptation plans[30].

One study conducted at ETH Zurich — based on high-resolution scenarios for Europe — showed that towards the end of the century, the distribution of the monthly means is such that 2003 is about average, which means that every second summer is going to be at least as warm as the summer of 2003. This A2 scenario (see Figure 7) points to a wider distribution of temperatures (higher variance), which means that some summers will be much hotter than 2003, while other ones will be considerably colder.

Box 5: What kind of climatic changes might Europe face?

Annual mean temperatures in Europe are *likely* to increase more than the global mean. Seasonally, the largest warming is *likely* to be in northern Europe in winter and in the Mediterranean area in summer. Minimum winter temperatures are *likely* to increase more than the average in northern Europe. Maximum summer temperatures are *likely* to increase more than the average in southern and central Europe. Annual precipitation is *very likely* to increase in most of northern Europe and decrease in most of the Mediterranean area. In central Europe, precipitation is *likely* to increase in winter but decrease in summer. Extremes of daily precipitation will *very likely* increase in northern Europe. The annual number of precipitation days is *very likely* to decrease in the Mediterranean area. The risk of summer drought is *likely* to increase in central Europe and in the Mediterranean area. The duration of the snow season is *very likely* to shorten, and snow depth is *likely* to decrease in most of Europe.

(IPCC WG1 2007; p. 850)

[30] http://www.ipcc.ch/SPM13apr07.pdf; p. 9. Cited 2007 May 28.

Case study — the Mediterranean

The Mediterranean, from a meteorological point of view, is a border area. In winter, it is part of Northern Europe. In summer, it is part of Africa. All the rain is concentrated in the winter, and this alternating situation creates the mild Mediterranean climate. It is characterised by hot and dry summers, but there is sufficient water because of the winter rainfall pattern. However, if this border shifts, even as little as 500 km north, then the region will experience a North African climate all year round. We are currently witnessing this phenomenon. Climate models predict a rise in average temperatures of 4–5 °C[31] and the loss of a quarter of the winter precipitation over the area. Whilst these changes may have no global consequences, they do have very important consequences for the region. One of the main challenges is to receive regional information with the right resolution and the right detail, so an impact study can be conducted in a reliable and effective way.

Climate-change effects on physical and biological ecosystems

Ecosystems are fundamental to our existence, as they provide food, water and fuel. They also provide regulating services like carbon sequestration. Ecosystems can help to slow down climate change, prevent floods and erosion. They clean the air, regulate pests and diseases. Ecosystems are also instrumental in maintaining biodiversity.

Many biological and physical systems are already affected:

September 1979

September 2003

Figure 8: Observed sea ice[32]

Above are images of the North Pole ice caps that allow us to compare today's situation to the situation thirty years ago — when there was much greater coverage. In respect to Europe, we can say that already a quarter of our glaciers has been reduced in volume, as these images (1988 to 2004) demonstrate:

[31] As reported at the workshop.
[32] Composite satellite reconstruction, NASA. From Jonathan Patz's presentation.

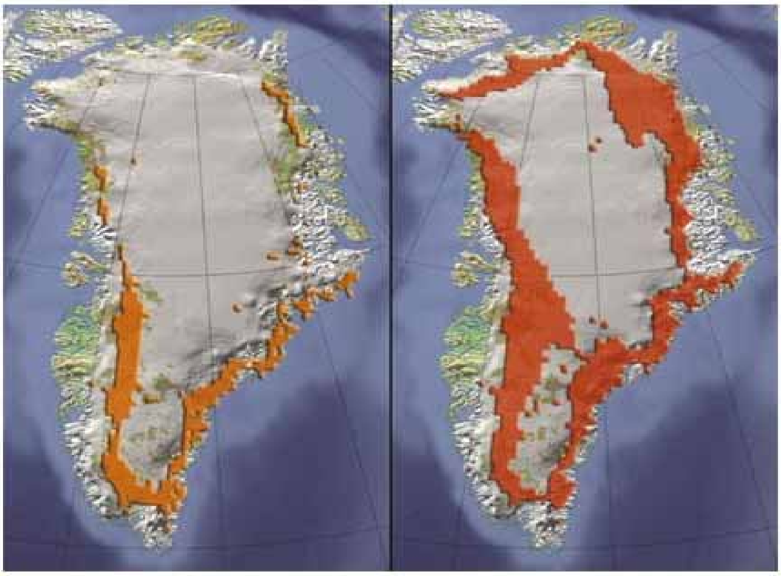


***Figure 9: Changes in Greenland ice mass 1988 to 2004*[33]**

Outside Europe, one of the world's most vulnerable ecosystems, the coral reefs, are experiencing the aftereffects of rising surface temperatures.

There are many effects of climate change on physical and biological systems, especially when moving down the chain of ecosystems. However, not all changes are negative. Climate is affecting some ecosystems in a positive way. Warmer temperatures combined with simultaneous higher precipitation can result in increased productivity. This can also be negative if those ecosystems fall victim to a drought. The overall balance is very delicate. We have observed a lot of recovery taking place in European forests after the heatwave of 2003. Evidence from remote sensing shows how difficult it is to see lasting changes in these forests that can be traced back to the summer of 2003. But if such heatwaves will become more frequent, ecosystems are likely to be permanently affected. One model[34], which makes projections about what future forests will look like, predicts that during this century and particularly the next, many beech forests will be converted into oak forests.

Biodiversity (as reported by IPCC Working Group 2) will be significantly impacted by climate change, particularly by stress scenarios beyond A2. 'Significant' is understood to mean that at least 20% of the area will be undergoing major changes. Predictions for the future show the same pattern.

This is causing and will continue to cause major consequences for disease vectors that directly depend on these ecosystems. This is also going to be very important in terms of how transmissions take place for the entire epidemiology that would form in such an environment.

[33] Available from: http://polarmet.mps.ohio-state.edu/jbox/pubs/Box_et_al_2005_J_Climate.pdf; p. 48.
[34] Reported during the meeting by Andreas Fischlin.

Chapter III

FEATURES OF CLIMATE AND ECOLOGICAL CHANGE THAT INCREASE THE RISK OF INFECTIOUS DISEASES

Building upon the discussions regarding global climate and ecological changes, the focus of the meeting now shifted to some of the features of climate and other ecological changes that increase the human risk for infectious diseases. Included in this discussion were factors related to temperature, water, spatial, temporal (seasonal), habitat and genetic changes[35].

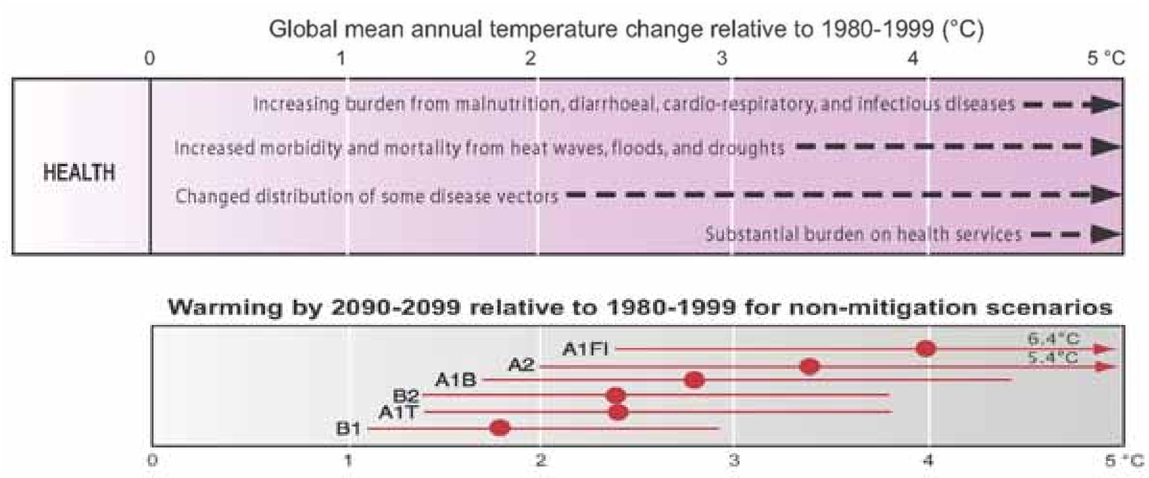


Figure 10: IPCC 4th Assessment[36].

Adapted from Figure SPM.2 (IPCC, 2007). Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century [T20.8]. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of the text indicates the approximate onset of a given impact. Adaptation to climate change is not included in these estimations. All entries are from published studies recorded in the chapters of the Assessment. Confidence levels for all statements are high.

At the meeting, it was reiterated that climate and ecological factors are part of a broad spectrum of determinants of disease (see Figure 11), all of which interact. Even now, we are beginning to see the effect that global warming has on infectious diseases.

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[35] Adapted from presentations by Jonathan Patz and Bettina Menne.
[36] Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE, editors. IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press; 2007. p 7-22.

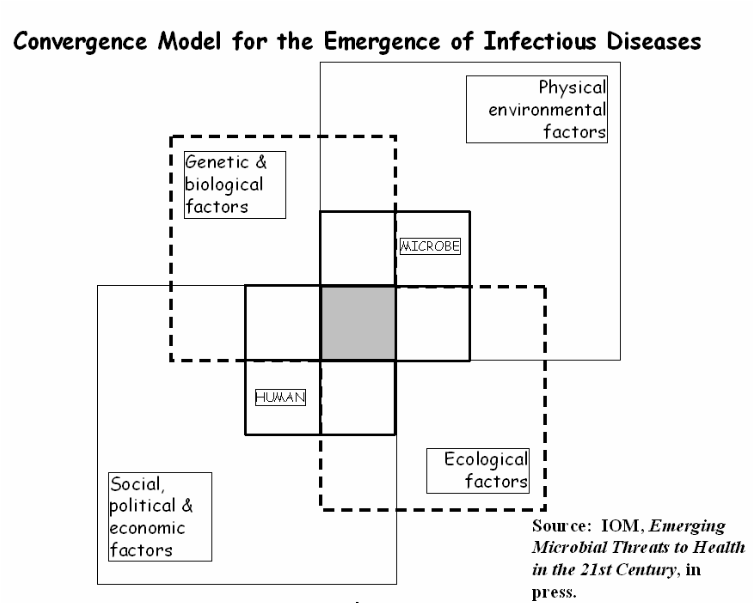


Figure 11: Convergence model for the emergence of infectious diseases[37].

Figure 12 describes the cluster of factors that influences the changing disease burden caused by Lyme disease.

Factors influencing vector and reservoir animal abundance:

- Land use and land cover changes (the latter due to human activities or from natural causes) that affect tick habitats and host animal populations.
- Global changes, such as climate change, with direct effects on the survival and development of ticks, and indirect effects on tick abundance and pathogen transmission through impacts on the composition of plant and animal species, and on the on-set and length of the seasonal activity periods of the tick

Factors influencing human–tick encounters:

- Changes in human settlements and other demographic changes in relation to the proximity to risk areas
- Changes in human recreational behaviour, including changes caused by altered climatic conditions
- Changes in use of areas for commercial purpose, e.g. forestry, game-keeping, hunting and eco-tourism
- Effectiveness of information campaigns on LB disease risk, and the use of different self-protective methods.

Factors affecting society's adaptive capability to changes:

- Socioeconomic and technological level
- Presence of monitoring and surveillance centres and networks
- Capability of the public health sector and local communities to handle acute and long-term changes in disease outbreaks and risk
- Type of energy and transportation systems in use and other factors influencing the society's contribution to present and future greenhouse gas emissions

[37] US National Academy of Sciences, Institute of Medicine. From a presentation by Jonathan Patz.

Figure 12: Factors influencing changes in the disease burden of Lyme borreliosis.[38]

Additionally, it was noted that ecological changes result not only from climate change but also from other environmental causes [39]. These other environmental change factors include land use change as a result of deforestation, mining, or water projects. Some argue that the speed of land use change affects local climate conditions much more rapidly than global warming. However, other issues arise when habitat and biodiversity are changed. Environmental and climate change are important, but changing land use is happening even faster. An area of rainforest the size of Germany is being deforested every year.

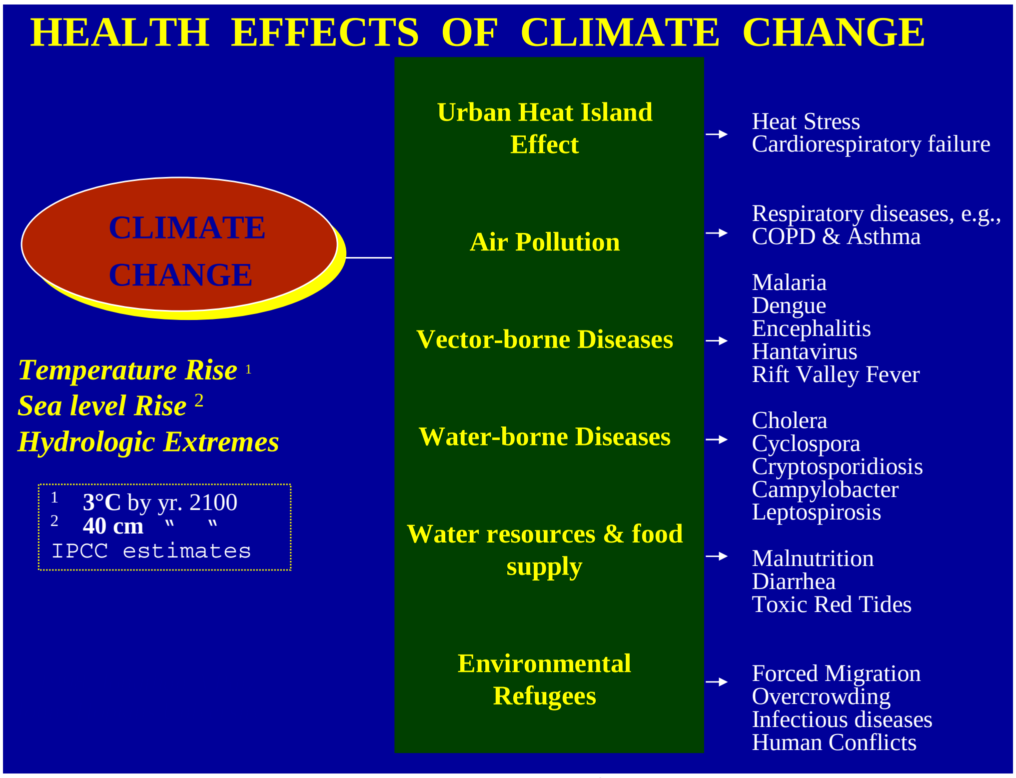


Figure 13: Health effects of climate change[40].

The key physical attributes of climate change (rising temperatures, sea-level rise and extremes of the water cycle) cut across many health areas (see Figure 14).

[38] Modified from: Lindgren E, Jaenson TGT. 2006; p. 171.
[39] Adapted from a presentation by Jonathan Patz.
[40] Source: Presentation by Jonathan Patz.

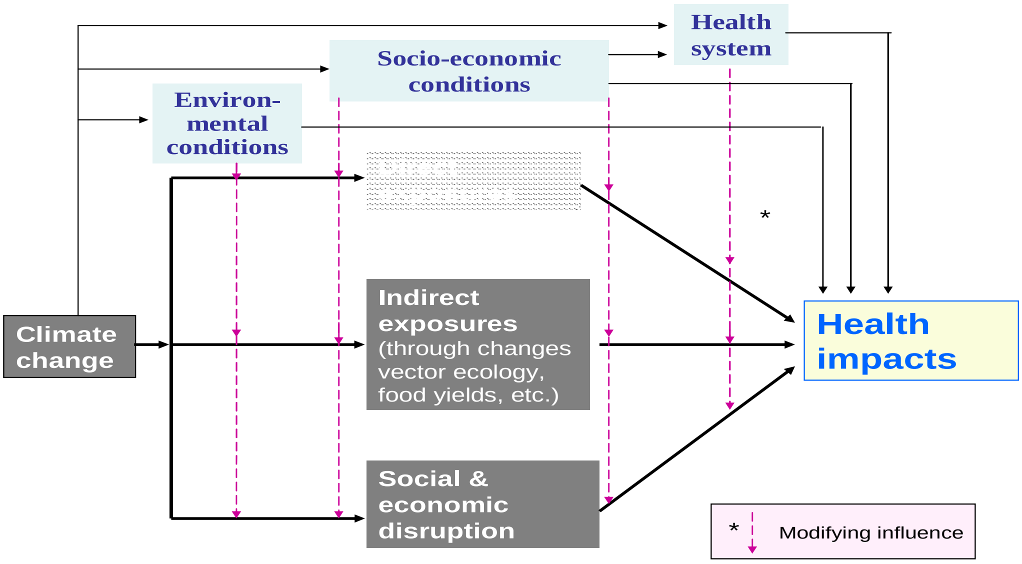


Figure 14: Pathways by which climate change and variability affects health[41].

A WHO quantitative assessment that took into account only a subset of the possible health impacts, concluded that the effects of the climate change that has occurred since the mid-1970s may have caused over 150 000 deaths worldwide in 2000 alone[42].

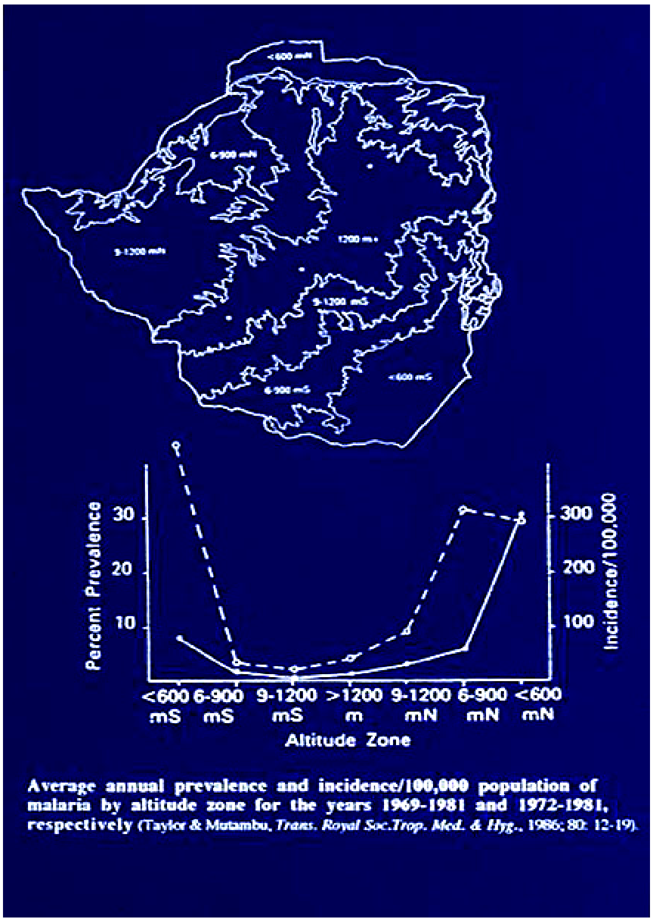
General impact on vectors and infectious agents

Temperature

Mosquitoes are cold-blooded, and air temperature determines their body temperature. When we talk about adapting to increasing temperatures, it must be kept in mind that there is a big difference between warm-blooded mammals and mosquitoes, where a fraction of a degree can change ecology and transmission dynamics.

The following map of Zimbabwe, for example, shows how high altitude areas have a very low incidence of malaria, but with lower altitudes, average temperatures and malaria increase.

[41] Source: Confalonieri U, Menne B, Akhtar R, Ebi KL, Hauengue M, Kovats RS, et al. 2007; p. 7. From a presentation by Bettina Menne.
[42] http://www.who.int/mediacentre/factsheets/fs266/en/. Cited 2006 Jun 27.



Average annual prevalence and incidence/100,000 population of malaria by altitude zone for the years 1969-1981 and 1972-1981, respectively (Taylor & Mutambu, *Trans. Royal Soc.Trop. Med. & Hyg.*, 1986; 80: 12-19).

Figure 15: Relationship between malaria and altitude, Zimbabwe[43].

Altitude is a good surrogate for temperature: the average temperatures decrease with altitude = 6 °C per 1000 meters.

Climate is not the only relevant issue when it comes to infectious diseases. Drug resistance, nutrition status and all sorts of others factors come into play. But there is also a climate envelope. The parasite that causes malaria cannot develop unless the temperature is above 16–18 °C, depending on the species. This is why malaria is a tropical disease. It cannot develop below a certain temperature, and the warmer the temperature, the faster the parasite develops. Other factors such as mosquito survival also come into play.

For smaller countries like Honduras, Nicaragua and Thailand, predictions based on a climate-driven mosquito (*aedes*) index model compare very well to the actual number of nationally reported cases. For larger countries like Brazil, with several distinct climate zones, there is not much correlation.

[43] Source: Taylor P, Mutambu SL. 1986. From a presentation by Jonathan Patz.

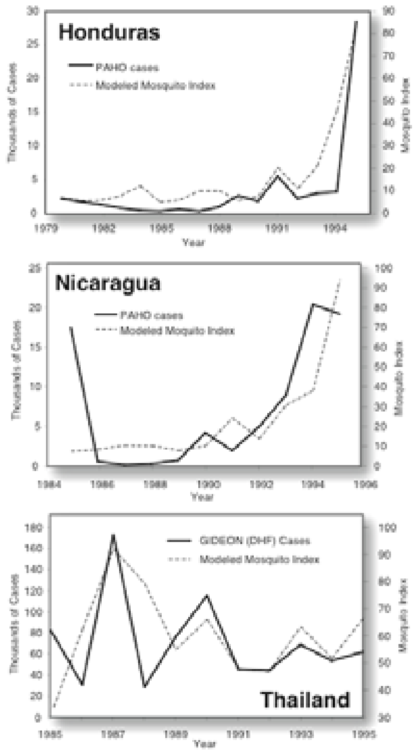


Figure 16: Dengue fever[44].

Aedes mosquito index (climate-based model) compared to nationally reported dengue cases. Hopp M, Foley J. 2003.

As far as diseases relevant to Europe are concerned, West Nile virus (see Box 8) appears to be influenced by extreme climate, especially hot temperatures, and drought conditions. The *culex* mosquito, which spreads the virus, thrives in droughts and dirty urban water. In recent large outbreaks of West Nile virus in Romania, the Russian Federation, Israel and the United States of America, the outbreaks were always associated with either a drought or a heatwave.

[44] Source: Presentation by Jonathan Patz.

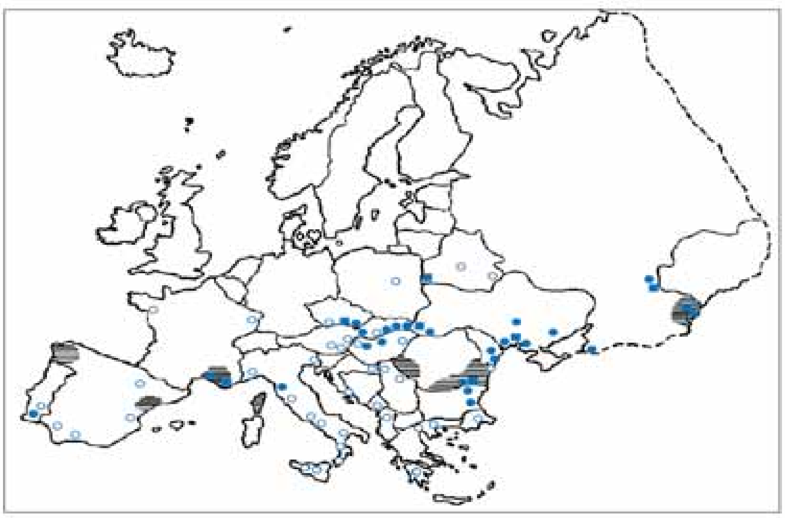


Fig. 1. Geographical distribution of West Nile virus in Europe: full circles, the virus isolated from mosquitoes or vertebrates; full squares, laboratory/confirmed human or equine cases of West Nile fever; circles and hatched areas, presence of specific antibodies (Hubálek and Halouzka, 1999)

Figure 17: Geographical distribution of West Nile virus in Europe[45].

Hydrological factors

As noted in the WNV example given above, hydrological extremes[46], in addition to temperatures, play an important role. A study looking at extreme precipitation related to water-borne diseases for all reported outbreaks in the US from 1948–1994 (excluding outbreaks with known engineering failures) found that 67% of water-borne disease outbreaks were preceded by extremely heavy rainfall in the upper eightieth percentile[47]. A correlation between this and combined sewage overflow events has been made[48]. Lack of fresh water is associated with a variety of challenges to sustainable development.

[45] Hubálek Z, Kriz B, Menne B. 2006; p. 218. From Bettina Menne's presentation.
[46] There is some indication that epidemics of WNF and ecologically similar St. Louis encephalitis in North America occur often after long, dry summers, followed by one wet summer (Epstein P. 2001). The data, however, are insufficient at present.
[47] Presented by Jonathan Patz.
[48] Curriero F, Patz JA, Rose JB, Lele S. 2001. Adapted from a presentation by Jonathan Patz.

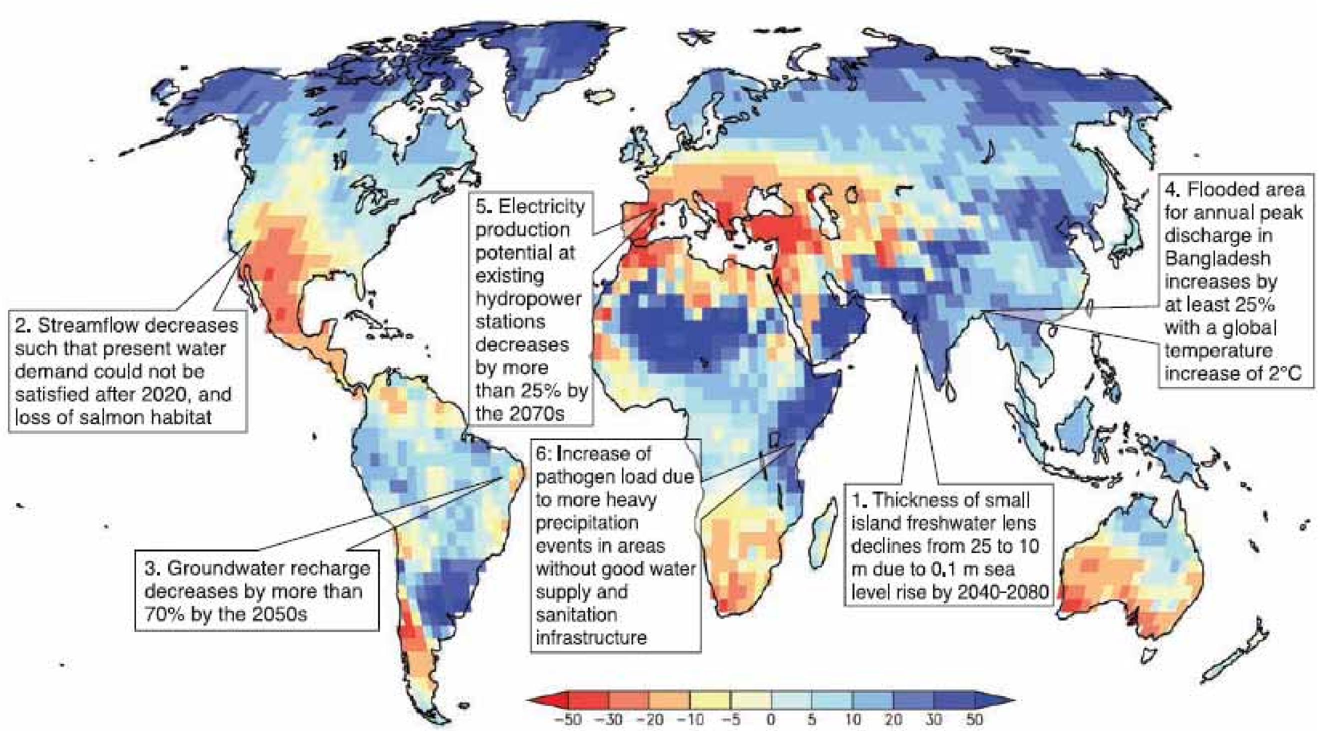


Figure 18: Water stress[49].
Illustrative map of future climate change impacts on freshwater which are a threat to the sustainable development of the affected regions.

Habitat fragmentation and biodiversity

Land use change is taking place all over the world, and habitat fragmentation changes species biodiversity, which in turn can affect health. A look at a study on Lyme disease[50] demonstrates how this may occur. If white-footed mice are the only reservoir host, 80% of ticks will be carrying the bacteria that cause Lyme disease. However, with a lot of biodiversity there are several other hosts for ticks that are less than ideal carriers for Lyme bacteria. Therefore, the risk of Lyme disease is lower, with maybe only 30% of all ticks carrying the Lyme disease bacteria.

[49] Figure 3.8 in: Kundzewicz ZW, Mata LJ, Arnell NW, Döll P, Kabat P, Jiménez B, et al. Freshwater resources and their management. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210.
[50] Rick Ostfeld (Institute for Ecosystems Studies), cited by Jonathan Patz in his presentation.

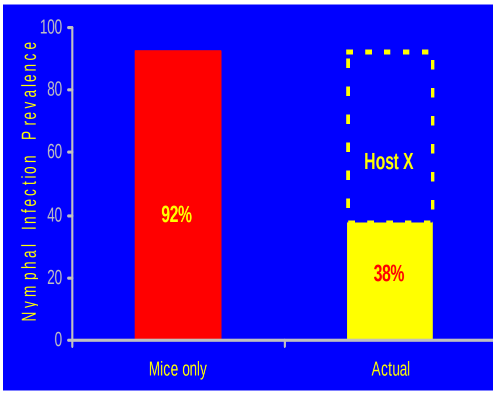


Figure 19: Nymphal infection prevalence[51].

Deforestation

A study in the Peruvian Amazon comparing pristine jungle with disturbed areas [52] observed major differences in the number of mosquito (*Anopheles darlingii)* larvae. In the disturbed areas, researches counted six or seven times as many larvae, implying that deforestation increased the risk of malaria infections.

Seasonality

In Europe, pollen season now lasts longer. On average, it has increased by 10–11 days over the last 30 years (Menzel A, Estrella N, Fabian P. 2001). The introduction of new invasive plant species with highly allergenic pollen, in particular ragweed (*Ambrosia artemisiifolia*), presents significant risks to human health.

Many food- and water-borne diseases show strong seasonal patterns that reflect their mode of transmission. Ambient seasonal temperature changes have been estimated as drivers in approximately 30% of reported Salmonellosis cases in ten European countries, with a 5–10% rise in Salmonella infection incidence for each 1 °C increase in weekly temperatures above 5 °C (WHO 2005, p24).

Spatial changes

These temperature, hydrological and other changes have resulted in the spread of infectious agents into new areas. For example, *Ixodes ricinus* has been observed in higher latitudes and altitudes over the last 50 years (see Figure 20). With regard to leishmaniasis, new endemic areas have been detected (WHO 2005; p. 22).

[51] Source: Schmidt KA, Ostfeld RS. 2001. From a presentation by Jonathan Patz.
[52] Jonathan Patz with Amy Vittor.

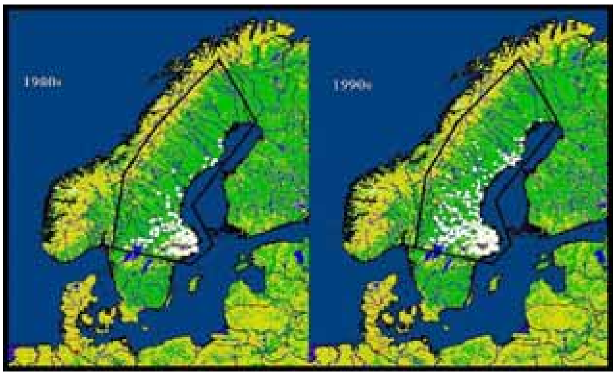


***Figure 20: Movement of* Ixodes ricinus *in Scandinavia*[53].**

Also affecting spatial distribution are changes in bird migration, travel and transport. The effects of these factors on the spread of SARS and Avian Flu have been reported (http://www.newscientist.com/channel/health/bird-flu). Invasion of exotic species, like ragweed, has been noted in new areas. Northward movement of some cyanobacteria has also been reported (http://www.int-res.com/articles/meps/211/m211p193.pdf) (see Figure 21). Attribution is a key challenge here.

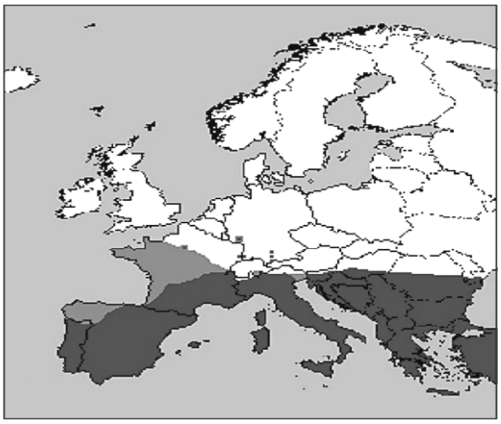


***Figure 21: Approximate distribution of visceral leishmaniasis (dark, southern region) and its sandfly vector (light, smaller area) in Europe*[54].**

Genetic shifts

Genetic shifts have also been noted in response to global warming. Bradshaw and Holzapfel (2001) noted shifts in a number of behaviours and seasonality.

[53] Lindgren E, Tälleklint L, Polfeldt T. 2000. From a presentation by Bettina Menne.
[54] Adapted from Lindgren E, Naucke T, Marty P, Menne B. 2006; p. 134. From a presentation by Bettina Menne.

Genetic shift in photoperiodic response correlated with global warming

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To date, all altered patterns of seasonal interactions observed in insects, birds, amphibians, and plants associated with global warming during the latter half of the 20th century are explicable as variable expressions of plastic phenotypes. Over the last 30 years, the genetically controlled photoperiodic response of the pitcher-plant mosquito, *Wyeomyia smithii*, has shifted toward shorter, more southern daylengths as growing seasons have become longer. This shift is detectable over a time interval as short as 5 years. Faster evolutionary response has occurred in northern pop-

Adaptive animals. The Yukon red squirrel (*Tamiascurus hudsonicus*) **(left)**, the pitcher-plant mosquito (*Wyeomyia smithii*, shown descending into its carnivorous host, *Sarracenia purpurea*) **(middle)**, and the European blackcap (*Sylvia atricapilla*) **(right)** show genetically based shifts in the timing of their seasonal reproduction, dormancy, or migration during recent, rapid climate warming.

Figure 22: Genetic shifts[55].

[55] Adapted from Bradshaw WE, Holzapfel CM. 2001. From presentation by Bettina Menne.

Chapter IV

INFECTIOUS DISEASES CURRENTLY OR LIKELY TO BE INFLUENCED BY CLIMATE AND ECOLOGICAL CHANGE[56]

In order to better address issues related to infectious diseases which are changing (or are likely to change) their spatial, temporal (seasonal) or virulence characteristics due to current and predicted climate and ecological change, participants were divided into four groups and asked to respond to a series of questions (see below).

Box 6: Group discussion questions

- What are the biggest infectious disease threats?
- What are the changing patterns of exposure related to distribution, importation, globalisation, etc.?
- What are the critical risk factors?
  - personal, e.g. recreational water use, occupational exposure, etc.;
  - environmental, e.g. water contamination;
  - community-level, e.g. land use and zoning (vicinity to forested areas, urban heat islands); and
  - climatic/geographic, e.g. rising temperatures, sea-level rise, etc.
- Who is most at risk? Groups and subpopulations must be classifed according to risk.
- Demographic variables (age, sex, SES, etc.) ?
- Marginalised groups (immigrants)?
- Medical risk factors (immunocompromised)?

- What implications do these issues have on policy making?

Each group focused on a 'mode of transmission' set: vector/rodent, air, water and food/zoonoses [57]. Findings of the group discussions are summarised here.

[56] Based on Group 1 reports (see programme) and supplemented by a variety of web-based information sheets.
[57] Since the discussion groups were set up along the lines of transmission groups, participants expressed concern that focusing only on a limited number of diseases might increase the probability of missing an unexpected event. Noted was the fact that there is a broad diversity of threats, a diversity of eco-regions and a diversity of risk factors in Europe. Participants suggested to focus on risk-based strategic pan-European surveillance networks (diseases and vectors), instead of becoming preoccupied with specific diseases. This consideration will be further discussed in Section VI when discussing action plans.

Vector- / rodent-borne diseases

Box 7: Vector-borne diseases (VBD)

Vector-borne diseases (VBD) are infections transmitted by the bite of infected arthropod species, such as mosquitoes, ticks, bugs and flies. VBDs are important health outcomes that are associated with climatic changes due to their widespread occurrence and sensitivity to climatic factors. Climate change can affect VBD in several ways, namely the survival and reproduction rates of vectors, in turn determining their distribution and abundance. Their intensity and temporal pattern of vector activity is also affected (particularly biting rates) throughout the year as are the rates of development, survival and reproduction of pathogens within vectors.

(Menne B, Ebi KL, editors. 2006; p. 129)

The working group identified five groups of vector- and rodent-borne diseases, namely mosquito-borne, tick-borne, sandfly-borne, rodent-borne and midge-borne.

Mosquito-borne diseases

- Arbovirus: West Nile (WE, CE, EE, SE), dengue (OT), chikungunya (OT), Rift Valley fever (Sub-Saharan Africa), Tahyna (California Group) (SE, CE, EE).
- Parasite: malaria[58] (SE, EE).

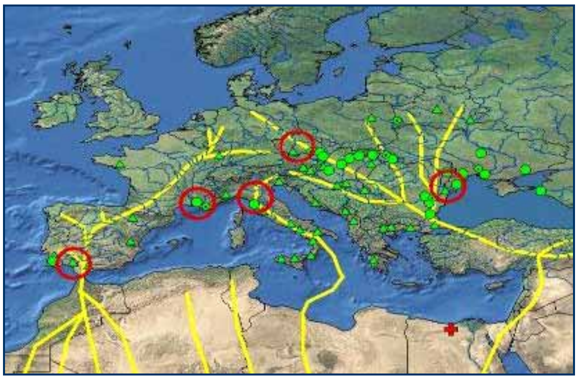

Figure 23: West Nile Virus.

Box 8: West Nile Virus

West Nile flavivirus (WNV) has emerged or re-emerged in recent years in the temperate regions of Europe, North Africa and North America, presenting a threat to public, equine and animal health.

[58] Although several models predicted a potential increase of malaria in Europe, there is agreement that under current socioeconomic conditions the risk is very low. The greatest risk probably exists in those eastern European countries where per capita health expenditure is relatively low, so that health services are less efficient at detecting and treating malaria cases. Also, in many of these countries environmental measures to control mosquito distribution are poorly implemented, if at all (WHO 2005, p. 23).

WNV is transmitted infrequently to humans through the bite of an infected mosquito, usually of the genus Culex, but sometimes also by non-Culex mosquito bridge vectors. The virus can be transmitted also from person to person through blood transfusion or organ transplantation (CDC 2002).

The incidence of human WNV infections in Europe remains largely unknown, and only some of the epidemics with tens or hundreds of West Nile flu cases have probably been recorded (Bárdoš V, Adamcová J, Dedei S, Gjini N, Rosický B, Šimková A. 1959. Hubálek Z, Halouzka J. 1999).

Factors making WNV transmission easier include favourable weather conditions (temperature, humidity and their appropriate annual distribution) (Reeves WC, Hardy JL, Reisen WK, Milby MM 1994. Reiter 2001); abundant competent mosquito vectors (Culex pipiens pipiens, Cx. modestus, Mansonia richiardii), which require the presence of suitable breeding habitats for mosquitoes, e.g. flooded basements in blockhouses (Bucharest 1996–98) and rainwater sewage systems with sediment traps (New York 1999–2000).

(Adapted from: Hubálek Z, Kriz B, Menne B. 2006.)

Box 9: West Nile Virus and climate change

The main season for WNF among humans and horses in Europe (as well as in North America) is from July to October, with a peak in August and September, due to the enhanced seasonal activity of vector mosquitoes.

The principal vectors of WNF in Europe are mosquitoes of the genus Culex: Cx. pipiens complex, and Cx. modestus. Whereas Cx. pipiens is distributed widely over all of Europe, Cx. modestus is confined to wetland and fishpond areas of southern and central Europe and only lives in reedbelt (Phragmites communis, Typha spp.) habitats. Global climate changes can hardly affect the geographic range of Cx. pipiens in Europe, but if the scenario of global warming is correct, anticipated increased temperatures could lead to a higher population density of vector mosquitoes. More importantly, higher temperatures would cause an accelerated reproduction rate of WNV in the vector. However, it should be noted that large mosquito populations alone are not sufficient to cause epidemic transmission. The virulent strain must also be present.

(Hubálek Z, Kriz B, Menne B. 2006; p. 229)

With mosquito-borne diseases there is always the possibility of arboviruses, parasites, or even vectors to emerge and threaten Europe.

Box 10: Malaria in Europe: is it really a threat?

From a policy perspective, it is important to understand the various drivers of disease expansion and retreat. A variety of recent modelling efforts have shown that, assuming no future human-imposed constraints on malaria transmission, changes in temperature and precipitation could alter its geographic distribution and intensity, with previously unsuitable areas of dense human population becoming suitable for transmission (Martens & Hall 2000; Parry et al 2001). Projected changes include an expansion in latitude and altitude, and, in some regions, a longer season during which malaria may be present. Such changes could dramatically increase the number of people at risk. The potential for malaria and other 'tropical' diseases to invade southern Europe is commonly cited as an example of the territorial expansion of risk. However, many of these diseases existed in Europe in the past and have been essentially eliminated by public health programmes. For example, in the early part of the twentieth century malaria was endemic in many parts of southern Europe (Kuhn 2006; Kuhn et al 2003; Kuhn et al 2002), but its prevalence was reduced primarily via improved land drainage, better quality of housing construction and higher levels of socioeconomic development, including better education and nutrition. Any role that climate played in malaria reduction would have been small. Note that this does not provide assurance that climate will not play a larger role in determining the future range and intensity of malaria transmission.

(WHO 2005; p. 23)

Box 11: Dengue

Dengue is the most important arboviral disease of humans. Dengue and the related syndromes of dengue haemorrhagic fever and dengue shock syndrome are a leading cause of child mortality in Asia.

Dengue is not now present in Europe […] Dengue is included in this report because there is a risk it may be re-introduced into the European Region.

The principal vector of dengue is the mosquito Ae. aegypti, which is adapted to urban environments. Historically, Ae. aegypti has been recorded in several European and North African countries in the Mediterranean region, including France and Portugal.

Another dengue vector, Ae. albopictus, is currently extending its range in Europe. It was introduced into Italy in 1990 and has been reported from 10 regions and 19 provinces since. It has also been separately reported from Albania since 1979. The climatic limits to the distribution of Ae. albopictus are a monthly mean winter temperature below 0 °C, a mean annual rainfall exceeding 50 cm and a mean summer temperature exceeding 20 °C. Countries in the European Region that currently meet such criteria include Albania, France, Greece, Portugal, Spain […] (Knudsen et al 1996).

Epidemiological studies have shown that temperature is a major factor in dengue transmission in urban areas (McMichael et al 1996). An increase in global mean temperature of 2 °C by 2100 can potentially increase the latitudinal and altitudinal range of transmission of the disease. In temperate locations, climate change would increase the length of the transmission season (Jetten & Focks 1997).

Focks et al. (1995) have developed and validated a mathematical model of dengue transmission. The model indicates that dengue transmission could occur in Athens for a short period in late summer under current climate conditions if the vector and virus were introduced (Jetten & Focks 1997). This is consistent with observed transmission, as Athens experienced a large outbreak of dengue in 1928. An increase in mean temperature would only result in seasonal dengue transmission in southern Europe if the vector and virus were to be established.

(Kovats S, Menne B, McMichael A, Bertollini R, Soskolne C, editors. 2000; p. 44-5.)

Sandfly-borne diseases

- Arbovirus: Toscana (MR)
- Parasite: leishmaniasis (MR)

Figure 24: Distribution Leishmania tropica.

The second group of diseases is borne by sandflies. Leishmaniasis (see map) is already present in Europe but is now spreading north due to occurring changes.

Box 12: Leishmaniasis

Leishmaniasis occurs in two forms, both of which are present in Europe (Desjeux 1991). Both the visceral and the cutaneous form are caused by Leishmania donovani infantum. Cutaneous leishmaniasis cases have been reported from France, Italy, Spain and countries in central Asia. Zoonotic visceral leishmaniasis (also known as kala-azar) is endemic in all countries bordering the Mediterranean Sea. It has become a co-infection with HIV in France, Italy and Spain. (Dedet JP, Lambert M, Pratlong F. 1995).

Leishmaniasis is transmitted by sandflies inhabiting semiarid regions. Sandflies are very susceptible to DDT and were significantly reduced in Europe following the malaria eradication campaigns of the 1960s and 1970s. As vector control declined, however, vector densities increased. The reservoirs or intermediate hosts of the pathogen are rodents, foxes and domestic or stray dogs. In endemic urban areas, the black rat may play a role in transmission.

There are two sandfly vectors of leishmaniasis in Europe. Phlebotomus perniciosus is distributed throughout the Mediterranean region (France, Portugal, Spain, Tunisia and Turkey). Ph. Perfiliewi has more of a northern distribution, extending from Cyprus, Greece and Malta (but not North Africa) to Eastern Europe […].

Sandfly vectors are not actively controlled in Europe. Cutaneous leishmaniasis and zoonotic visceral leishmaniasis are controlled by treating human cases. In Europe, canine leishmaniasis is a major veterinary problem, and a dog vaccine is considered highly desirable. A vaccine is currently being developed for use in humans.

The distribution of zoonotic visceral leishmaniasis in Europe is probably limited by the distribution of the sandfly vectors. Climate change is likely to extend the range of the sandfly vectors northwards. One study on leishmaniasis in Italy (Kuhn KG. 1997) indicates that climate change may extend the range of Ph. perniciosus but reduce that of Ph. perfiliewi. Higher temperatures would accelerate the maturation of the protozoal parasite, thereby increasing the risk of infection (Rioux JA, Perieres J, Killick-Kendrick R, Lanotte G, Bailly M. 1985). An important vector in southwestern Asia (including Israel), Ph. papatasi has been mapped using climate and satellite data (Cross ER, Newcomb WW, Tucker, CJ. 1996). It has been estimated that a rise in temperature of 3° C would greatly increase both the geographical and seasonal distribution of Ph. papatasi in this region (Cross ER, Hyams KC. 1996).

(Kovats S, Menne B, McMichael AJ, Bertollini R, Soskolne C, editors. 2000; p. 43-4)

While there is no current compelling evidence that sandfly and visceral leishmaniasis distributions in Europe have changed in response to recent climate changes, the cCASHh analysis points to a considerable potential for climate-driven changes in leishmaniasis distribution in the future. Sandfly vectors already have a wider range than the pathogen (L. infantum), and imported dogs infected with L. infantum are common in central and northern Europe. Once conditions make transmission possible in northern latitudes, the imported dog cases could become a source of new endemic foci. Thus, climate-induced changes in sandfly abundance may increase the risk of the emergence of new diseases in the region.

(Lindgren E, Naucke T, et al. 2006) (WHO 2005; p. 22).

Tick-borne diseases

- Arboviruses: TBE (CE, NE, EE), CCHF (Balkan, EE).
- Parasite: *Babesia microti.*
- Bacteria: Lyme disease (WE, CE, NE, EE).

Figure 25: TBE foci.

Tick-borne diseases are already present in Europe, and as with leishmaniasis, they are currently spreading due to global or climate change, but also due to changing human behaviour.

Box 13: Tick-borne diseases

Ticks transmit several bacterial, rickettsial and viral pathogens to humans. Ticks are ectoparasites and their geographical distribution depends upon the availability of suitable habitat vegetation and host species, usually rodents, large mammals, such as deer. The distribution and population density of ticks is also limited by climatic factors. Tick vectors are long-lived and are active in the springsummer- early autumn months. Temperature must be sufficiently high for completion of the tick's life cycle during the warmer part of the year (i.e. above 5-8 °C), and high enough in winter to suspend the life cycle. Humidity must be sufficient to prevent both eggs and ticks from drying out. Higher temperatures enhance proliferation of the infectious agent within the ticks, although temperatures above the optimum range reduce the survival rate of both ticks and parasites.

The northern limit of the distribution of ticks in Sweden has changed between 1980 and 1994 (Tälleklint and Jaenson, 1998). In regions where ticks were prevalent in 1980s, population density has increased between the early 1980s and mid 1990s. Unpublished data show that changes in distribution and density over time are correlated with changes in seasonal daily minimum temperatures

(Lindgren et al., 1999).

Ixodid ticks such as Ixodes ricinus and I. persulcatus, which are widely distributed in temperate regions, transmit tick-borne diseases in Europe. People most at risk of infection are those who spend time in the countryside or come into contact with the ticks in vegetation in periurban areas. People have also been infected in city parks. Tick populations are difficult to control directly using pesticides. It is also difficult to control the host animal populations due to the diversity of species that can provide ticks with a blood meal. Tick populations may be controlled indirectly by modifying the local vegetation type but this can only be done on a small scale. Currently, the most effective public health measure is to raise public awareness about tick-borne diseases and how to avoid infection.

(Kovats S, Menne B, McMichael A, Bertollini R, Soskolne C, editors. 1999; p. 40)

Box 14: Lyme disease

Lyme disease is caused by infection with the spirochete Borrelia burgdorferi. It is transmitted by ticks of the Ixodes ricinus complex. Lyme disease has a global distribution in temperate countries of North America, Europe, and Asia. The transmission cycle of Lyme disease involves a range of mammalian and avian species, as well as tick species, all of which are affected by local ecology. With the onset of climate change, a shift toward milder winter temperatures may enable the expansion of the range of Lyme disease into higher latitudes and altitudes, but only if all of the vertebrate host species required by the tick vector also are able to expand their distribution. A combination of milder winters and extended spring and autumn seasons would be expected to prolong seasons for tick activity and enhance endemicity, but this would not be expected to change disease activity because humans usually are infected by the nymphal stage, which feeds at a specific time during the second year of the cycle.

(IPCC 2001. 9.7.8.1)

Lyme Borreliosis or Lyme disease is prevalent over much of Europe. The disease agent was described in 1975 after an outbreak in the US and the disease is therefore considered as an emerging infection. It is now the most prevalent arthropod-borne disease in temperate climate zones. Increase in disease incidence has been observed in several European countries (e.g. Sweden, Finland, Slovenia, the Russian Federation, Germany and Scotland). This may partly be due to increased reporting, as well as a real trend. For example, an increase in Lyme disease during the last decade has been serologically confirmed in Sweden (Berglund et al., 1995).

(Kovats S, Menne B, McMichael A, Bertollini R, Soskolne C, editors. 2000; p. 47)

Box 15: Tick-borne encephalitis

Tick-borne encephalitis is present in southern Scandinavia and in central and Eastern Europe. Tick-borne encephalitis is caused by a flavivirus with at least two subtypes: the central European type, prevalent in Europe, and the Russian spring-summer encephalitis subtype. The latter comprises other subtypes that cause diseases worldwide: louping-ill in Ireland, Norway and Scotland, Omsk haemorrhagic fever in Siberia, Kyasanur Forest disease in India and Powassan encephalitis in North America. The risk of contracting the disease from a single tick bite is 1 in 600 in endemic regions (Gustafson 1994). The mortality rate for tick-borne encephalitis is 1%, and 10% of cases lead to permanent paralysis. Mortality rates are higher for the Russian spring-summer encephalitis subtype. A vaccine for tick-borne encephalitis is available, and people at high risk of infection (such as those who live or work in endemic areas) are vaccinated in Sweden and other countries.

The tick-borne encephalitis virus is transferred mainly from small rodents to humans by ticks. The virus has also been shown to infect humans via unpasteurised goat's milk, leading to some rare localised outbreaks in the eastern part of the European region. A study lasting nearly four decades in a highly endemic region in Sweden found that the incidence of tick-borne encephalitis increased after milder winters (fewer days with temperatures below –7 °C) combined with extended spring and autumn seasons for two successive years (Lindgren 1998). The range of tick-borne encephalitis in Europe may lessen significantly as well as shift to higher latitudes and altitudes (Randolph & Rogers 2000), as its transmission depends on a particular pattern of tick seasonal dynamics, which may be disrupted by climate change.

(Kovats S, Menne B, McMichael A, Bertollini R, Soskolne C, editors. 2000; p. 47-49)

Unlike Lyme disease, sustainable transmission of TBE requires a high level of coincident feeding of larval and nymphal ticks. This seasonal synchrony depends on a particular seasonal profile of land surface temperature, specifically a rapid rate of cooling in the autumn. Synchrony may be disrupted by climate change as patterns of overwinter development by ticks are changed. A statistical model, based on the current distribution of TBE, indicates significant net contraction in the geographic distribution of TBE under mid-range climate scenarios by the 2050s (Randolph & Rogers 2000). The model indicates that although disease foci spread to higher latitudes and altitudes, current foci in central Europe largely disappear as a result of disruption of the tick seasonal dynamic by climate change. Thus, one model suggests that it is unlikely that warming would increase the incidence or net geographic distribution of TBE in Europe.

(IPCC 2001; 9.7.8.2)

Rodent-borne diseases

- Viruses: hanta[59] (pan-European), lymphocytic choriomeningitis (LCM).
- Bacteria: leptospirosis (?), tularemia (?), plague (EE and Central Asia).

[59] Hantavirus causes a rare infection that can cause haemorrhagic fever with renal syndrome (HFRS). It is transmitted from rodent to rodent through body fluids and excreta, and humans are infected only occasionally. Theory suggests that changing climates have influenced rodent migration patterns and the physiological viral adaptation processes. However, further research is needed to clarify the relationships between climate change, rodents, viruses and humans (Pejcoch MK. 2006) (WHO 2005; p. 23).

Figure 26: The distribution of* Clethrionomys glareolus*, rodent host of human hantavirus infections (nephropathia epidemica) caused by Puumala virus.

Rodent-borne diseases are less known by the European public because their outbreaks attract less attention in Europe than they would in the Americas or in Asia, yet they are still present in many countries. They are mainly limited to Northern Europe but seem to be spreading south. Whether they are actually expanding or are just recorded more frequently requires further study.

Box 16: Rodent-borne diseases

Rodents are carriers of a number of infectious diseases. Rodents can act as both intermediate infected hosts or as hosts for arthropod vectors such as fleas and ticks. Rodent populations are affected by weather conditions. In particular, warm, wet winters and springs increase rodent populations. With the onset of climate change, rodent populations could increase in temperate zones, resulting in greater interaction between humans and rodents and a higher risk of disease transmission, especially in urban areas. Rat populations have increased significantly in recent years. In some European countries, the breakdown in sanitation controls and inadequate hygiene are contributing to the rat infestation problem.

Hantaviruses are present in Europe and cause haemorrhagic disease. Epidemic haemorrhagic fever (also called haemorrhagic fever with renal syndrome) is a major problem in the Balkans. The Puumala strain caused an outbreak of more than 20 000 cases of epidemic haemorrhagic fever in the west of the Russian Federation (Bonn 1998). In Finland, studies have shown that the number of cases is linked to the population density of the host vole.

Rats are carriers of Leptospirosa interrogans, the causal agent of leptospirosis or Weil's disease. Human infections can occur after direct contact with soil or water contaminated with rat urine or faeces. Thus, flooding increases the risk of human infection.

(Kovats S, Menne B, McMichael A, Bertollini R, Soskolne C, editors. 1999; p. 43)

Midge-borne diseases

- Tropical midge and BTV 1-2-4-9-16 (SE).
- BTV 8 (BE, NL, DE, FR, LUX, etc.).
- More than 50 other viruses: African horse sickness, equine encephalitis, Akabane virus, bovine ephemeral fever, etc.

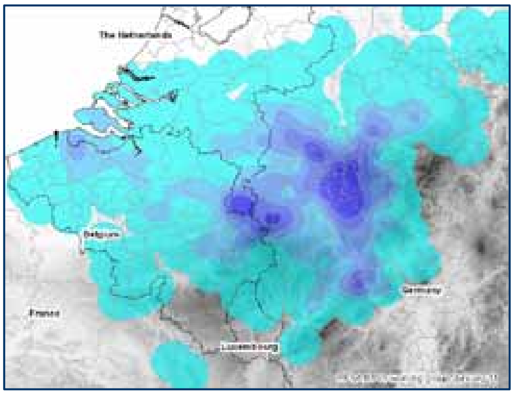

Figure 27: BTV8 2006.

Midge-borne diseases are animal health diseases, but it was noted that these types of diseases may be important, especially because of their economic impact. In Europe, there are two main areas. The first is the Mediterranean area where since the end of the 1990s to early 2000 there has been an invasion of both tropical midge and various virus serotypes. Midge-borne diseases may arguably be one of the more important types of diseases that can already be related to global change patterns. In 2007, there was a completely unexpected outbreak of a new serotype north of the 51st parallel. In just a few months, this virus spread to the resident vector population at a rate of about 15 km per week. These midges can harbour more than 50 other viruses, including the African horse sickness, equine encephalitis, Akabane virus and bovine ephemeral fever.

Box 17: Controlling VBD and rodent-borne diseases

The measures currently available to control vector- and rodent-borne diseases are disease-specific and can be broadly classified into diagnosis and treatment, vaccination, vector control and reservoir host control.

Some specific measures might need to be strengthened in risk areas, such as TBE vaccination and raising the awareness on collective and individual protection measures, like wearing suitable clothing, and self-inspection after outdoor activities to remove ticks early.

Leishmaniasis control strategies have varied little for decades, but in recent years there have been advances in diagnosis, treatment, and prevention. Important control strategies include local control of sandfly populations, the use of insecticide-impregnated dog collars and providing targeted information to at risk populations.

In order to capture early signs of climate-induced changes, active collaboration between veterinary services and health services is essential.

(WHO 2005; p. 24)

Water-related diseases

Four categories of water-related diseases which might be associated with climate change were identified by the working group (see Box 18 below). The group assumed that the biggest infectious disease threat would come from water-borne diseases.

Box 18: Classification of water-related diseases:

1. water-borne (e.g. cholera);
2. water-washed (e.g. trachoma and scabies);
3. water-associated (e.g. West Nile virus and malaria); and
4. water-based (e.g. dams, bacteria (worm-related diseases)).

Changing patterns of exposure identified included potential changes in sea levels, atmospheric humidity, precipitation, ground water levels, surface run-off and irrigation. These may cause flooding, water scarcity, the need for water storage or a discontinuation of water supply. The group pointed out that Europe should be prepared for:

- imported diseases coming from countries more seriously affected by climate changes (e.g. cholera-infected tourists returning from Africa);
- localised outbreaks which might result from infected drinking water or from flooding;
- sewage problems that could spread diseases like salmonella; and
- new transmissions as travellers visit places with cooler climates.

While mortality in Europe from water-borne diseases may not be high, evidence points to significant increases in morbidity, costs of care and associated loss of work time (WHO 2005). For these reasons, the group thought that the severity of water-related diseases as a consequence of climate change should be taken into consideration.

Box 19: Cryptosporidiosis

The most significant water-borne disease associated with the public water supply in Western Europe is cryptosporidiosis. Cryptosporidium is an intracellular parasite present in the gastrointestinal and respiratory tracts of numerous animals. Cryptosporidium oocysts can survive several months in 48 °C water and are among the most chlorine-resistant pathogens. The sporocysts are resistant to most chemical disinfectants (including water treatment chemicals), but are susceptible to drying and ultraviolet sunlight. When contamination occurs, it has the potential to infect very large numbers of people (Meinhardt et al, 1996).

A recent study assessed the role of environmental factors in all cases of cryptosporidiosis by examining the association between all monthly reported cases, weather, and river flows in England and Wales between 1989 and 1996 (Lake et al, 2005). In April, a correlation was found between the cases of cryptosporidiosis and the maximum river flow in the current month. Between May and July cryptosporidiosis was positively linked to maximum river flows in the current and previous month. Cryptosporidiosis in August and September fell in relation to rainfall in the previous three months and no associations were found between October and March. These relationships are consistent with an animal-to-human transmission pathway, and indicate that rainfall may play an important role in sporadic cases of the disease in the spring time, due to inadequate water treatment especially in northern parts of the country.

(Kovats S, Tirado C. 2006; p. 281-82)

Several studies have investigated an association between drinking water turbidity and health (Schwartz and Levin, 1999; Aramini et al, 2000; Schwartz et al, 2000; Lim et al, 2002). There is some indication that is a determinant of gastrointestinal illness in the general population, at least in North America and Europe. Rainfall appears to increase concentrations of Giardia and Cryptosporidium in surface water through its effect on the amount of matter in the water. There may be a link between when Cryptosporidium and Giardia concentrations peak and when, for instance, turbidity reaches its highest level. Open finished water reservoirs are at risk for post-treatment faecal contamination by animals including those that shed species of Giardia and Cryptosporidium that are potentially pathogenic to humans. A study carried out in the United States found a statistically significant association between extreme rainfall events and monthly reports of outbreaks (Curriero et al, 2001).

In Europe, it is likely that extreme weather contributes to only a small proportion of water-borne disease episodes. When a link to the water supply has been established (by epidemiological survey), only a proportion of the reported outbreaks are related to weather events. Some outbreaks are related to maintenance failures, with rainfall as an additional causative factor, such as the Cryptosporidium outbreak in Milwaukee (MacKenzie et al, 1994). Many outbreaks in Europe have also been preceded by heavy rainfall (e.g. Atherton et al, 1995; Miettinen et al, 2001).

A considerable proportion of the population in the WHO European region does not have access to improved water and is at risk of water-borne infectious disease. New and emerging pathogens, such as Giardia, Cryptosporidium and chemicals, pose additional challenges in the short-term, while extreme weather events, like floods and possibly increased water scarcity, pose challenges for the medium-term future. In the WHO European region, almost 140 million (16%) do not have a household connection to a drinking-water supply; 85 million (10%) do not have standard sanitation; and over 41 million (5%) lack access to a safe drinking water supply.

(Kovats S, Tirado C. 2006; p. 278-81)

Air-borne infections

The working group on air-borne diseases chose to focus on people with individual lung diseases, like asthma and chronic obstructive pulmonary disease (COPD) because of the huge public health burden this represents. Approximately 80% of all exacerbations of asthma are infection-related due to viral infections, and many acute COPD episodes are related to bacterial and viral infection, including influenza (http://www.jr2.ox.ac.uk/bandolier/band113/b113-3.html; from Peter Helms' presentation).

These diseases are very common. Chronic obstructive lung disease — progressive diminution of airway function — is now the fourth major cause of mortality in the industrialised world. In Europe, 10–15% of children suffer from asthma, and 6% of the adult population over the age of 50 have COPD (http://www.jr2.ox.ac.uk/bandolier/band113/b113-3.html; from Peter Helms' presentation). These individuals are at high risk of serious morbidity and mortality caused by the interaction between the infective agents in the environment and the quality of the air (there is a symbiotic relationship between the two). The vulnerability of these individuals is greatly increased by oxidative damage (inflammatory response) due to particulates and gaseous elements, e.g. from burning fossil fuels, and ozone produced by sunlight interacting with these polluting agents.

Figure 28: Chronic Obstructive Pulmonary Disease[60].

The group of experts considered aggravation of these conditions due to infection or other climate-related environmental changes a potentially useful marker of climate change influences.

A variety of exposure risks were identified. Extreme weather events were acknowledged as critical triggers for acute attacks. Smog and phytochemical reactivity are associated with warm sunny days and increased levels of humidity. Changes in vegetation, particularly increased amounts of mold, are associated with high levels of humidity.

Another potential issue with respect to the changing pattern of exposure was the phenological shifts associated with earlier peaks in pollen abundance and the potential for the

[60] ERS 2003; p. 34. From Peter Helms' presentation.

development of different sorts of pollen as illustrated previously in the shift from *fagus*- to *quercus*-dominated forests.

Critical risk factors in terms of the actual environmental components identified included increased levels of ozone, particularly associated with photochemical reactivity, and nitrogen dioxide. The role of PM10 and PM2.5 particulates was also discussed. The potential effects of these components acting alone and in combination with small diameter orbicules generated from a variety of plant species was also noted by the group.

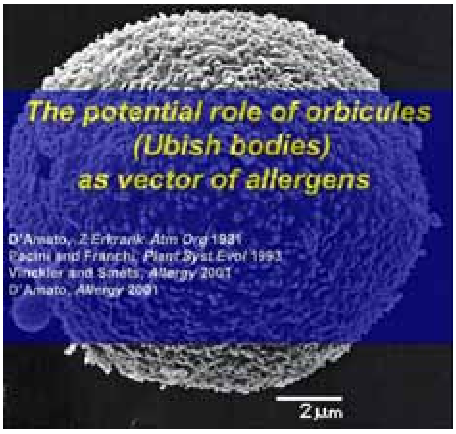

Figure 28: The potential role of orbicules (Ubish bodies) as vector of allergens[61].

At the community level, urban areas were noted to be at greater risk because of heat island effects and higher levels of emissions, including those related to industry and traffic. Rural areas, however, will also be affected because of the greater potential for increases in forest fires.

With regard to who is at risk health-wise, asthma and COPD sufferers were key target groups. Risks to these groups are further influenced by social class. Communicable diseases have a disproportionate effect on lower income groups, partially due to the prevalence of pre-existing sub-standard conditions within those groups. Their spatial distribution within urban areas also heightens their risk because they tend to be closer to sources of poor air quality, such as urban highways and industrial sites (Gilmour MI, Jaakkola MS, London SJ, Nel AE, Rogers CA. 2006. Stach A, Prieto-Baena J, Garcia-Mozo H, Czarnecka-Operacz M, Jenerowicz D, Silny W, et al. 2007).

Food-borne diseases and zoonoses

The group pointed out that all food-borne diseases were potentially affected by climate change and could not identify any to be specifically excluded, as they felt it was difficult to

[61] Adapted from: Vinckier S, Smets E; p. 1133. From a presentation by Peter Helms.

prioritise. Key food-borne disease threats[62] from environmental change in Europe noted by the working group included salmonellosis[63] and campylobacteriosis[64].

A variety of changing behavioral patterns was found to have an influence on food-borne infections. These are summarised in Figure 29 and discussed below.

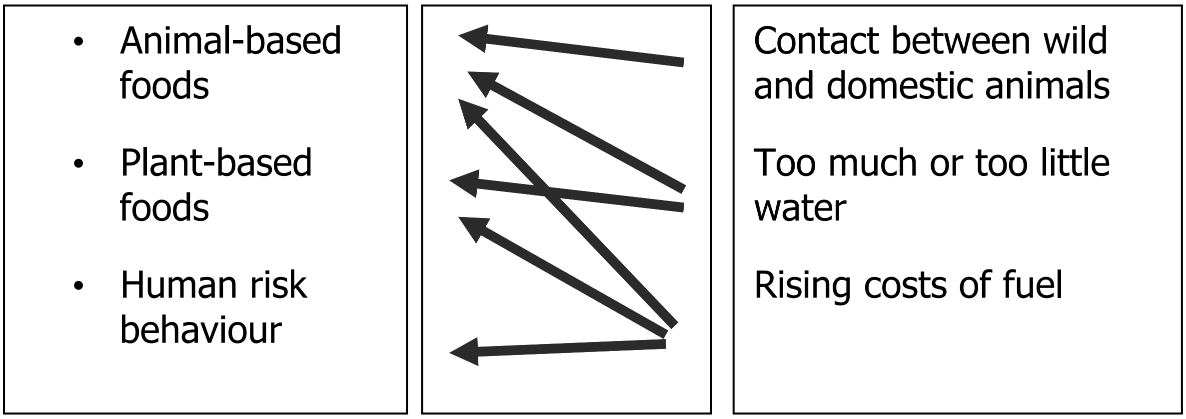

Figure 29: Animal-based foods.

Animal-based foods

Wild animals transmit zoonotic agents to domestic animals, e.g. campylobacter , which is found more frequently in organically raised chickens. Two factors associated with increased contact between domestic and wild animals are:

- during drought, wild animals may move closer to human/farm habitats for access to water;

[62] Diarrhoeal diseases are one of the most important causes of ill health in Europe, secondary to foodborne and waterborne infections. They are recognised to be highly sensitive to climate, showing strong seasonal variations in numerous sites (Kovats S, Tirado C. 2006). However, it is not possible to generalise the effects of weather on the transmission of pathogens, which depends on the local situation, the pathogen and numerous environmental pathways. The effectiveness of national control programmes varies across countries, providing opportunities for decreasing current burdens of foodborne diseases (WHO 2005; p. 24).

[63] cCASHh studies on food borne diseases show that, in general, cases of salmonellosis, the most common food-borne disease, increase by 5-10% for each one-degree increase in weekly temperature, for ambient temperatures above about 5º C. The effect of temperature is most apparent when temperatures during the week preceding the onset of the illness are considered, thus indicating that inappropriate food preparation and storage rather than time of consumption is the most important factor. It was estimated that temperature influences the transmission of infection in about 35% of cases of salmonellosis in England and Wales, Poland, the Netherlands, the Czech Republic, Switzerland and Spain. Rates of salmonellosis are declining in most countries in Europe, suggesting that further improvement of current measures will be an effective adaptation to controlling salmonella under warmer climate conditions (Kovats S, Edwards S, Hajat S, Armstrong B, Ebi K, Menne B. 2004; Kovats S, Edwards S, Charron D, Cowden J, D'Souza R, Ebi K. 2005; Lake IR, Bentham CG, Kovats S, Nichols G. 2005) (WHO 2005; p. 24).

[64] The role of weather in triggering short-term increases in campylobacter infections has yet to be resolved. There are various potential transmission routes (water supplies, bird activity, fly activity and recreational contact) that could be affected by weather. However, the effect of short-term increases in temperature on campylobacter transmission is, at most, weak, in contrast to the one consistently observed with salmonella transmission (Kovats S, Edwards S, Charron D, Cowden J, D'Souza R, Ebi K. 2005) (WHO 2005; p. 24).

- higher fuel costs may be a factor to keep domestic animals outside instead of inside. There are also ventilation and animal-welfare issues.

Limited genetic diversity of farm animals also poses problems in terms of disease susceptibility.

Box 20: Campylobacter

Campylobacter bacteria are important agents of enteritis and reported infections have been increasing in most European countries (Schmidt and Tirado, 2001). A range of mechanisms for Campylobacter transmission in Europe are reported in the literature: the consumption of contaminated foods, mostly chicken, and water and the consumption of insufficiently treated milk products. Other risk factors identified for Campylobacter infection include recent travel abroad and pets. Campylobacter infection is rarely transmitted from person to person (Dowell, 2001). Current knowledge of risk factors cannot explain all cases (the known attributable fraction is less than 50%). Risk assessment of Campylobacter spp. in broiler chickens has been undertaken by WHO and FAO in the framework of the Joint FAO/WHO Expert Consultation on Risk Assessment of Microbiological hazards in food (FAO and WHO, 2002).

Although it has been suggested that Campylobacter may be transmitted through the public water supply there is no epidemiological evidence that heavy rainfall events or run-off are associated with increases in the number of cases. The proportion of cases transmitted through the public water supply is unknown.

The effect of weather and climate was investigated in relation to reported cases of Campylobacteriosis in Europe. For the cCASHh project, data on reported campylobacteriosis were analysed for 15 populations in Europe, Canada, Australia and New Zealand. Weekly time series data were obtained for most countries. Most countries in Europe show an early spring peak (typically in April or May) in Campylobacter infection; however, not all countries follow this pattern. The Czech Republic appears to have two peaks of infection in summer. Denmark, Switzerland and the Netherlands have late summer peaks with the peak of cases occurring after the peak of temperature. The seasonality is less pronounced in Australian cities than in New Zealand. For all Canada, the peak occurs in late June to early July, and lowest in February to March.

Within countries, there can be geographical variation in the seasonal patterns. In Ireland, the highest incidence rates are in the west of the country and the lowest rates are in the north-east and middle of the country. There is a sustained plateau in incidence seasonal patterns, from mid May until early August. However, the timing of the seasonal peak is earlier in the west of the country compared to the north-east (McKeown, 2003, personal communication). In Scotland, the prominence of the peak varied between regions (Miller et al., 2004). The authors noted that Lothian, with a mixed urban/rural population, had a more prominent peak than Greater Glasgow, which has a predominantly urban population. Differences in the timing of the peak of infection have been observed between the North and South Island in New Zealand (Hearnden et al., 2003).

A statistically significant association was detected between both mean winter and spring temperature and timing of peak (Kovats et al., 2005). That is, campylobacter peaks earlier in warmer countries. There is no strong evidence that the year-to-year variation in the onset of the peak was related to seasonal temperatures. However, climate may explain some differences in the seasonal variation between countries (Kovats et al., 2005). Although there is an apparent relationship with temperature and cases in the time series studies (Tam et al., 2005), it should be interpreted with caution, as the affect is confined to temperatures between about 5 °C and 10–15 °C, corresponding to the spring months. If temperature was an important mechanism, cases would remain high throughout the summer months, as with salmonellosis. Laboratory studies show that Campylobacters only replicate in microaeorophilic environments and do not multiply at room temperature on food (Kapperud and Aasen, 1992; Altekruse et al., 1999).

It has been recently suggested the non-biting flies may play an important role in campylobacter transmission (Nichols, 2005). Fly activity is closely related to environmental temperatures (Goulson et al., 2005), and flies emerge in Spring around the same time as Campylobacteriosis cases begin to increase. Flies have been shown to be an important source of campylobacter infection of broiler flocks in the summer (Hald et al., 2004). The fly mechanism would also explain the lack of identification of single food vehicle or source. However, this hypothesis needs further investigation. The transmission of campylobacteriosis in humans is a complex ecological process with multiple hosts and routes (Skelly and Weinstein, 2003). More specific questions relating to the role of climate variability can be addressed once more detailed information on vehicles or serotyping become available. Campylobacters are so widely distributed in nature that there is no prospect of reducing the reservoir of bacteria.

(Kovats S, Tirado C. 2006; p. 275-8)

Plant-based foods

Plant-based foods are seen as the source of an increase in food-borne infections when produce is contaminated through floods, extreme precipitation events or the use of low-quality irrigation waters during times of water scarcity.

Human risk behaviour

Human risk associated factors relate to the consequences of a longer outdoor season with increased opportunity for food-handling mistakes, e.g. more BBQing and more exposure to wildlife zoonoses due to recreational activities. Additionally, energy saving efforts may inadvertently cause more food-borne illness (e.g. if fridge temperature is set too high).

A variety of personal risk factors were also noted, including occupational, rural and recreational. Environmental, land use-related, zoning-related and climato-geographic risk factors noted included water availability, contact with (river) flood waters (i.e. because of new residential development in flood-prone areas), and the geographical location of large-scale farming operations.

Those identified by the working group as 'most at risk' included:

- the poor and less educated;
- the very old and very young;
- those with pre-existing illness;
- immuno-compromised people;
- marginalised groups;
- travellers exposed abroad; and
- migrants spending time in their home countries.

Chapter V

TOWARDS AN ADAPTIVE PUBLIC HEALTH STRATEGY

The preceding sections have reviewed the discussion related to climate change and presented the existing evidence linking climate change to changing transmission patterns of infectious diseases. In light of this preliminary data, Chapter 5 reports on the meeting's attention to the essential functions of public health services — a necessary consideration in developing a strategic action plan to address the links between climate change and infectious disease. This action plan is introduced in Chapter 6 and will be subsequently developed in ECDC work.

Public health capacities to identify and respond to climate change-driven infectious diseases

In looking at the public health risk management skills needed to deal with climate change threats in general and infectious disease threats specifically, there was a consensus amongst participants that the skills required are core public health competencies and represent values that exist — or should exist — in all countries. Therefore, strengthening capacities to deal with 'new' infectious disease threats related to climate change can be seen as a way of strengthening public health more broadly. Of particular importance is the need for coordination of intersectoral and interagency work[65].

Participants were divided into four groups that looked at core public health capacities and were asked to explore relevant issues and identify areas in need of strengthening. The four general areas of public health competencies addressed were surveillance, research, assurance and policy (see Figure 30 and Box 20).

[65] From Group 2 reports.

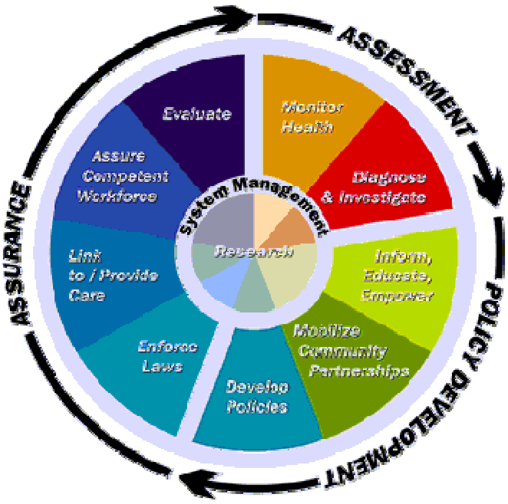

Figure 30: Essential Public Health Services[66].

Box 21: 10 essential public health services[67]:

- monitor health status to identify community health problems;
- diagnose and investigate health problems and health hazards in the community;
- inform, educate, and empower people about health issues;
- mobilise community partnerships to identify and solve health problems;
- develop policies and plans that support individual and community health efforts;
- enforce laws and regulations that protect health and ensure safety;
- link people to needed personal health services and assure the provision of healthcare when it is otherwise unavailable;
- assure a competent public health and personal healthcare workforce;
- evaluate effectiveness, accessibility, and quality of personal and population-based health services; and
- research for new insights and innovative solutions to health problems.

Surveillance

Box 22: Group assignment:

- identify existing surveillance systems at EU and country level in order to monitor variations in incidence and prevalence of high risk diseases/outbreaks;
- identify strengths, weaknesses and gaps with respect to:
  - surveillance of new and emerging infectious diseases;
  - monitoring of health status among high risk populations;

[66] Source: US Department of Health and Human Services, Public Health Service. For a healthy nation: returns on investment in public health. Washington (DC): US Government Printing Office; 1995.

- – investigation of health problems (outbreak investigations);
- – identification of exposure pathways;
- assess possibilities for tracking and linking the capacity of surveillance systems; and
- discuss: What are the implications for policy making?

The group identified a wide variety of relevant reporting, monitoring and surveillance systems in the Member States and on a regional level. Many of these focus on the specific diseases and/or needs of the country, as can be seen when analysing the Czech TBE reporting experience over the last ten years. At the moment there is no single pan-European surveillance system monitoring all the diseases which may need tracking. While there are several existing disease-specific surveillance systems (see Annexes 3, 5 and 7), none currently provides the type of information needed to identify the influence of climate change on infectious diseases.

While strategies for surveillance of some climate change problems, such as heatwaves, are in in use, there remain gaps in the area of infectious diseases. For the European Commission, this is a new area of work. The following issues were identified as essential when dealing with this problem.

Risk assessment

Participants felt that a necessary first step would be to perform an assessment of global environmental change risks for infectious diseases[67]. Such an assessment would identify risk factors and vulnerable groups and would lay the evidential foundation for public health, clinical guidelines and policy recommendations. The group pointed out that a lot of work had already been done in this area and that the main challenge was bringing it all together.

Entomology knowledge base

A major obstacle identified was a gap in entomological knowledge, and the participants recommended to strengthen training in entomology. Participants also noted that there are currently no universities with faculties involved in this field.

Reporting systems

The lack of a comprehensive monitoring system was noted, but the group agreed that there was no need to set up a system that covered all of Europe because many of the potential diseases are rather rare in some areas. Concerns were raised about stressing or overtaxing existing reporting systems with additional tasks.

The group stated that the best approach was to establish syndromic surveillance, using a sentinel monitoring system (see discussions above). Several problems with infectious disease reporting systems were noted. Currently, when there is an outbreak, many case reports are generated and stored in a way that limits access: not everyone who needs the information has access to it. Sometimes reports are not stored in just one, but in several parallel systems.

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[67] Several participants suggested that this risk assessment should be undertaken or coordinated by ECDC on a European level (with collaboration from other agencies and national institutes).

All these reports need to be integrated in a cooperative coordinated way, for example when assessing Bluetongue disease (see Annex 4).

Criteria

The following list of reporting criteria were suggested (in no particular order):

- case fatality rate;
- number of cases;
- severity of illness;
- pandemic potential;
- preventability;
- DALYS;
- mode of transmission; and
- curability.

The three top climate change-mediated vector disease threats identified by the group[68] included:

- TBE;
- rodent-borne infections; and
- leishmaniasis.

This correlates well with priority diseases identified by the EDEN group[69] (see Box 23).

Box 23: EDEN's selected pathogen groups[70]:

- tick-borne pathogens causing diseases already present in Europe that have recently shown increases in incidence. This higher incidence is at least partially due to changes in human behaviour in relation to the environment;
- rodent-borne viruses that are widespread, but cause under-reported diseases within Europe and have strong links with habitat and landscape structures;
- leishmaniasis — persistent on the southern fringes of Europe and beyond (southern Mediterranean basin), with the potential to expand as environmental conditions change;
- West Nile Virus, whose periodic and occasionally severe local outbreaks currently show strong associations with landscape patterns but also potential for explosive spread;
- malaria, an ancient scourge of Europe, is currently present on the continent's southern and eastern fringes, with the potential for re-emergence following environmental changes;

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[68] The priority diseases identified by designated MS focal points in the ECDC questionnaire were:
1. borreliosis (66.7% agreed strongly, 25% somewhat);
2. tick-borne encephalitis (TBE) (50% agreed strongly, 33.3% somewhat); and
3. hanta (8.3% agreed strongly, 66.7% somewhat).

[69] The EDEN Scientific Committee has selected a series of 'indicator diseases' (i) with a strong link to the environment, (ii) currently at risk of (re-)emerging or spreading due to environmental and other changes, (iii) representative as a group of a wide geographical range of (changing) eco-systems, and (iv) representative of the main epidemiological processes involved in emergence. http://www.cirad.fr/upload/fr/agenda/eden.pdf. Cited 2007 May 25.

- diseases emanating in Africa such as new strains of West Nile Virus and new diseases such as Rift Valley fever may be introduced to Europe from tropical regions linked by bird and other (e.g. traded livestock) migratory routes to Europe.

Other issues of concern requiring surveillance:

- directly transmitted diseases;
- illegal food imports; and
- A/H5N1.

The group identified several obstacles to developing surveillance systems. There is a need for harmonisation of methods between and within countries. Currently, there are different collection and reporting methods from country to country. Database links between relevant agencies are weak, and there is a clear need to strengthen the interoperability of systems. There is also a need to provide data to forecasting systems and to share global information.

Research

The participants discussed research gaps and necessary interventions, and then identified a variety of topic-related issues.

Box 24: Group assignment

- What are the research gaps?
- What interventions are needed and what do we know about the effectiveness of available interventions?
- What additional research is needed on new, potentially emerging infectious diseases?
- What are the implications for policy making?

Indicators

Both Group 1 and Group 2 participants felt that there was a need to create measurable indicators in order to quantify the health impact of climate change-related infectious diseases upon the population. Because of the impact on the population, acute respiratory events were identified as a potential early indicator to alert the public of adverse health effects caused by climate change and related environmental factors. Other valid and useful indicators need to be identified in order to help with risk assessments and forecasting.

Vulnerable groups

Identifying particularly vulnerable groups will be important. For example, the heatwave in France and Central Europe in 2003 demonstrated that the young and the old were particularly vulnerable, as well as those with illnesses that pre-disposed them to the negative effects of the heatwave. The group noticed that the same segments of the population would also be

[70] http://www.cirad.fr/upload/fr/agenda/eden.pdf. Cited 2007 May 5.

vulnerable to infections and effects of climate change, but that further research in this area was needed.

Other economic, environmental and psychological factors that could influence well-being should also be researched, the group found.

Obstacles to research action

Capacity: Participants noted that there are clearly different capacities in different Member States in respect to their ability to carry out monitoring and research functions and to execute surveillance and response actions related to climate change. It was expressed that the use of sentinel sites in all countries might be a quick solution for gathering Europe-wide data until all public health and monitoring systems are fully functional.

Long-term data: Access to data, especially long-term data, was identified as another shortcoming of the current system. There are clear challenges in linking these data to satellite data and arriving at useful conclusions and predictions related to human health. The attribution of a long-term process related to climate change is another research challenge, for example changing pollens. Are they responsible for worsening allergies? Is it pollen or pollution 'adjuvants'? Is there a threshold that induces respiratory diseases and/or exacerbations? Is climate change responsible?

In terms of emerging infectious diseases, the group remarked that important areas of research included the effect of temperature on mutation rate, plasmid sharing in pathogens, and the effect on the organisms involved.

Other research topics noted included studying the change in the epidemic distribution of disease. Here researchers face the problem of imported diseases that come from immigration and tourism. An additional problem are vector-borne diseases that have been reported in Europe and are gradually moving north.

Identifying the best ways to use all this data and evidence for policy change advocacy was another research challenge noted by the group. How best to educate the healthcare sector is something that needs clarification. The group observed that it was very important to have undergraduate and postgraduate training courses for doctors, nurses and other members of the healthcare community, focusing on the kind of diseases and problems that we are going to see in the coming decades.

Box 25: Research gaps summarised

There is a need for more evidence-based information on:

- indicators;
- data requirements;
- relevance of health outcomes;
- different infectious diseases;
- respiratory problems;
- vulnerability and how best to assess it (e.g. young and old, pre-disposing illnesses:

respiratory, cardiovascular, etc.);

- economic, environmental and other factors — not just human health issues;
- methods for conducting national assessments;
- sentinel sites (representative practices);
  - current infrastructure
  - outdated water systems
- appropriateness of statistical methods for modelling (early warning, prediction, impacts);
  - different results
- access to data;
  - meta data: adequate coverage
- landscape metrics;
  - lack of long-term data
  - spatial data
  - translation to human health
- sentinel disease(s) as an indicator for climate change (strong signal);
  - e.g. respiratory disease exacerbations
- attribution of long-term processes to climate change;
  - e.g. pollen +/- pollution 'adjuvants' — is there a threshold that induces respiratory diseases and/or exacerbations?
- change in the endemic distribution of diseases;
- problem of imported diseases (immigration, tourism);
- vector-borne diseases at the pan-European level reported to ECDC;
- climate change surveillance centres;
- new satellite data;
  - mapping of land use, vectors
- health effects: media strategies to raise awareness;
- adaptation approaches;
- health sector education;
- preparation and training for new health threats;
- moderating factors (changing land use);
  - for example, E. coli and spinach: human-created conditions setting the stage for disease transmission

Box 26: Policy-influencing research: learning from the tobacco control experience

The breakout group discussing research pointed out that key tasks include identifying potential risks and finding effective ways of how to prepare the public health community, the public and policy-makers for these changes and help them communicate these changes in the best possible way.

The group pointed to useful lessons to be learned from the tobacco control experience, i.e. how education and policy change are required to effect behavioural changes: people are addicted to a lifestyle that causes problems — just as smokers are addicted to the chemicals in cigarette smoke. The group remarked that research findings should be packaged in a way that could influence politicians to act. Thus, a key objective for research would be to provide data that can underpin advocacy for change in policy. These advocacy activities could be carried out by scientists, health professionals, NGOs, associations and the media.

Participants agreed that significant funding for climate change/infectious disease research will be required. Specifics related to funding were not discussed as the economics of this research were not part of the workshop's remit.

Subject	Gaps	Audience
Water- and food-borne diseases	• Better understanding of the impacts of climate change on domestic water supplies in Europe. • Better understanding of how weather and climate could affect the transmission of pathogens. • Better understanding of the links between weather (particularly extreme events), water quality and measurable health outcomes. • Incorporation of projected climate variability and change in food safety regulations and standards.	Health sector; regulatory agencies; international law.
Vector-borne diseases	• Development of quantitative models of vector-borne disease transmission. • Better understanding of the factors that determine the geographic distribution of vectors (including rodents) and how distributions may change with climate change. • Better understanding of the role of climate in vector-host relationships, particularly in endangered ecosystems. • Creation of additional international integrated surveillance networks, including those for potentially emerging or re-emerging pathogens. • Standardisation of methods for vector control activities, including monitoring and evaluation of results. • Development of scenarios that incorporate the drivers of vector-borne diseases.	Health sector; climate change community; international health regulation.
Other infectious diseases	• Better understanding of the potential risk of introduction of new or re-emerging diseases.	Health sector; security; international health regulation.

Table 2: cCASHh-identified research gaps in understanding projected health impacts of — and adaptations to — climate variability and change (Menne B, Ebi KL; p. 423-4).

Assurance

The group debated several points of view on the overall question of climate change and infectious diseases. The general consensus was, at this time, for a 'respond when needed' approach. This approach focuses on flexibility and quick responses to problems as they emerge. It assumes that very few of these infectious disease problems — in relation to climate change or indeed any other environmental issue — are pressing problems. Many of them are rather theoretical or just possibly emerging problems and do not requiring immediate attention. And even when such problems do emerge, they may not be identified as climate-related but rather as yet another case of diarrhoea or as a vector-borne disease. If the vector-borne disease is new, it constitutes a new problem and a new surveillance/response system would then be set in motion.

Box 27: Group assignment

Identify and assess public health and healthcare infrastructure capacity required to protect the public from new and emerging infectious diseases due to climate and ecological changes.

Infrastructure and capacity that need to be reviewed might include:

- surveillance of infectious diseases;
- laboratory and/or clinical diagnosis and investigation of infectious disease outbreaks;
- health promotion and health education concerning emerging infectious disease threats;
- media advocacy and outreach to respond to environmental change;
- community-based participation and response to environmental change;
- policy development to address environmental change;
- regulations and law enforcement to protect the public from environmental change;
- access to care and preventive services (vaccinations);
- training of public health workforce in order to deal with environmental change;
- assessing the effectiveness of interventions targeting the consequences of environmental change; and
- research on established and emerging infectious diseases linked to environmental change (e.g. environmental contaminants, urban planning, land use, zoning, quarantine, community-based public health measures, travel, globalisation, etc.).

According to the group of experts, the key public health challenge lies in identifying the appropriate mechanisms for monitoring trends and looking for early detection of particular signals. Research must underpin the public health response. The group felt that there is a need for disease-specific and location-specific sentinel monitoring or surveillance. This process needs to be informed and facilitated by discussions about the nature of the encountered problems, by assessments of where problems might emerge, and by an evaluation of where to invest resources in the most efficient way. Rather than a general surveillance system, the group expressed that at this stage a specific system for detecting particular signals would be the most appropriate approach.

Surveillance

In respect to surveillance, the group noted the importance of the new International Health Regulations that came into force in June. These will require mandatory reporting of certain diseases and syndromes across Europe and beyond. Additionally, the group felt that integrating data from various streams (as has been described by the US CDC) is a good strategy. Linking data in an integrated analytical system using specialist teams would be useful, especially for facilitating interagency cooperation. For example, with the flooding issue it would be prudent to join up with the meteorological services, the environmental agencies and the public health bodies of other countries. Exactly how this is best achieved will depend on the particular issue.

Laboratory/clinical competencies

In relation to laboratory or clinical services, the first step is to identify the gaps and weaknesses, both in monitoring and research needs. The group felt that there was a need to address clinical competencies for the identification and reporting of certain diseases. Also, there may be a need for standardisation of methods, for example in relation to specific serology or other new systems. Again, these measures need to be tailored to both new and emerging problems.

Education

As to health education activities, the group felt that timing is of the essence. Perhaps health education activities are best and most appropriate when conducted while diseases gradually emerge. On the whole, the group felt that health promotion and education seems premature until it is clear that there are in fact new emerging threats. But there are two exceptions: The climate change debate, or any other environmental change debate, is always a good opportunity to reinforce general messages. Secondly, there may be infectious disease needs in relation to some of the non-infectious threats that are already known, for example all heat-related problems.

Regarding training, the group felt that several kinds of training for professionals would be useful. There are significant gaps in entomological and vector-borne diseases training. There may also be training needs with respect to surveillance/sentinel site reporting systems.

Public awareness

The group concluded that awareness should be raised among the public (and perhaps among professionals as well) about some of the changes that the group thought might occur. When a disease actually emerges, awareness should be raised in regard to media and advocacy.

The magnitude of the awareness problem should not be underestimated. It was pointed out that although the meeting participants could be considered 'quite an enlightened audience', there were 68 light bulbs turned on in the meeting room — on a bright day. The group calculated that roughly 15 tons of carbon dioxide had been generated getting people to and from the meeting. Consequently, there is a broad debate — even among those who see an urgent need to promote environmental messages and an ecological lifestyle.

Opportunism

With regard to community participation and response, the group thought that the main issue here was to explore how to deliver effective messages. According to the group, it is important to keep an eye on the public perceptions of some of the emerging debates on disease risks and to understand the methods of health or social marketing — as these methods may be applied to alleviate communication problems. Overall, the group thought it best to tailor the message to the moment. Often audiences are most receptive when there is a big event or a disaster. If there is a heatwave, it provides a great opportunity for reinforcing messages. If there is a disease outbreak, it provides an opportunity for getting out a particular message.

Policy development

As far as policy development, the group saw a possible role in relation to mitigation, vaccination policy, reporting systems and other issues.

Evaluation

Eventually, there will be a need to strengthen evaluation capacities, but this needs to be done in the context of particular interventions or strategies. At current, only a few such strategies exist (including one for heatwaves), but so far only a few have been evaluated.

Surveillance	(Group A) • IHR requires mandatory reporting of certain health data (June 2007); • environmental public health tracking system (as in US); • integration of various data streams (environmental, satellite, health) and analysis by specialist teams.
Interagency working	• specific to issue: e.g. flooding (meteorological, environmental and public health); • cooperation with agencies and working arrangements, depending on issue; • flexibility needed.
Laboratory/ clinical services	Need to first identify gaps/weaknesses in monitoring and research needs. There is a questionnaire on priorities. Issues to address: • clinical competence (for disease reporting); and • standard methods, e.g. specific serology.
Health promotion/ education	Takes place when diseases emerge. Exceptions: • excuse/opportunity to reinforce general hygiene messages; • current health issue is mainly non-infectious (e.g. in relation to heat) but may have some infectious disease elements.

Media/advocacy	Takes place when a disease emerges: • but debates on environmental change issues are always appropriate; • inform public regarding mitigation needs.
Community participation and response	• explore how to make messages effective: public perceptions, health (social) marketing methods; • tailor to situations like weather events or disasters.
Policy development	(Group D) • legislation, regulation as needs arise; • possible role in relation to: mitigation, reporting, vaccination policy; please note environmental health regulations; • development of guidelines.
Training	• awareness training of CC/environmental questions; • surveillance reporting systems; • laboratory testing, emergency response as need arises; • VBDs.
Evaluation	• assessment of interventions/strategies when implemented (e.g. heatwave plan; not yet clear what specific interventions exist for infectious diseases).

Table 3: Assurance group summary.

Box 28: Group assignment:

- identify existing EU-level and national policies which will help to understand, anticipate, and confront environmental change, adapt to it and thus help cope with newly emerging threats;
- identify any additional policies which you feel are needed;
- identify the community-based interventions that are needed;
- assess implementation of these measures at the EU and country levels; and
- evaluate the effectiveness of interventions and policies.

Policy

When looking at existing EU-level and national policies, it is clear that the issue of infectious diseases and mitigation of diseases cuts across many areas of policy. The group generated a long list of relevant policies that includes climate change, public health, land use, transport, trade and foreign relations. Many of these policies conflict, particularly when the policy is developed in a non-health sector. For example, recommendations in the EU for animal husbandry may counteract measures against disease propagation from veterinary animals to humans. To give a specific example, there is one recommendation to keep animals on a certain type of surface, but this recommendation may promote the transfer of disease to humans because the animals act as a vector.

Some of these policy conflicts have economic roots, while others relate to the very different community competencies and approaches used in public health and environment issues.

Public health policy is centred around prevention and evidence-based recommendations, while the environmental policies are focused on precautions and regulations. Public health action competencies at the Community level are knowledge-based and recommendation-based. Environmental policies are legislation-based. This leads to a major challenge in Europe. All health service (and most public health) policies are under the control of Member States, and the EU has only an advisory role[71]. SARS control is a good example, where different countries in Europe employed different strategies.

Environmental policy at the European level, on the other hand, yields a much stronger influence, e.g. when looking at regulations regarding animal health in the Community. Repeatedly, fast and significant action has been taken in different situations, sometimes within weeks, or, in case of emergencies, within days. On the public health side, this is not possible. It is up to the individual countries to decide what actions to take, which invariably leads to problems with harmonisation.

After outlining additional areas that required action, the group discussed the need to stimulate development of cross-sectoral policies and improve coordination between policies. This can be done, for example, through the EU inter-service consultation process where every proposal that may have an impact on a specific policy area is reviewed.

As far as new Community-based interventions are concerned, the group considered education — particularly training in entomology — as very important. Fewer and fewer people are being trained as traditional entomologists, and it was noted that measures should be taken to stimulate education in this area.

The group also looked at whether there should be a human bio-monitoring programme for disease exposure in Europe, but concluded that this was not justified. Such a programme could be justified for specific targets in certain areas with specific problems. The group suggested that this goal could also be achieved by exploring available sources. For example, blood from blood donors could be used for the monitoring of diseases, provided the donors consented. Finally, the group expressed that the new Green Paper on climate change offers a unique opportunity to strengthen the EU Commission's capacity in health policies. If health aspects could be included, it would help develop the Commission's policy-making capacity in this area, mainly by linking action to areas where regulation is possible.

[71] This underlines a fundamental difference between the US and Europe. The US is a federation, while Europe is a community of independent states, and although there is a treaty regulating how the states interact, the states are still independent — particularly in relation to health issues.

Chapter VI

POLICY ACTION RECOMMENDATIONS

This chapter focuses on recommendations made by participants and groups relevant to policy making and implementation at both the regional and national levels. It draws from the group work during the meeting, especially the last sessions on overcoming obstacles and advocacy needs. These recommendations for action can be seen as a set of informed principles that will guide upcoming ECDC and collaborative work on climate change and infectious diseases. Their aim is to provide a sound scientific basis for informing European adaptive public health measures to climate change.

1. Build on existing initiatives and capacities!

Emphasised throughout was the need to build on existing initiatives and capacities. This includes both legally binding international treaties and protocols like the IHR 2005 and the Water Protocol (see Boxes 27 and 28), as well as other UN instruments such as the Intergovernmental Panel on Climate Control reports.

Box 29: International Health Regulations (2005)

In May 2005, the 192 Member States of WHO unanimously adopted a significantly revised and modernised version of the IHR 2005, which constitute the only legal framework governing the reporting of outbreaks of disease and prevention of their international spread. The revised regulations recognise that the infectious disease threat has grown in terms of both the number of diseases that need to be watched very closely and the risk that more new diseases will emerge. Scope has been expanded accordingly, and now encompasses all public health emergencies of international concern, including those caused by chemical agents and radionuclear materials. Secondly, reporting requirements and timeframes have been tightened, reflecting the heightened sense of urgency and the greater speed allowed by electronic communications. Thirdly, procedures have been put in place to compensate for weak detection and response capacities in many countries. The kinds of support offered by GOARN response teams are fully recognised. The regulations further acknowledge that strengthened national capacities are the best solution, as they aim to detect and stop an outbreak at the source; core capacity requirements for surveillance and response in individual countries are set out in an annex. The regulations also recognise that media reports may pre-empt official notification of an event, and include provisions for WHO actions in such a situation. Finally, by assigning responsibilities and establishing internationally agreed rules and procedures, the regulations can exert pressure on nations that fail to comply. IHR (2005) will come into force in June 2007.

(WHO 2006; p. 22)

Box 30: Water Protocol

The drinking water and recreational protocol of the United Nations Economic Commission for Europe (UNECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes calls upon countries to take all appropriate measures towards achieving:

- adequate supplies of potable drinking-water;
- adequate sanitation sufficiently protective of human health and the environment;
- effective protection of water resources used as sources of drinking-water and their related ecosystems from pollution;
- adequate safeguards for human health against water-related diseases;
- effective systems for monitoring and responding to outbreaks or incidents of water-related diseases.

(WHO 2005; p. 25)

2. Intersectoral work: Create a win-win culture!

A win-win culture related to intersectoral and interagency work needs to be developed. There was concern that sectors and agencies are dominated by a silo mentality and do not communicate with each other. Some agencies seem to think that if they strengthen the neighbouring silo, they will weaken themselves in the process. It is essential to overcome silo thinking. Ideally, strengthening the silo next to you means strengthening your own organisation. The goal is to develop a public health infrastructure that is able to adapt to the effects of future environmental changes.

3. Acknowledge the diversity of the region and build upon it!

The needs of different parts of the region will vary (see Table 4). Arctic areas, mountain regions, coastal zones, wetlands and the Mediterranean region are all going to experience the impacts of climate change in different ways. Ecosystems in those different regions are going to change very differently.

While changes and pressures vary in different parts of the region, the requisite public health response to climate-change issues is an intrinsic part of the functions that exist in public health systems. Any public health action has specific needs in regard to strengthening collaboration, partnership and response integration with other sectors, e.g. the social sector or the meteorological sector. Additionally, there is a need for coordinating the involvement of a wide range of civil society groupings and business sector organisations — in combination with synergistic actions at all levels that might involve the European Commission and a wide variety of national and local organisations.

Regions	Climate change impacts
Arctic, Greenland	• economic and cultural impacts on indigenous communities; • loss of native species; • reduced seasonal sea ice; • thawing of permafrost.
Mountain regions	• retreat of glaciers; • changes in water discharge; • changes in avalanche frequency; • less frequent and secure snow cover; • loss of endemic plant species.
Coastal zones and wetlands	• changes in water quality due to algae blooms; • coastal erosion due to sea level rise; • more frequent floods due to extreme events.
Mediterranean region	• more frequent droughts and fires; • land degradation due to salinisation; • water constraints in agriculture.

Table 4: Vulnerable regions in Europe[72].

4. Be realistic: consider country perspectives!

Any feasible framework has to be realistic and implementable and needs to consider country perspectives. Proposed frameworks must acknowledge different response capacities in different Member States. Climate change is one of many public health priorities. Recommended actions should be broadly applicable when responding to various public health challenges, e.g. sentinel surveillance sites might be used to screen for a variety of infectious disease syndromes.

5. Explore a variety of surveillance approaches!

Participants recommended that a variety of possible surveillance approaches should be explored, including disease-, vector-, risk-based and sentinel-centred approaches.

A disease network approach would establish a list of diseases susceptible to environmental change for reporting. ECDC should provide guidelines, e.g. case definitions, for EU countries and also maintain a centralised pan-EU information registry with analytical and communication capacities.

A vector network approach would focus on geographical areas at risk and anticipate problems related to controlling vectors, e.g. in protected biodiversity areas. Participants noted that EDEN is actually doing this in some respect (see Annex 7), so EDEN could be the basis of such a network.

[72] From a presentation by Merylyn Hedger-McKenzie.

Others suggested that a risk-based strategic pan-European surveillance network (covering several diseases and vectors) was needed, or, alternatively, a mechanism looking for 'viral chatter'. The risk-based approach would not be screening all of Europe (and consequently have a low positive predictive value and many false positives) but instead would focus on high-risk areas. The 'viral chatter' approach could be done through Google news searches[73] or other digital media-screening instruments.

It was suggested that sentinel syndromes and site approaches could utilise GP practices or European Societies as listening posts. Respiratory diseases could be used as sentinel conditions; 'episodic peaks' could be related to acute events in terms of public health implications, but also in terms of air quality measures, thus looking at the correlative relationship between poor air quality and acute health events.

There are several very good examples of this: In the paediatric environment, there are surveys (by circulating questionnaires among specialist paediatricians, simply asking 'Have you observed any cases of x, y, or z?') that boast a 90% monthly response rate. This is a surveillance system starting with those individuals who are most likely to encounter emerging cases — and an excellent way of identifying early signals.

Ideally, ECDC should arrange for a review of best practices in syndrome surveillance systems and analyse interoperability (sharing information between disciplines), language and possible ways of coordinating animal, human, environmental and climatological information.

6. Address surveillance obstacles!

Participants pointed out that key obstacles to developing surveillance networks — particularly those networks that could report risk threats connected to climate change-related infectious diseases — included legal reporting requirements, harmonisation efforts, case definitions and data sharing.

Legal requirements

While there are some requirements for reporting diseases in the EU and beyond, there appear to be gaps, e.g. there is no legal requirement to submit reports on some exotic/imported viruses, such as Ebola[74]. It was noted, however, that the IHR of 2005 should help address these gaps, and the meeting was informed of EU plans to develop good IHR reporting practice.

It was also noted that tensions exists between parts of Europe where nothing gets done unless required by law, and other parts of Europe where relevant laws exists but are often ignored.

[73] Google itself is about to launch the equivalent of ProMed, but on a much bigger scale, so Google will be looking at the global literature on infectious diseases.
[74] The only exeption are cases considered 'newsworthy'. Such cases are required to be reported so that MS ministers can prepeare for the potential media demand.

Harmonisation

There is a lack of harmonisation regarding a variety of diagnostic issues across the region, e.g. standardised serological diagnosis. Specifically noted was the need for case definitions as well as the need to collect and, more importantly, share comparable data on national morbidity rates.

There was general consensus that ECDC could play an active role by directly using its networks in order to address these obstacles. It was expressed that ECDC, for example, should take the lead role in providing guidelines for EU countries, similar to the guidelines issued by CDC Atlanta that carry sufficient scientific weight to be generally accepted by the individual states, even without any binding regulations.

7. Collaborate to develop a comprehensive horizon scanning risk strategy!

ECDC, in collaboration with WHO EURO, EEA, JRC and others, should develop a horizon scanning strategy that takes into account future potential developments in the field of infectious diseases that are tied to environmental changes. Of paramount importance is the collection of data proving that the climate is indeed changing and the linking of these data to track the spread of infectious diseases.

Participants suggested that this strategy should include Web search engine tools to identify potential emerging risks, correlation analysis of morbidity rates with environmental variables, research on changes in pathogens and vectors, and analysis of the usefulness of different GIS and other predictive models. It was noted that one of the key limitations of current modelling tools is the lack of data to validate the models.

It is essential to look at ways to best monitor trends and changes and to share lessons learnt. This should include a multi-disciplinary analysis of failures and the identification of effective management practices. Participants noted the need for health impact assessments of infrastructural development and suggested another look at urban planning and design in order to start to mitigate some of the potential implications, such as spatial separation.

8. Facilitate the development and implementation of professional educational programmes!

Several participants called for a strengthening of training activities for entomologists across Europe. Others suggested training targeted to infectious disease networks, focusing on understanding the health impacts of global changes and how to measure them. It was remarked that educational materials should be developed by a joint partnership of multiple agencies, including ECDC. These materials could be adapted by the Member States for the training of their public health workforce and help them in dealing with environmental change.

As risk knowledge becomes clearer, a framework for education on prevention and risk avoidance should be developed.

9. Strengthen communication capacities!

Participants strongly agreed to strengthen capacity in order to raise public awareness and to better communicate risks, particularly in regard to appropriate behaviours. Valuable messages, it was felt, are drowned out by too much information. It is very important to communicate what has been found, what is new and what can be done. Clarity is very important in this situation.

It was also noted that key audiences needed to be clearly identified so that communication can be specifically targeted. Engaging health professionals working with risks and risk groups was thought to be vital. Existing capacity and resources should be integrated and duplication avoided. At the European level, competent bodies for this type of communication, especially regarding environmental components, already exist, e.g. the EEA.

The CDC Infopages were presented as a good example of public information about any disease within the USA (West Nile virus, plague, hantavirus). They are at approximately the right level for beginning ecologists as well as members of the general public. When applying this approach to Europe, language barriers and cultural differences should be kept in mind, especially when communicating risks and adaptive strategies.

The communication challenges associated with multi-disciplinary work were also emphasised, especially in regard to miscommunication between different types of scientific communities and different specialities. Another problem noted, although this is changing in some countries, is the lack of funding for multi-disciplinary projects and the lack of high-level multi-disciplinary journals.

The role of the media was considered essential, especially for creating awareness in the general public, but also in order to push policy makers to take a certain stance. However, it was emphasised that it is important to ensure that what the media publish is relevant and based on facts. Once again, the role of communication between research and media is crucial.

Scientists should learn how to communicate to the media. As scientists are generally supported by public money, there is an obligation or a responsibility to communicate findings to the public.

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ANNEX 2: PREPARING FOR ACTION

Meeting at CDC Atlanta

In January, CDC Atlanta gathered 30 experts to brainstorm about action areas for climate change and health. CDC Atlanta's five major climate change vulnerability areas identified included direct effects (heat, cold and catastrophic storms), vector- and water-borne diseases, air pollution and mental health. The last item only marginally refers to post-traumatic stress syndrome; for the most part it refers to anxiety or chronic depression because of the plight of the earth[75].

Action priorities identified (see Box 31) tend to be cross-cutting, research and data-gathering activities.

Box 31: Action priorities

Action priorities include:

- maintenance and development of existing programmes;
- education;
- data: surveillance, evidence base;
- research: exposure and impact identification and assessment, thresholds, modeling, cross-cutting effects, cost-benefit analysis, HABs, attributable risk;
- information needs for risk perception, outcomes to collect;
- jurisdiction-specific epidemiologic studies;
- local sentinel systems, local governance;
- identification and involvement of stakeholders;
- overcome hurdles: reporting, communicating uncertainty;
- CDC needs to make a case based on probability of events, precaution; and
- clarification of mental health issues.

Participants emphasised the need to communicate (see Box 32) and outlined methods on how to present these issues to both the public and policy makers/decision makers. Many different potential partners were identified, ranging from the faith community to the Chinese CDC. Neighbourhood associations and structures were explicitely mentioned, as it was felt that the response will start at the local level.

[75] Public Health Response to Global Climate Change Workshop, Centers for Disease Control and Prevention, 2007 Jan 25-26, Atlanta, Georgia, USA. From a presentation by Josephine Malilay.

Box 32: Methods and approaches

- audiences: healthcare providers, schools, public, vulnerable populations, industry;
- readiness to communicate, communicate locally, win-win messages, effective strategies;
- warning thresholds;
- identification of spokespersons;
- translation of each sector's research;
- need for funding stream for environmental health;
- economic impacts;
- lead by example;
- partners will vary and change;
- stigma of mental illness;
- resilience;
- social consequences beyond mental health;
- use of case studies from previous disaster work.

ANNEX 3: ENTER-NET

The international network for the surveillance of enteric infections — salmonella, VTEC O157 and campylobacter

Enter-net is an international surveillance network for human gastrointestinal infections. The participants in the network are the microbiologists in charge of the national reference laboratory for salmonella and *E. coli* infections, and the epidemiologists responsible for the national surveillance of these diseases. The network involves all 30 countries of the ECDC geographical area, plus Australia, Canada, Japan, South Africa and New Zealand. The network is funded by ECDC and conducts international surveillance of salmonellosis and verocytotoxin producing *Escherichia coli* (VTEC) O157, including antimicrobial resistance.

Enter-net's purpose is to maintain and develop international laboratory-based surveillance of the major enteric bacterial pathogens through a coordinated network; actively involved are the microbiologists responsible for national reference services and the epidemiologists responsible for national surveillance of these bacteria.

The Enter-net aims and objectives are to:

- improve the quality and timely distribution of regularly-collated data on human salmonella and verocytotoxin-producing *Escherichia coli* O157 (VTEC) infections;
- facilitate the investigation of international outbreaks, or widely distributed national outbreaks, of enteric bacterial pathogens through the rapid exchange of information and strains;
- extend international surveillance to include non-O157 VTEC;
- continue to harmonise the surveillance of antimicrobial resistance through repeat calibration studies and a pilot of agreed sensitivity testing methods;
- establish routine quality assurance of salmonella serotyping and phage-typing by national reference laboratories through extending the existing ring-trial arrangements;
- continue to promote and facilitate collaborative international research on typing and antimicrobial resistance testing of human enteric bacteria;
- review the Enter-net collaboration principles with participants, Commission staff and members of the Network Committee of Directorate General Health and Consumer Affairs (DG SANCO);
- develop a consensus on international surveillance standards against which the performance of Enter-net participants and co-ordinators can be assessed; and
- continue to strengthen global surveillance of these infections through collaboration with WHO and non-EU countries, including EU candidate countries, Canada, the United States, South Africa, Japan and Australia.

The operational aims of Enter-net can be summarised as having three main parts: monitoring trends, requesting and disseminating information on potential international incidents and recognising and reacting to international outbreaks of food-borne pathogens. Significant progress has been made in each of these areas. To underpin these aims, quality assurance of the reference laboratories is an integral part of the management of the network and is built into the project.

Limited data on each laboratory-confirmed case of salmonella or *E.coli* infection identified by the national reference laboratories are transferred to the central database at the Enter-net hub. These records include microbiological and epidemiological data and are analysed on a regular basis and shared with all participants. The creation of a central database allows Enter-net to monitor trends in infection and recognise unusual events that can only be observed when data are pooled internationally. The quality of these data is supported by the regular Quality Assurance programmes within Enter-net.

The hub also acts as the distribution point for all urgent enquiries on incidents and outbreaks of enteric pathogens. Often these only affect individual countries, but international outbreaks have been identified by conveying information on outbreaks between members of the network. When international outbreaks are recognised the co-ordination of the investigation is managed by the hub.

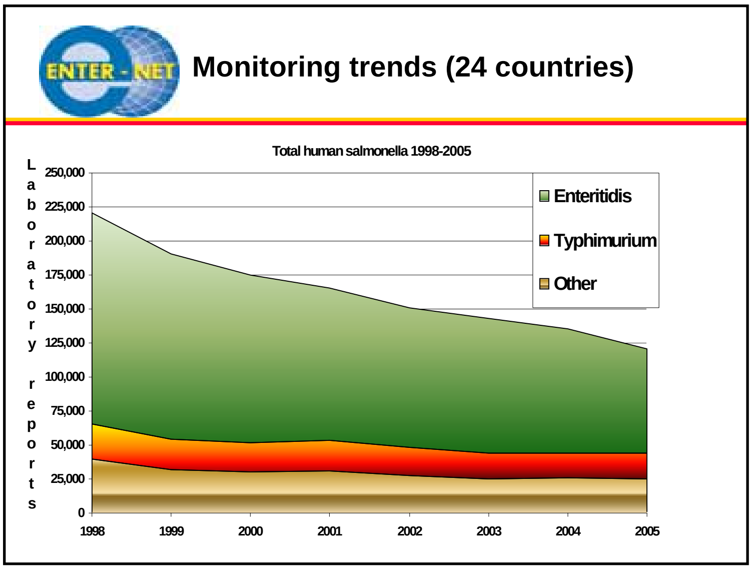

Figure 31: Monitoring trends[76].

Source: Enter-net annual report: 2005 — surveillance of enteric pathogens in Europe and beyond. Enter-net surveillance hub, HPA, Centre for Infections, Colindale, London. Available from: http://www.hpa.org.uk/hpa/inter/enter-net_reports.htm.

[76] From Ian Fisher's presentation.

ANNEX 4: CASE STUDY

EFSA Epidemiology (Epi) Working Group (WG) for Bluetongue (BT) virus serotype 8 epidemic

Overall conclusions: epidemic results from interactions:

- biology: both virus and vector;
- environment: may be influenced by climate change;
- human intervention: can affect the movement of infected animals and vectors.

Overall conclusions: success factors for epidemiological transboundary animal disease outbreak investigations.

- the good cooperation between institutions involved:
  - Member States;
  - the Commission; and
  - EFSA.
- data access:
  - confidentiality issues;
  - consistency of data from different Member States;
  - quality small ruminant data.
- preparedness through training and standardisation.

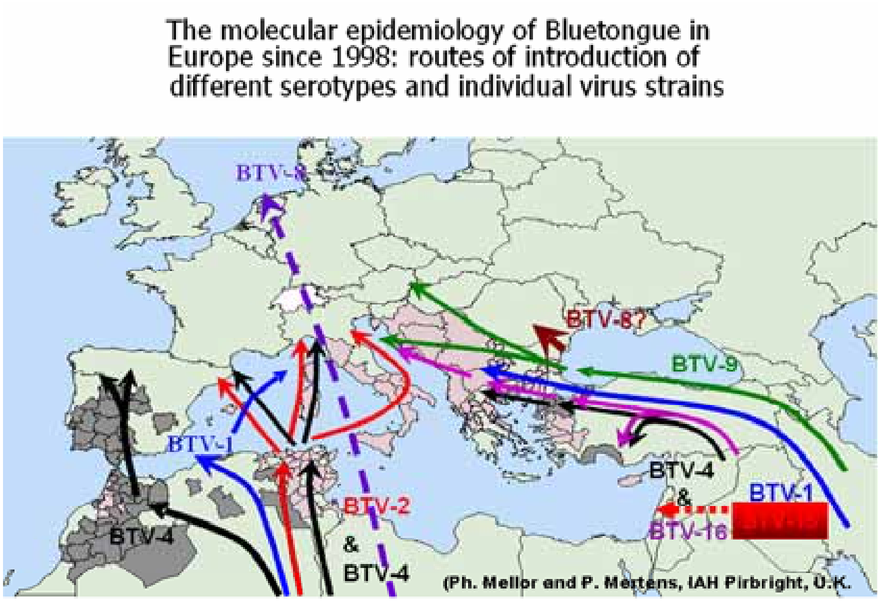

Figure 32: The molecular epidemiology of Bluetongue in Europe since 1998[77].

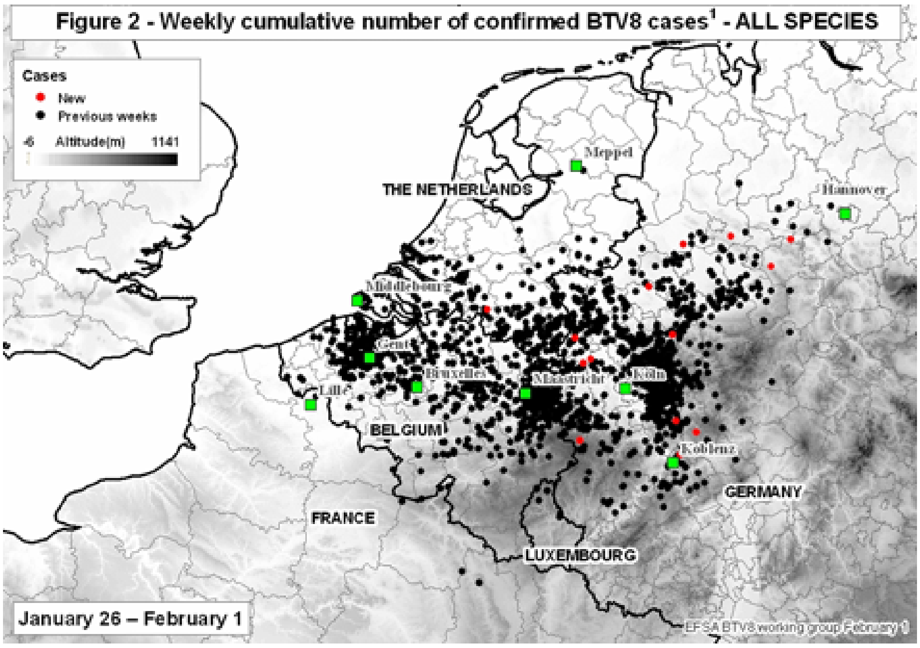

Figure 33: Weekly cumulative number of confirmed BTV8 cases[78].

[77] EFSA. From Hubert Deluyker's presentation.
[78] EFSA. From Hubert Deluyker's presentation. The weekly bulletin and Report on Epidemiological analysis of the 2006 Bluetongue virus serotype 8 epidemic in NW Europe is available from: http://www.efsa.europa.eu/EFSA/KeyTopics/efsa_locale-1178620753812_Bluetongue.htm.

ANNEX 5: EUROPEAN NETWORK FOR DIAGNOSTICS OF 'IMPORTED' VIRAL DISEASES (ENIVD)

Numerous viral outbreaks in the last few years, like Ebola in Kikwit/Zaire, Côte d'Ivoire and Liberia in 1996-97, and Nipha Virus in Malaysia in 1998, led to the establishement of the European Network for Diagnostics of 'Imported' Viral Diseases (ENIVD). After several meetings, scientists from university medical centres, country health departments and hospitals all over Europe created this network and agreed to collaborate on some of the major tasks for the future, supported by a mandate that was signed by all members and their institutions.

The ENIVD members meet regularly with representatives from the European Commission and WHO in order to exchange and gather information. One of the major goals of ENVID is to help develop further collaboration and improve diagnostics for 'imported' viral diseases in Europe. Sharing the duties and strengthening the collaboration in the European Commission will help enhance the emergency preparedness in all participating countries for the benefit of their citizens.

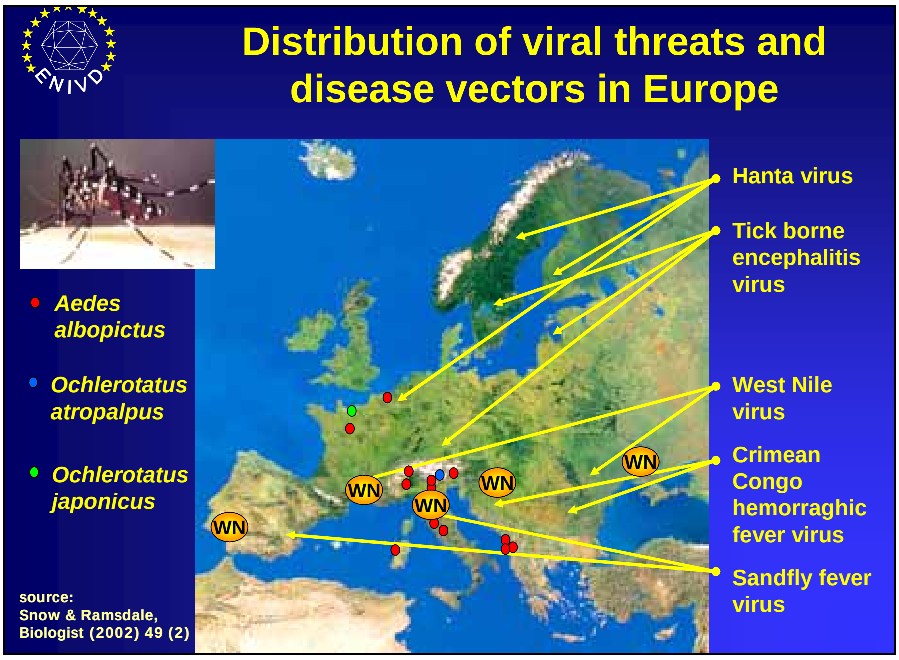

Figure 34: Distribution of viral threats and disease vectors in Europe[79].

[79] Snow K, Ramsdale C. 2002. From Matthias Niedrig's presentation.

Examples of work:

Collaboration between the European Network for Diagnostc of imported Viral Diseases (ENIVD) with the Global Outbreak and Alert Network (GOARN-WHO) in preparation of a SARS standard for PCR:

- preparation of inactivated SARS standard preparation for establishing and evaluating SARS diagnostic PCR;
- characterisation of the standard preparation (copy n°, virus concentration) in collaboration with Bernhard Nocht Institut, Hamburg;
- samples were distributed to over hundred laboratories all over the world. Over 200 scientists went to CDC China for a SARS training course.

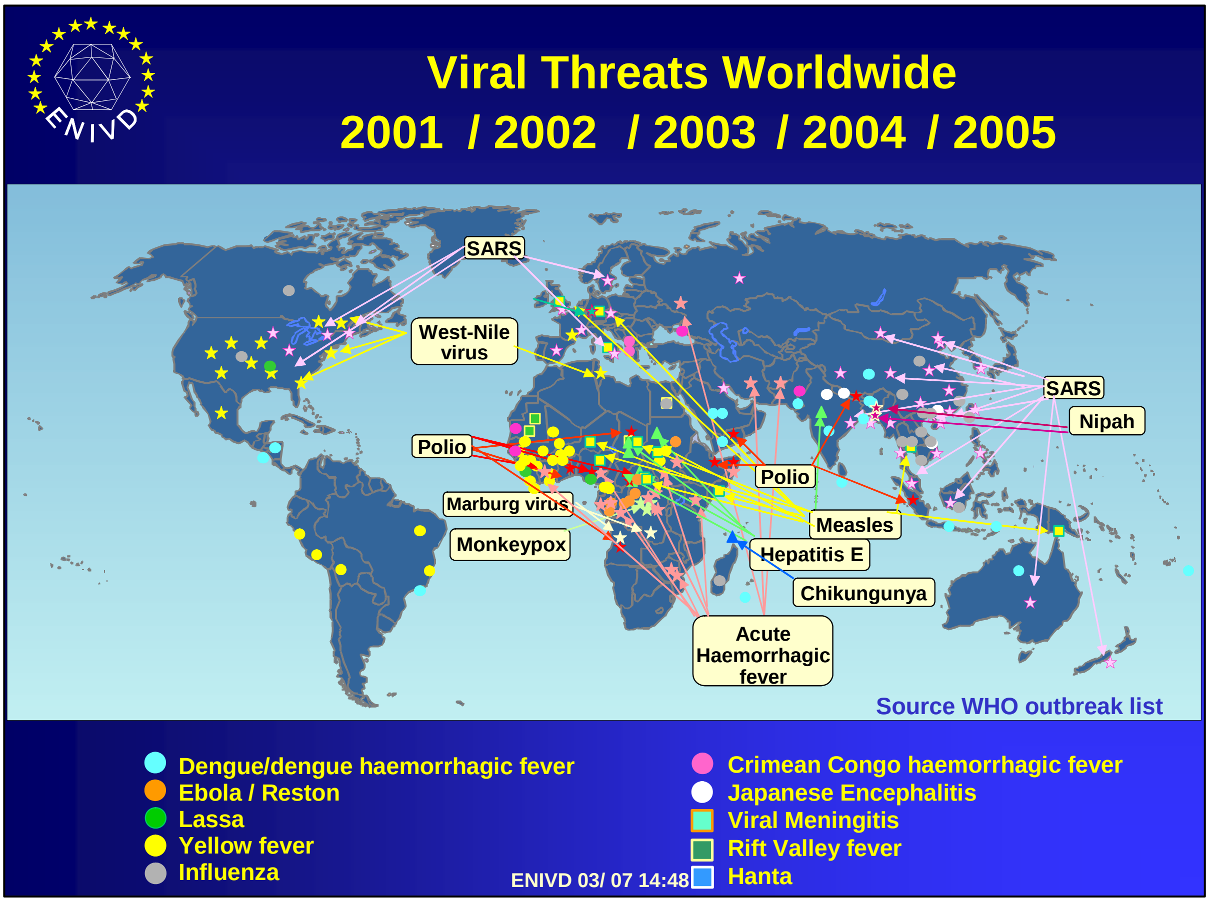

Figure 35: Viral threats worldwide[80].

[80] Source: WHO Outbreak list. From Matthias Niedrig's presentation.

ANNEX 6: UK FORESIGHT PROJECT

Infectious diseases: preparing for the future

Project aim: To produce a challenging and long-term vision for the detection, identification and monitoring (DIM) of infectious diseases across plants, animals and humans.

Future advances in DIM technology could help us to better manage disease risk. Such technology will take into account advances in science, the changing needs of users and the developing risks in the future — both in a UK and in an African context.

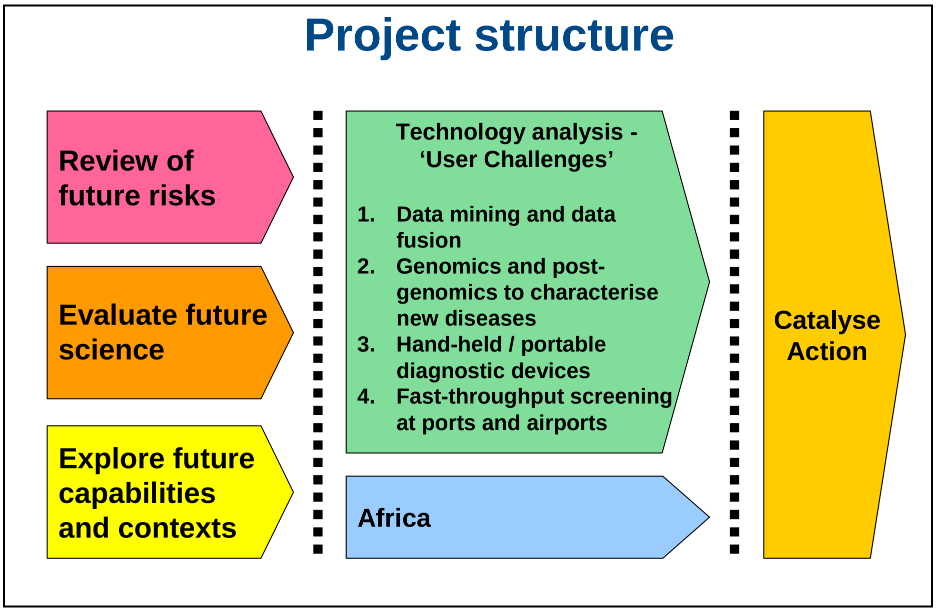

Figure 36: Project structure[81].

[81] Reproduced with kind permission from Jon Parke, Assistant Director, Foresight Programme. From Jeff Waage's presentation.

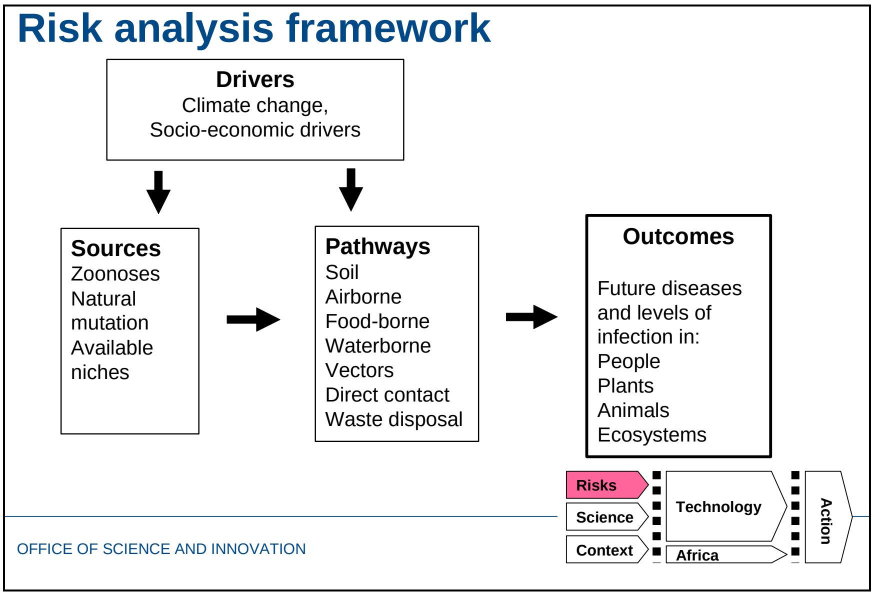

Figure 37: Risk analysis framework*[82]*.

Key Messages

Many existing diseases will remain important, but we should also expect a succession of new diseases to emerge in the future. To cope with them, we:

- need to take a dynamic view of future risk; and
- must formulate policies that are flexible enough to deal with future uncertainties.

Substantial gains to be obtained by breaking down silos and joining up better:

- between the plant, animal and human disease-management communities, nationally and internationally;
- in the social and natural sciences; and
- across research communities and government laboratories.

New DIM systems have the potential to transform our capabilities in managing future disease risks by:

- the early detection of new pathogens;
- promoting better monitoring of diseases in the wild animal reservoir;
- linked effective control measures; and
- taking into account societal contexts that will be crucial in realising the benefits.

[82] Reproduced with kind permission from Jon Parke, Assistant Director, Foresight Programme. From Jeff Waage's presentation.

ANNEX 7: THE EDEN PROJECT

Emerging diseases in a changing European environment

The goal of EDEN is to identify, evaluate and catalogue European ecosystems and environmental conditions linked to global change, which can influence the spatial and temporal distribution and dynamics of pathogenic agents. A coordinated European approach has been adopted to provide predictive emergence and spread models including global and regional preventive, early warning, surveillance, and monitoring tools and scenarios. Such tools will have a major impact on improved EU policy development and decision making.

The general objectives of the EDEN project are related both to scientific innovations and knowledge improvement on the epidemiological processes involved in the emergence and spread of diseases in a changing environment, and to the methodological development of tools for risk assessment, early warning and policy making. In chronological order this translates as follows:

1. Health-environment research objectives:

- to describe the epidemiological cycles of selected candidate diseases (see below) in a variety of representative environmental settings through an integrated and multidisciplinary approach;
- to characterise the infectious agents most likely to emerge in Europe, and the competence and capacity of potential vectors, hosts and reservoirs likely to integrate, perpetuate or spread new functioning disease cycles;
- to identify intrinsic and extrinsic factors triggering or modulating emergence and spread in Europe and the endemic disease areas, i.e. change indicators and risk factors, further referred to as 'indicators';
- to develop and implement methodologies for pan-European predictive emergence and spread models; and
- to examine current and (expected) future changes in the European environment likely to favour the emergence or re-emergence of vector-borne diseases.

2. The EDEN strategy for integration:

- to develop and apply an EDEN strategy proposing an innovative integrated 'transdisciplinary' health/environment approach for the unified analysis and exploitation of the various EDEN health environment research outputs;
- this strategy aims at the development of generic tools based on the description and follow up of the set of change indicators and risk factors extracted from the study of disease patterns and processes;
- a major expected output is to define new methodologies combining statistical approaches and biological models in the definition of these indicators;
- a particular effort will be made to involve the environmental sciences;

3. Tools and policies. To develop, as stated in the strategy description, and make available to the EDEN and the international community a set of generic tools for risk assessment and decision making (maps, risk indicators, scenarios) enabling improved public health decision making at the EU and country levels. More specifically:

- to catalogue ecosystems and environmental conditions considered, or predicted, to be at risk ('emerging disease hotspots');
- to develop preventive, early warning, surveillance and mitigation tools and to examine future 'what if' scenarios at different spatial and temporal scales (local to global); and
- to contribute to decision support and policy making through collaborative initiatives with relevant groups.

4. To promote, through a coordinated European approach, the dissemination of information through awareness raising and communication in line with social demand from the general public, user groups and the scientific community through websites, leaflets, newsletters, workshops and international meetings, articles and papers, collaborative initiatives, etc.

ANNEX 8: CLIMATE CHANGE AND ADAPTATION STRATEGIES FOR HUMAN HEALTH (cCASHh)

www.euro.who.int/ccashh

The cCASHh project aimed to describe with facts and figures the early observed effects of climate change on health and to identify the available public health measures to cope with the additional risks. Activities focused on answering the following 5 questions:

- What can be learned from observed health impacts of climate change and vulnerabilities?
- What strategies, policies and measures are currently available to reduce impacts of climate variability and change?
- What are the damages/benefits?
- What are the projected health impacts?
- Which policy responses need to be strengthened or developed?

As a result the following points were identified:

Integration: Addressing the health impacts of climate change requires integration of public health and climate change knowledge. Integration requires reciprocal understanding of terminology, goals and methods. Beyond this it requires working together to achieve the goal of reducing deaths, disease and disabilities.

Action: A key message from the research is that the measures considered in adapting to future climate change are not generally new, and that most of them build on well established public health approaches. In general, early action was found to be most possible and effective when: action measures have already been shown to be effective under current climate conditions; severe impacts are possible; multisectoral alliances, partnerships, and networks are in place; adaptation measures have a long lead time; decisions have long-term effects; and there is a need to reverse trends that threaten adaptive capacity.

Communication: cCASHh surveys reveal a limited public or policy-maker appreciation of the risks of climate change and variability and what to do about them, partly because of the perception that the problem is too big to manage, lies outside of the health sector and its impacts are long-term. In particular there is a need for a more strategic approach to those at risk and those who can play a part in enhancing adaptability.

Climate change — infectious disease-specific adaptation

Vector-borne diseases: The measures currently available to control vector-and rodent-borne diseases are disease-specific and can be broadly classified into diagnosis and treatment, vaccination, vector control, reservoir host control, information and health education and disease surveillance and monitoring.

CASHh data and other studies have shown that the tick transmitting Lyme borreliosis and tick-borne encephalitis (TBE) (Ixodes ricinus) has spread into higher latitudes (in Sweden) and altitudes (in the Czech Republic) in recent decades and has become more abundant in many places. Some specific measures might need to be strengthened in risk areas, such as TBE vaccination and raising awareness of collective and individual protection measures, like wearing suitable clothing, and self-inspection after outdoor activities to remove ticks early. Although several models predicted a potential increase of malaria in Europe, there is agreement that the risk is very low under current socioeconomic conditions. There are some hypotheses that point to a considerable potential for climate-driven changes in Leishmaniasis distribution in the future. Important control strategies include local control of sand fly populations, the use of insecticide impregnated dog collars, and information targeted to populations at risk as well as to public health personnel. In order to detect early signs of climate induced changes, active collaboration between veterinary services and health services is essential.

Foodborne diseases: cCASHh studies on foodborne diseases show that, in general, cases of salmonellosis, increase by 5% to 10% for each one-degree increase in weekly temperature, for ambient temperatures above about 5º C. The number of cases of salmonella can be reduced by controlling and monitoring along the food chain. The level of implementation varies by countries. High levels of control measures and more information on food handling and storage would be needed to confront the potential climatic risks.

ANNEX 9: CLIMATE CHANGE — DEFINITION OF TERMS[83]

Adaptive capacity

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) in order to moderate potential damages, take advantage of opportunities, or cope with the consequences.

Adaptation

Adaptation is the adjustment that takes place in natural or human systems in response to actual or expected climatic stimuli or their effects and moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

Climate

Climate in a narrow sense is usually defined as the 'average weather', or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The typical period of time is 30 years, as defined by the World Meteorological Organisation (WMO).

Climate variability

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). See also 'climate change'.

Climate change

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines 'climate change' as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.' See also 'climate variability'.

Climate prediction

A climate prediction or climate forecast is the result of an attempt to produce an estimate of the actual evolution of the climate in the future, e.g. on seasonal, interannual or long-term time scales. See also 'climate projection' and 'climate scenario'.

[83] Glossary of the Intergovernmental Panel of Climate Change, cited in WHO 2005; p. 10.

Climate projection

The calculated response of the climate system to emission or concentration scenarios of greenhouse gases and aerosols, or radiative forcing scenarios, often based on simulations by climate models. Climate projections are distinct from climate predictions, in that the former critically depend on the emission/concentration/radiative forcing scenario used, and therefore on highly uncertain assumptions of future socioeconomic and technological development.

Climate scenario

A climate scenario is a plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models. A 'climate change scenario' is the difference between a climate scenario and the current climate.

Detection and attribution

Detection of change in a system (natural or human) is the process of demonstrating that the system has changed in some defined statistical sense, without providing a reason for that change.

Attribution of such an observed change in a system to anthropogenic climate change is usually a two-stage process. First, the observed change in the system must be demonstrated to be associated with an observed regional climate change with a specified degree of confidence. Second, a measurable portion of the observed regional climate change, or the associated observed change in the system, must be attributed to anthropogenic climate forcing with a similar degree of confidence.

Vulnerability

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

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