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Edited by Tanja Wolf and Bettina Menne

Environment and health risks from climate change and variability in Italy

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ABSTRACT

The World Health Organization (WHO) and the Italian Agency for Environmental Protection and Technical Services (Agenzia per la Protezione dell' Ambiente er per i servizi Technici, APAT) are collaborating in a project on climate change and health. This report is one of the results of that project.

Climate change is already having an effect in Italy, as elsewhere. The global effects of an increasing concentration of greenhouse gases in the atmosphere are reflected in the growing number of extreme weather events, such as heat-waves and intense rainfall. These have various consequences for the health of a population, both directly in terms of mortality and morbidity, and indirectly through changes in the ecosystem.

As there has been, as yet, no systematic national climate change impact assessment in Italy, this report is a preliminary evaluation of the situation, using international and national literature and with the help of expert advice. The aim is to assess the potential risks of climate change to human health in Italy, to see what adaptive and preventive measures are available and to suggest what may be additionally needed.

Keywords
CLIMATE
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Foreword I

Climate change and climate variability are and will be a threat to human health, as has been highlighted by the recently published fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC). Climate change already affects human health directly, for example through increased heat stress or loss of life in floods and storms, and indirectly through changes in water availability, air pollution and the ranges of disease vectors (for example mosquitoes), waterborne pathogens and foodborne diseases.

In Italy, the heat-waves in 2003 and 2006, the changes in rainfall patterns and temperature and the already visible effects on fauna and flora have given a strong signal of the public health challenges that need to be addressed now and in the near future. The Mediterranean countries, Italy among them, are one of the regions of the world most vulnerable to climate change. Because of the global and national delay in putting into practice any effective mitigation strategies, more effort will have to be put into adaptation measures to limit the societal consequences of the changes in climate which are already occurring.

I believe this first report on climate change in Italy shows the need both for further research and prompt action. The report shows that information to assist in anticipating potential threats and impacts can be developed and can be extremely useful in preparing people and the overall societal structure for adverse events, as well as in facilitating the response as extreme weather-related events occur. This is a new dimension for public health which reverses traditional thinking: from describing what has already occurred to taking action on the basis of prediction, surveillance, monitoring and early warning to prevent negative health consequences in large populations. This requires the development of policies which effectively address expected events, empowering people with information and education, strengthening partnerships between different economic and social sectors, as well as ensuring that existing services are maintained and upgraded as necessary to allow for an effective response. Adaptation strategies will need to address health issues through a comprehensive approach alongside other interventions: this synergy, together with more effective results, will guarantee a more economically sustainable approach.

The preparation of this report has generated a number of conclusions and recommendations for Italy and the whole international community. The challenge is now to translate this knowledge into policy, action and, where necessary, into further research to improve modelling, extend time frames of predictions and enhance the effectiveness of adaptation and mitigation strategies. Undertaking actions to decrease the extent, speed and intensity of climate change, coupled with adaptation policies and measures, will help to limit the impact of climate change and to protect the health of both present and future generations. We hope this report can contribute towards moving the agenda forward without further unjustified delay. The time to act is now!

Roberto Bertollini, Director

Special Programme on Health and Environment, WHO Regional Office for Europe

Foreword II

The World Health Organization (WHO) estimates that about 20% of mortality in Europe is attributable to environmental causes. This is based on the available evidence and highlights the importance of improving action to combat environmental risks. For this reason the environment and the health sector are among the priorities of the Agency for Environmental Protection and Technical Services (APAT) programme.

On the other hand, the monitoring of the environment is one of APAT's most difficult tasks. To improve environmental monitoring, a network of competent and experienced partners is essential. The need for such a network is even more prominent in the case of monitoring that aims to identify environmental health determinants. The selection of these determinants necessarily has to be the result of consultation with experts from both the environmental and the health sectors.

This led APAT to collaboration with organizations in the health sector, primarily with WHO and the Istituto Superiore di Sanità, with the aim of directing initiatives and assessing exposure levels of the population to different health risk factors. Among the initiatives which have resulted in important reports are those on the health effects of environmental air pollution in Italian cities, realized in collaboration with WHO in 1999 and 2005.

The aim of APAT is, however, not only to increase knowledge on already known risk factors for people's health, but also to study and analyse emerging risk factors, for example noise, electromagnetic fields, contaminated sites and those related to environmental scenarios, so that environmental protection measures can be strengthened. As part of this perspective, APAT started the project on climate change and health in collaboration with WHO. For many years WHO has been investing resources into this field and has contributed substantially to the IPCC fourth Assessment report. Climate change is in fact an emerging environmental risk factor and a priority on the political agenda of the majority of countries. Italy too is facing the challenges on both, technical and institutional levels to measure, plan and act efficiently in order to prevent adverse health impacts in the medium and long term and to integrate this into national sustainable development policies.

The broadening of knowledge concerning the potential environmental consequences of changes in weather and climate on health, well-being and survival is a fundamental step for APAT, particularly at this moment when APAT and other environment agencies are fully involved in developing a national strategy on adaptation to climate change. Agreement on a national adaptation planwill be the aim of this National Conference on Climate Change.

At this meeting the report will represent a significant contribution towards an initial analysis of the national socioeconomic impacts and potential adaptation options. The contributions in this report result from expert evaluation of the available data and the most relevant results of international and national research into health and the environment. The results of this first national analysis already allow proactive reflection about the strengths and weaknesses of the present information system and knowledge on emerging risks.

The study of future scenarios requires our full commitment, in particular for enhancing strategic collaboration among the different institutions involved. Communication of our existing knowledge about the prevention of harms and our responses to climate change are essential to enable the informed participation of all citizens.

Giancarlo Viglione, President

APAT

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We hope that this publication will help to increase discussion in Italy and will support further initiatives in this field.

Tanja Wolf and Bettina Menne
WHO Regional Office for Europe

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1. Introduction

– by Tanja Wolf, Bettina Menne

Increasingly intense economic activities are triggering a range of global environmental risks to health and well-being of unprecedented scale and of a systemic nature. Climate change is a burgeoning reality. The global mean surface temperature has increased by 0.74±0.18°C over the last 100 years, while the global average sea level has risen by 1.8 mm per year since 1961, and Arctic sea ice is shrinking by 2.7±0.6% per decade. In addition, the sea surface temperature is rising, mountain glaciers are retreating at increasing rates, surface ocean waters are getting more acidic and more frequent extreme weather events have been observed.

Human beings are exposed to climate change through changing weather patterns (for example more intense and frequent extreme events) and indirectly through changes in water, air, food quality and quantity, ecosystem functions, agriculture and the economy.

Today, it is certain that climate change contributes to the global burden of disease and premature deaths. Emerging evidence of the effects of climate change on human health show that climate change has not only altered the distribution of some infectious disease vectors and the seasonal distribution of some allergenic pollen species, but has also increased the risk of heat-wave-related deaths. In the future, exposure to the effects of climate change is likely to lead to various trends related to human health, such as an increase in undernutrition globally and in the number of people suffering from diseases and injuries directly related to heat-waves, floods, storms, fires and drought. The incidence of diarrhoeal diseases and the frequency of cardiorespiratory diseases as a result of higher concentrations of ground level ozone are also likely to increase. Climate change is expected to have mixed effects on infectious diseases, and might bring some benefits to health, through, for example, fewer deaths from exposure to the cold. However, this is expected to be outweighed by the negative effects of rising temperatures worldwide, in particular in developing countries (Confalonieri et al., 2007).

The dilemma with climate change is that it is different from many of the other types of environmental exposures: all countries in the world are affected; it is expected to become more acute over the next decades, even with greenhouse gas emissions stabilizing at year 2000 levels – and thus children will be those most affected; it plays an important role in the spatial and temporal distribution of infectious diseases and thus can affect health security; the effects are unequally distributed and are particularly severe in countries with already high disease burdens or in populations with low adaptive capacity; and the effects are highly complex and will involve a number of processes, developments, sectors and activities.

Furthermore, recent events have demonstrated that populations and health systems may be unable to cope with increases in the frequency and intensity of extreme weather events. These events can reduce the resilience of communities, affect vulnerable regions and localities and overwhelm the coping capacities of most societies.

This is a preliminary evaluation report, using international and national literature and with the help of expert advice. The aim was to assess the potential risks of climate change to human health in Italy, to see what preventive actions are available and to suggest what may be additionally needed.

1.1 Current knowledge on climate change and health

Human societies have had long experience of naturally occurring climatic vicissitudes. The ancient Egyptians, Mesopotamians, Mayans and European populations were all affected by nature's great climatic cycles. More importantly, disasters and outbreaks of disease have occurred often in response to the extremes of regional climatic cycles. Hippocrates already recognized that people cannot understand diseases without looking at the wind, the sun and humidity.

Weather is the continuously changing condition of the atmosphere, usually considered on a time scale that extends from minutes to weeks. Climate is the average state of the lower atmosphere, and the associated characteristics of the underlying land or water, in a particular region, usually spanning at least several years. Climate variability is the variation around the average climate, including seasonal variations and large-scale regional cycles in atmospheric and ocean circulations such as the El Niño – Southern Oscillation (ENSO) or the North Atlantic Oscillation.

Climate change occurs over decades or longer time scales. Until now, changes in the global climate have occurred naturally, across centuries or millennia, due to continental drift, various astronomical cycles, variations in solar energy output and volcanic activity. Over the past few decades it has become increasingly apparent that human actions are changing the composition of the atmosphere, thereby causing global climate change.

The First World Climate Conference, in 1979, recognized climate change as an increasing problem. The World Meteorological Organization (WMO) initiated the World Climate Programme that same year. In 1988 the United Nations Environment Programme (UNEP) and WMO established the Intergovernmental Panel on Climate Change (IPCC). The IPCC was asked to assess the state of existing knowledge about the climate system and climate change; the environmental, economic, and social impacts of climate change; and the possible response strategies. Its first assessment report was released in 1990; the latest (the fourth assessment report) was released in 2007.

In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was initiated at the United Nations Conference on Environment and Development. The UNFCCC aims to stabilize greenhouse gas concentration in the atmosphere, within a time frame sufficient to allow ecosystems to adapt to climate change. It thus accepts that some change is inevitable. Impacts will be felt on ecosystems – and on human health – affecting agricultural production and food security, sea levels, biological diversity, water resources, infrastructure, industry and human settlements. The Kyoto Protocol to the UNFCCC has brought focus and strengthened the international response to climate change.

Recognition of the emerging problem of global climate change has hugely stimulated research into the working of the world's climate. Increasingly sophisticated models have been developed of entrapment of energy by gases in the lower atmosphere, of changing energy flows in the atmosphere and oceans, and of the resulting changes in temperature and precipitation around the world.

Studying the impact of weather events and climate variability on human health requires appropriate specification of the meteorological "exposure". Weather and climate can each be summarized using various spatial and temporal scales. The appropriate scale of analysis, and the choice of any lag period between exposure and effect, will depend on the anticipated nature of the relationship. Much of the research requires long-term data sets with information about weather/climate and health outcome on the same spatial and temporal scales. In all such research, there is a need to accommodate the several types of uncertainty that are inherent in these studies. Predictions about how complex systems such as regional climate systems and climate-dependent ecosystems will respond when pushed beyond critical limits are necessarily uncertain. Likewise, there are uncertainties about the future characteristics, behaviours and coping capacity of human populations.

In the early 1990s there was little awareness of the health risks posed by global climate change. This reflected a general lack of understanding of how the disruption of biophysical and ecological systems might affect the longer-term health and well-being of populations. There was little awareness among natural scientists that changes in their particular objects of study – climatic conditions, biodiversity stocks, ecosystem productivity and so on – were of potential importance to human health. Indeed, this was well reflected in the meagre reference to health risks in the first major report of the IPCC, published in 1991.

Subsequently, the situation has changed. The IPCC second assessment report (1996) devoted a full chapter to the potential risks to health. The third assessment report (2001) did likewise, this time including discussion of some early evidence of actual health impacts, along with an assessment of potential future health effects. That report also highlighted the anticipated health impacts by major geographic region. The fourth assessment report not only devotes a whole chapter to human health, but also has references to health throughout the report.

In 1996, the World Health Organization (WHO), recognized for the first time the challenges posed to human health by climate change and the World Health Assembly endorsed collaboration with other agencies in further identifying the problem. More than 10 years have passed since then and a growing body of research and assessment has been made available worldwide.

Knowledge concerning the observed health impacts of climate change in Europe derive from European studies (ACACIA, cCASHh, PHEWE, ENSEMBLES, EDEN), national climate change health impact assessments and studies carried out by several national research councils or agencies. These studies quantified the effects of weather and climate variability on health, pointed out early impacts on human health, estimated some of the future burden of disease and provided some idea of potential future risks.

1.2 The attribution of health effects to climate change

The challenges in identifying, quantifying and predicting the health impacts of climate change entail issues of scale, "exposure" specification and the elaboration of often complex and indirect causal pathways. First, the geographic scale of climate-related health impacts and the typically wide time spans are unfamiliar to most researchers. Epidemiologists usually study problems that are geographically localized, have relatively rapid onset and directly affect health. The individual is usually the natural unit of observation and causal thinking focuses on specific directly acting ("downstream") factors.

Second, the "exposure" variable – comprising weather, climate variability and climate trends – poses difficulties. There is no obvious "unexposed" group to act as baseline for comparison. Indeed, because there is little difference in weather/climate exposures between individuals in the same geographic locale, comparing sets of persons with different "exposures" is precluded. Rather, whole communities or populations must be compared – and, in so doing, attention must be paid to inter-community differences in vulnerability. For example, the excess death rate during the severe 2003 heat-wave varied greatly across cities and countries, because of differences in factors such as housing quality and health care preparedness.

Third, some health impacts occur via indirect and complex pathways. For example, the effects of temperature extremes on health are direct, whereas the effects of changes in temperature and cloud cover on diseases related to air pollution involve several intermediate steps. More complex still, changes in the composition and functioning of the ecosystem help mediate the impact of climatic change on transmission of vector-borne infectious diseases and on agricultural productivity.

A final challenge is the need to estimate health risks in relation to future climatic/environmental scenarios. Unlike most recognized environmental health hazards, much of the anticipated risk from global climate change lies years to decades into the future. Therefore, the best estimation of the future health effects of climate change will necessarily come from modelling based on current understanding of the effects of climate (not weather) variation on health from observations made in the present and recent past, acknowledging the influence of a large range of mediating factors (Ezzatti et al., 2004). These models are associated with substantial uncertainties.

For assessing the impacts of climate change on Italian populations, the authors applied the WHO guidance provided in "Methods of assessing human health vulnerability and public health adaptation to climate change" (WHO Regional Office for Europe, 2003).

The assessment is basic: reviewing the literature and seeking expert advice. Due to the paucity of information on the attribution of health effects to climate change in Italy, grey literature was also included (books, national assessments and reports, agency reports, etc.), as well as international or European studies that refer to Italy. Box 1 shows the search strategy used.

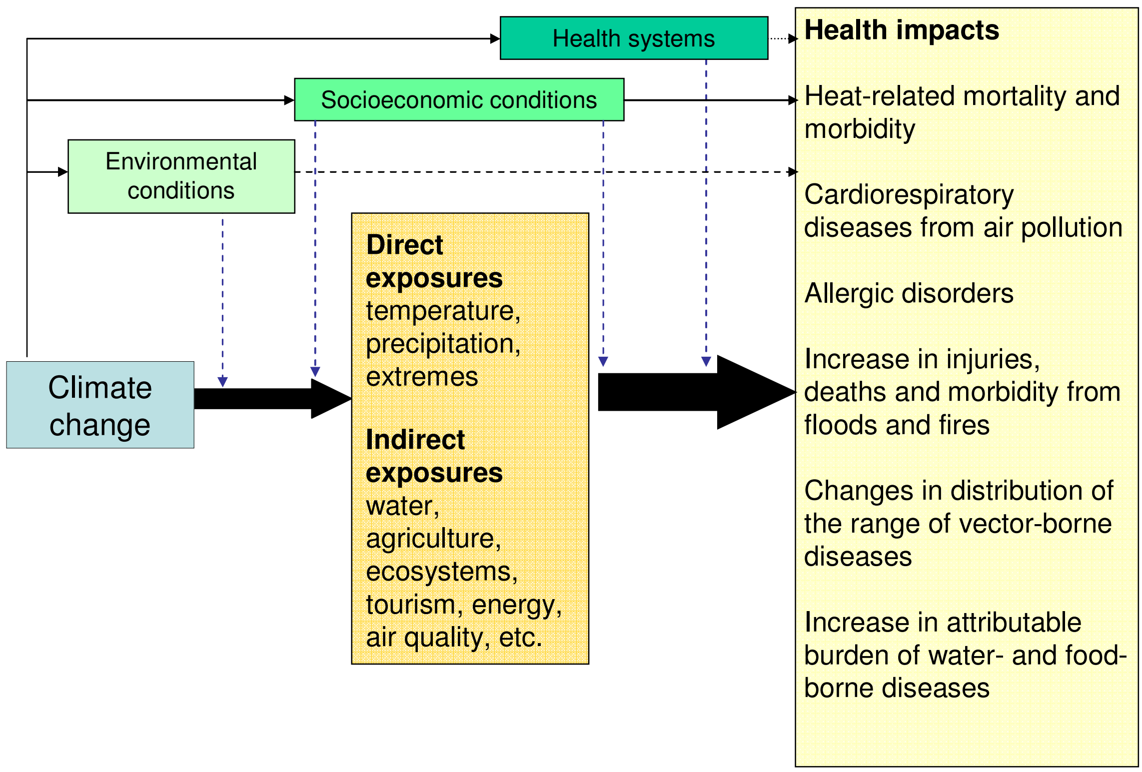
Box 1: Search strategy

- Internet: using keywords in English and Italian (e.g. "climate change and health", "cambiamento climatico e salute"); review of references in key documents.
- MEDLINE, PubMed and WHO databases: keywords were climate change, extreme events, heat-waves, flooding, air pollution, health, Europe, Italy and specific diseases (heat stroke, respiratory diseases, foodborne diseases, *Salmonella*, vector-borne diseases). Literature older than five years was excluded when more than fifty items were found in one search.
- The following climate hazards were taken into consideration: heat, cold, air pollution, heavy precipitation, disaster (landslide, flooding) and the following health outcomes identified for Italy: mortality due to heat, mortality and morbidity due to flooding and morbidity due to food- and vector-borne diseases.
- Inclusion criteria: all articles that included two or more key words. Epidemiological studies with low sample sizes were excluded. Where review articles were available, this is referred to.

1.3 The framework used in this assessment

As in other areas, populations in Italy are exposed to an increasing frequency and intensity of extreme events and weather variability and also to long-term changes in mean temperature and precipitation. These exposures either affect health directly or are associated with a number of changes in sectors and systems (such as water, agriculture, energy, etc.) that are important determinants of human health. There are many other determinants of health that may or may not be affected by the changing climate, such as health care infrastructure. The observations of the last decades show that impacts vary significantly by location and by population across Europe. Annual variability and multiple exposures may lead to enhanced effects, although we know little about this. The actual future impacts on human health will very much depend on the character, magnitude, and rate of climate variation to which "health" is exposed and the actual sensitivity and the ability of populations, governments and health systems to cope with the consequences. Figure 1 shows the different pathways of direct and indirect exposure taken into account in this assessment. These exposures and impacts will vary over time and will change with ongoing climatic changes.

Figure 1: Pathways by which climate change affects human health in Italy



Source: adapted from Confalonieri et al., 2007

1.4 Content of this publication

Chapter 1 gives an overview of the current knowledge on climate change and health effects globally and Chapter 2 highlights observed and projected climate change with a focus on Italy. For each subcategory, the evidence from the global and European levels is summarized then scaled down to the national Italian level. In Chapter 3 the associated impacts on systems and sectors are described. Sectors were selected based on their relevance to human health and their potential indirect effects on human health. Chapter 4 describes the evidence of observed and potential health impacts, Chapter 5 describes mitigation and adaptation actions and Chapter 6 lists the conclusions of this work.

With this publication the authors provide a comprehensive overview of the current knowledge on climate change and variability in Italy for the interested public and in particular for environment and health professionals, decision makers and stakeholders. The collection of evidence, but also the identification of data gaps and research needs, can be used to support decisions when setting priorities. Despite a remaining level of uncertainty for future scenarios, the negative effects of the changing climate are already visible and the threats are too dangerous to defer action. In addition, the mitigation and adaptation options have a range of positive side-effects and should be integrated into everyday policies and action at all levels.

2. Climate change and variability in Italy

– by Antonio Navarra, Franco Desiato, Domenico Gaudioso, Andrea Toreti and Tanja Wolf

Key messages

- Between 1990 and 2005 the total greenhouse gas emissions in Italy increased by 12.1%.
- The energy industries (32%) and transport (26%) are the main contributors to CO_2 emission.
- Italy is not yet succeeding in reducing national greenhouse gas emissions by 6.5% of the base level of 1990.

The Earth's climate is determined by complex interactions between the Sun, oceans, atmosphere, cryosphere, land surface and biosphere. The Sun is the principal driving force for weather and climate. The uneven heating of the Earth's surface (being greater nearer the equator) causes great convection flows in both the atmosphere and oceans, and is thus a major cause of winds and ocean currents.

Five concentric layers of atmosphere surround this planet. The lowest layer (troposphere) extends from ground level to around 10–12 km altitude on average. The weather that affects the Earth's surface develops within the troposphere. The next major layer (stratosphere) extends to about 50 km above the surface. The ozone within the stratosphere absorbs most of the Sun's higher-energy ultraviolet rays. Above the stratosphere are three more layers: the mesosphere, thermosphere and exosphere.

Overall, these five layers of the atmosphere approximately halve the amount of incoming solar radiation that reaches the Earth's surface. In particular, certain "greenhouse" gases, present as trace concentrations in the troposphere (and including water vapour, carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), halocarbons, and ozone) absorb about 17% of the solar energy passing through it.

Of the solar energy that reaches the Earth's surface, much is absorbed and reradiated as long-wave (infrared) radiation. Some of this outgoing infrared radiation is absorbed by greenhouse gases in the lower atmosphere, which causes further warming of the Earth's surface. This supplementary warming process is called "the greenhouse effect".

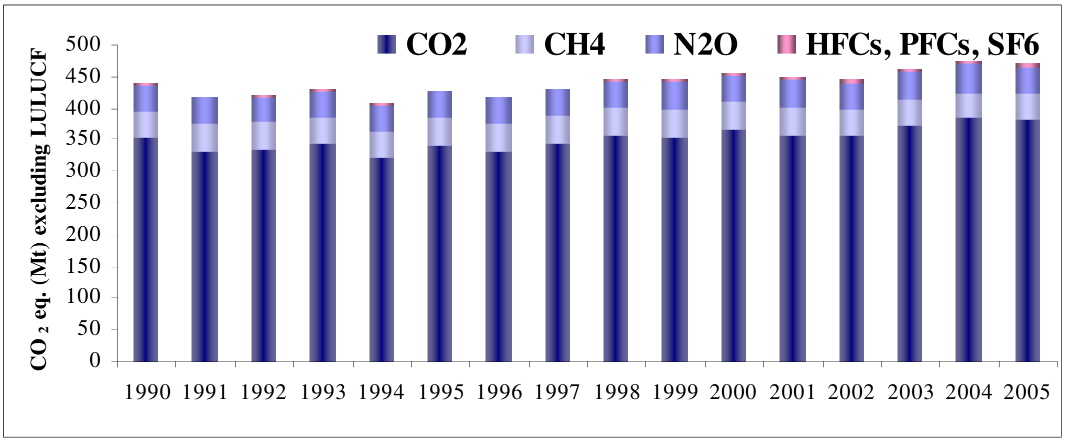
Human-induced increases in the atmospheric concentration of greenhouse gases are amplifying the greenhouse effect. Greenhouse gas emissions of CO_2, CH_4 and N_2O are the highest ever observed in the last 650 000 years, and it is very likely that greenhouse gas forcing is the dominant cause of observed warming of this century (Alley et al., 2007). Globally we can observe a significant change in numerous climatic parameters. Changing temperatures, extremes and precipitation can directly affect human health, as outlined in Figure 1. Also, Italy has contributed to the increases of greenhouse gases worldwide. This chapter looks at Italy's share of emissions, shows the observed changes in Italy as regards the environment and human health and indicates what the future projected changes for Italy may look like.

2.1 Italy's contribution to climate change

Following standardized methods and designated communication structures, national authorities produce the database of national atmospheric emissions. This national emissions inventory collects the data on emissions of greenhouse gases as well as emissions of acid and eutrophic substances, tropospheric ozone precursors, benzene, particles, heavy metals, polycyclic hydrocarbons, dioxins and many more. These data show that between 1990 ("base year") and 2005 the total greenhouse gas emissions in Italy increased by 12.1% (in CO_2 equivalent, excluding emissions and removals of

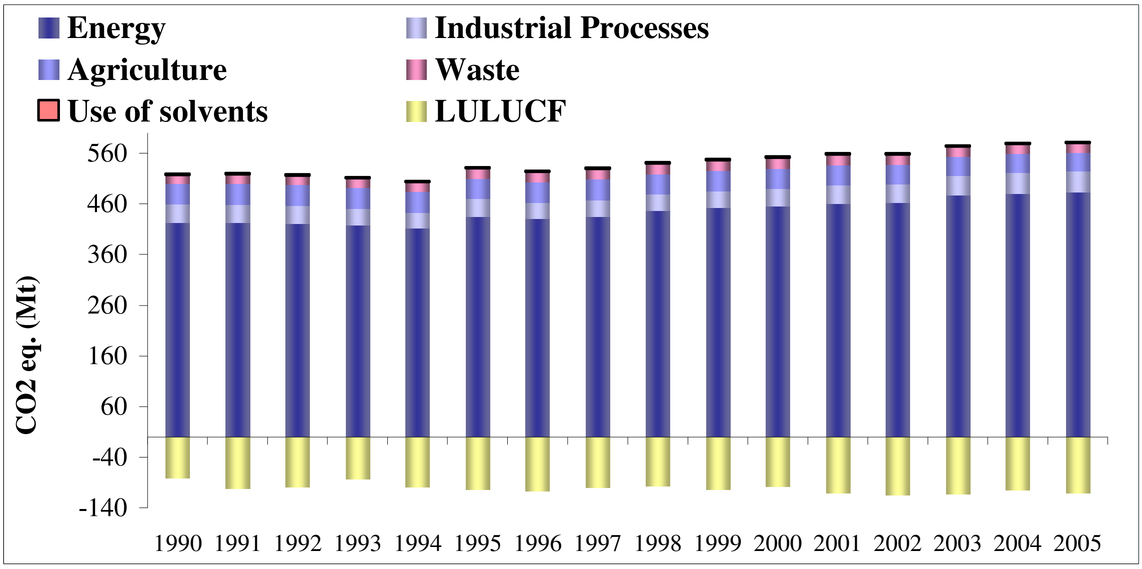
CO_2 from land use change) from 519.5 to 582.2 million CO_2 equivalent metric tons. The emissions and their increase is largely (90%) attributed to emissions of CO_2 rather than to the other greenhouse gases (see Figure 2). Splitting the CO_2 emissions up into the sectors as suggested by the UNFCCC, we see that most CO_2 emissions (94%) and their increase stem from the energy sector (see Figure 3). In the energy sector, energy industries (32%) and transport (26%) are main contributors to CO_2 emission (see Figure 4). Other greenhouse gases like CH_4 and N_2O accounted for 6.9% and 7.4%, respectively, of the total greenhouse gas emissions in 2005. CH_4 emissions decreased by 4.3% from 1990 to 2005, while N_2O increased by 5.8%. Other greenhouse gases, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), ranged from 0.3% to 1% of total emissions; at present, variations in these gases are not relevant to reaching the objectives for emissions reduction (see Figure 2) (APAT, 2007a; Romano et al., 2005).

Figure 2: Trend in greenhouse gas emissions in Italy, by gas



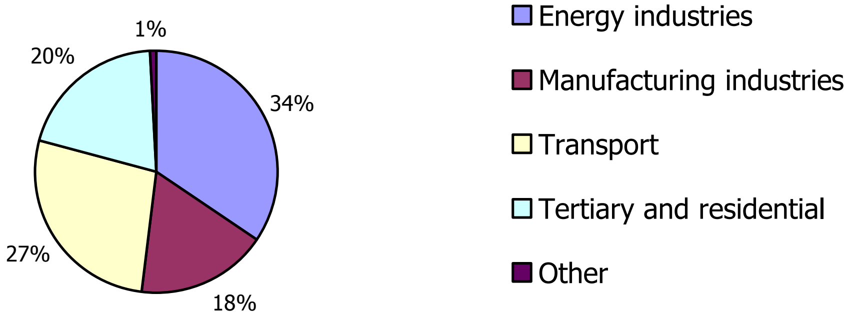
Source: APAT, 2007a

Figure 3: Trend in greenhouse gas emissions in Italy, by sector



Source: APAT, 2007a

Figure 4: Sources of CO_2 emission in the energy sector



Source: APAT, 2007a

In the context of the UNFCCC and the Kyoto Protocol, during the period 2008–2012 Italy is obliged to reduce national greenhouse gas emissions by 6.5% of the base level of 1990. Italy is far from succeeding in this aim. Emissions have been constantly increasing since 1997, although between 2004 and 2005 the increase rate was limited to 0.3% per year (APAT, 2007a). In a recent report, the European Environment Agency (EEA) said that as well as Belgium, Denmark, Ireland, Spain, Austria and Portugal, Italy too was not on track with regard to greenhouse gas emissions in 2004 and projects that it will miss the Kyoto targets despite the implementation of additional measures, the use of Kyoto mechanisms or the use of carbon sinks (EEA, 2006). The emission of about 580 million CO_2 equivalent metric tons of greenhouse gases in Italy corresponds to 11.2% of the 5200 million metric tons in Europe and 2.1% of the global 27 560 million.

Key messages

Italy has already observed:

- an increase in maximum temperature by 0.6°C in the north, and by 0.8°C in the centre-south over the last 50 years;
- a progressive reduction in precipitation since 1930, and, consequently, an increase in aridity;
- a decrease in precipitation between 1951 and 1996 of 14% throughout the country but most significantly in the centre and in the south;
- a rise in precipitation intensity both in the northern and southern regions;
- a more rapidly increasing number of tropical nights between 1981 and 2004; in the whole period, a net increase of about 14% of summer days has been estimated;
- a variation of -0.25 of frost days per year between 1961 and 2004, corresponding to an average reduction of about 20% of the number of frost days over 43 years.

2.2 Observed climate change in Italy

2.2.1 *Trends in temperature and precipitation*

At global level, the IPCC has found that 11 of the last 12 years (1995–2006) rank among the 12 warmest years in the instrumental record of global surface temperature (since 1850). The updated 100-year linear trend (1906 to 2005) of 0.74°C (+- 0.18°C) is therefore larger than the corresponding trend for 1901 to 2000 given in the third assessment report of 0.6°C (+- 0.2°C). The linear warming trend over the last 50 years (0.13°C +- 0.03°C per decade) is nearly twice that for the last 100 years. The total temperature increase from 1850–1899 to 2001–2005 is 0.76°C (+- 0.19°C) (Alley et al., 2007).

In Europe, studies concerning climate trends have been undertaken at various locations. However, results from these are not directly comparable because of inconsistencies in data set length and quality and the different methods used for data processing and trend analysis (Wijngaard, Tank and Konnen, 2003). Nevertheless, some common patterns appear to be emerging. For most locations across Europe, increases in minimum temperature appear to be greater than in maximum temperature (Klein Tank, Wijngaard & van Engelen, 2002) and in many cases this has been attributed to increasing nocturnal cloud cover (Brazdil et al., 1996; Huth, Kysely & Pokorna, 2000; Wibig & Glowicki, 2002).

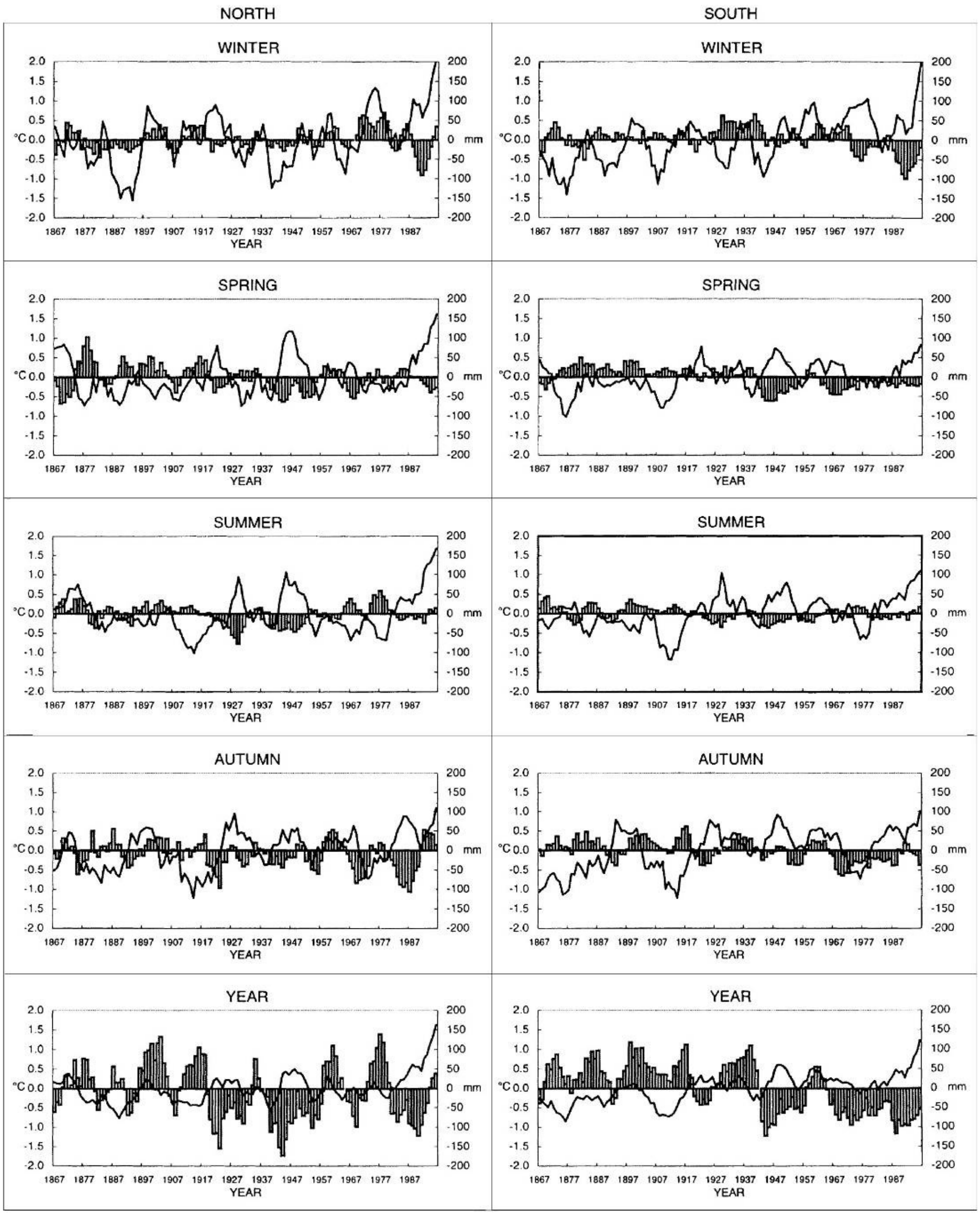
In Italy, a time series analysis from 1865 to 1996 of about 40 meteorological stations showed that monthly maximum and minimum temperature increases differ from the north to the centre-south. In the north, maximum temperatures increased by 0.6°C and by 0.8°C in the centre-south. Minimum temperatures increased by 0.4°C in the north and 0.7°C in the centre-south during the considered period. From 1930 on, both in the centre and in the south of Italy, in addition to these temperature increases, a progressive reduction in precipitation and, consequently, an increase in aridity have been recorded. The trend in temperature and precipitation as given in Figure 5 shows an inverse correlation. The graphs represent five year moving averages of temperature (solid line) and precipitation (histogram) anomalies. It demonstrates the increase in temperature (0.7°C per century for the north and 0.9°C per century for the south of Italy) and a decrease of precipitation for the same areas (Brunetti et al., 2000b; Brunetti et al., 2001; Buffoni, Maugeri & Nanni, 1999).

In addition to precipitation totals, changes in precipitation intensity are also important because of implications for flooding and soil erosion. Some studies point to intensity increases being associated with certain types of weather system (Widmann & Schar, 1997) and the changing relationships between wet day occurrence and wet day rainfall totals (Brunetti, Maugeri & Nanni, 2000, 2001). For the European Alpine region precipitation intensity has increased and is more marked for the winter months (Frei & Schar, 2001).

An Italian analysis of precipitation data gathered during the period of time 1951–1996 showed that precipitation decreased all over the national territory during the considered period, but most significantly in the centre and in the south. The reduction in rainy days throughout the national territory (about 14% both in the north and in the south) is statistically significant; greater reductions have been observed in wintertime. A rise in precipitation intensity has also been observed in both the northern and the southern regions; in the northern regions the persistence of dry periods increases in wintertime and in the southern regions in summertime (Brunetti et al., 2000a, 2001; Brunetti, Maugeri & Nanni, 2001).

These precipitation changes can be attributed both to variations in the atmospheric circulation and to an increase in atmospheric moisture as a consequence of local and global higher temperatures. The increase in precipitation intensity could be attributed to the intensification of the hydrologic cycle. Analysis of meteorological data available from 1950 up to 2000 in the Emilia Romagna region gave the following results: in summer, rainfall averages and precipitation extremes showed a significant positive trend; in autumn, no significant changes in average and extreme values were reported, with the exception of the average rainfall intensity for which a positive trend was observed; and in winter and spring a negative trend in the average volume of total rainfall was recorded (Tomozeiu et al., 2000; Tomozeiu, Busuioc & Stefan, 2002; Tomozeiu, Lazzeri & Cacciamani, 2002). Another study in the same region showed an increase of the rainfall average intensity during the autumn season (Cacciamani et al., 2000). A recent analysis of climate trends in the Veneto region during the last 4–5 decades highlighted increases in temperatures (both minimum and maximum values), an increase in autumnal rainfall, an increase in the frequency of extreme events (such as unusually strong rain or strong thermal variation between seasons) and a decrease in winter rainfall (Monai, 2004).

Figure 5: Five year moving average temperature and precipitation anomalies



Note: temperature: solid line; precipitation: histogram

Source: Brunetti, Maugeri & Nanni, 2000.

2.2.2 *Trends in weather extremes*

Extreme events are by definition rare stochastic events. Extreme weather events, such as extremely hot or cold temperatures directly affect human health (see Chapter 4). Others, such as rainfall in extreme quantity and frequency or strong wind, can cause or contribute to natural disasters: flooding and sometimes landslides often follow positive extremes in rainfall; drought is a consequence of negative extremes in rainfall and often leads to fires. In this section on observed trends in climate extremes, only the simple events like hot and cold days are tackled. The more complex extreme events such as drought and flooding are dealt with in the impact section (Chapter 3). At the global level the IPCC summarizes the recent trends (IPCC, 2007) as given in Table 1 below.

In Europe, extreme temperatures will occur more frequently. The yearly maximum temperature is expected to increase much more in southern and central Europe than in northern Europe (Räisänen et al., 2004; Kjellström et al., 2004). In addition, Kjellström (2004) shows that in summer the warming of large parts of central, southern and eastern Europe may be more closely connected to higher temperatures on warm days than to a general warming, which means that extreme temperatures will be reached. A large increase is also expected for yearly minimum temperature in most of Europe, which in many locations exceeds the average winter warming by a factor of two to three. Much of the warming in winter is connected to higher temperatures on cold days, which indicates a decrease in winter temperature variability. An increase in the lowest winter temperatures, even if quite large, would primarily mean that current cold extremes would decrease. On the other hand, a large increase in the highest summer temperatures would expose Europeans to unprecedented high temperatures.

Table 1: Recent trends for extreme weather events in the late 20th century

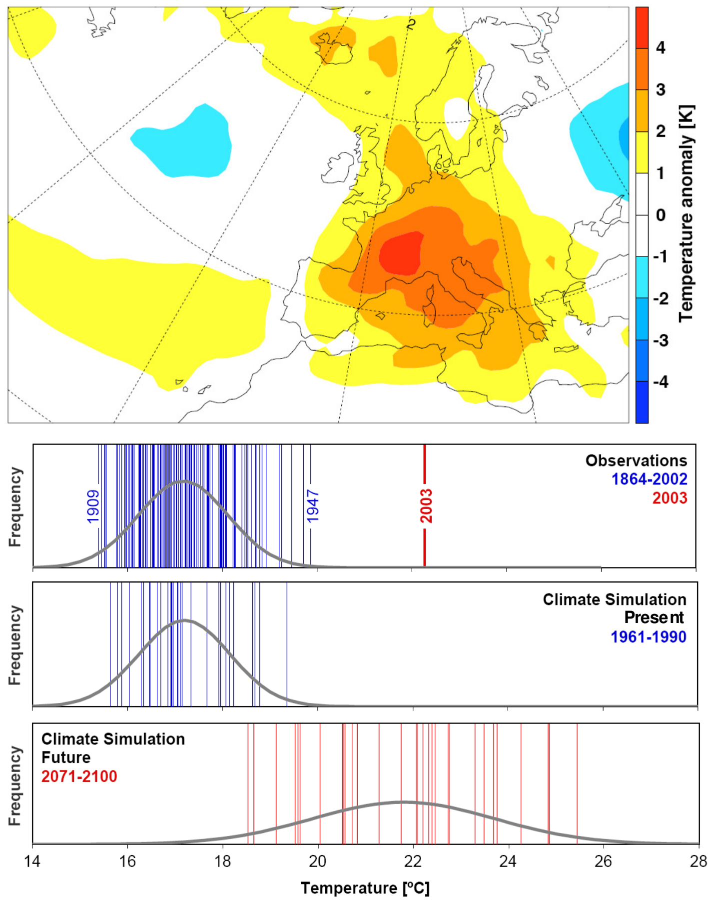
Phenomenon and direction of trend	Likelihood that trend occurred in late 20th century	Likelihood of a human contribution to observed trend	Likelihood of future trend based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	very likely	likely	virtually certain
Warmer and more frequent hot days and nights over most land areas	very likely	likely (nights)	virtually certain
Warm spells/heat waves: frequency increases over most land areas	likely	more likely than not	very likely
Heavy precipitation events: frequency (or proportion of total rainfall from heavy falls) increases over most areas	likely	more likely than not	very likely
Area affected by droughts increases	likely in many regions since 1970s	more likely than not	likely
Intense tropical cyclone activity increases	likely in some regions since 1970s	more likely than not	likely
Increased incidence of extreme high sea level (excludes tsunamis)	likely	more likely than not	likely

Source: IPCC, 2007

With regard to precipitation, Christensen and Christensen (2003), Giorgi, Bi & Pal (2004) and Kjellström (2004) all found a substantial increase in the intensity of daily precipitation events in Europe. This holds true even for areas with a decrease in mean precipitation, such as central Europe and the Mediterranean region during summer. It is associated with both changes in the number of wet days (decreasing for southern Europe) and changes in the amount of precipitation on wet days. The Mediterranean and even much of eastern Europe may experience an increase in dry periods by the late 21st century (Polemio, Casarano & Dragone, 2006).

The combined effects of warmer temperatures and reduced mean summer precipitation would lead to more heat-waves and droughts. Schär et al. (2004) conclude that the future European summer climate would experience a pronounced increase in year-to-year variability and thus a higher incidence of heat-waves and droughts (see Figure 6). Beniston (2006) estimated that countries in central Europe would experience the same number of hot days as currently occur in southern Europe and that Mediterranean droughts would start earlier in the year and last longer. The regions most affected could be the southern Iberian Peninsula, the Alps, the eastern Adriatic seaboard and southern Greece. Although only the eastern Mediterranean currently has a regularly recurring dry period, the rest of the Mediterranean and even much of eastern Europe may also experience such periods by the late 21st century. According to Good et al. (2006), the longest yearly dry spell would increase by as much as 50%, especially over France and central Europe. However, there is some recent evidence (Lenderink et al., 2006) that these projections for droughts and heat-waves may be slightly overestimated due to the parameterization of soil moisture (soil storage capacity is limited, resulting in soil drying out easily) in regional climate models. There is more information on drought as an extreme event in Chapter 3.

Figure 6: Characteristics of the summer 2003 heat-wave

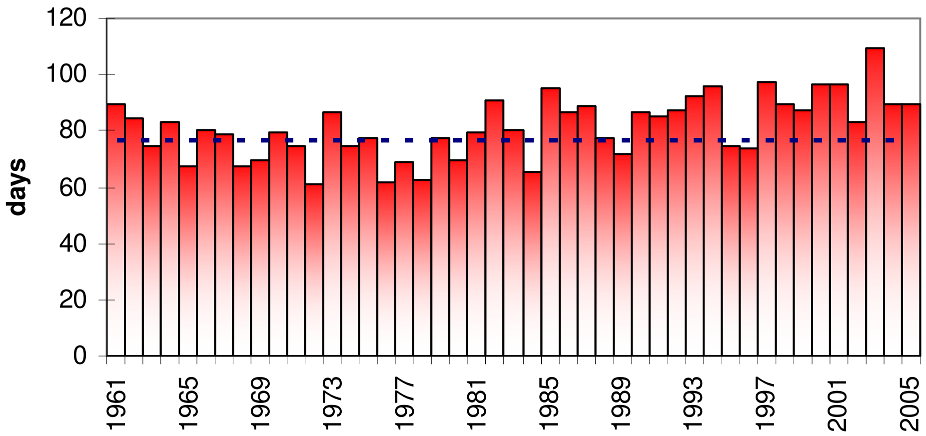


Notes: (a) June, July, August (JJA) temperature anomaly with respect to 1961–1990; (a)-(d) JJA temperatures for Switzerland observed during 1864-2003; (b) simulated using an RCM for the period 1961-1990; (c) and simulated for 2071-2100 under the A2 scenario.

Source: adapted from Schär et al., 2004

In Italy, several important indicators of climate change and variability may be derived from the statistical values of meteorological variables.[1] For the assessment of the "frost days" and "hot days" events, three indices among those defined by the CCl/CLIVAR Working Group on Climate Change Detection (Peterson et al., 2001) have been used: the annual average number of frost days in Italy, that is, the number of days in a year with a daily minimum temperature of 0°C or below; the annual average number of tropical nights in Italy, that is, the number of days in a year with a daily minimum temperature greater than 20°C; and the annual average number of summer days in Italy, that is, the number of days in a year with a daily maximum temperature greater than 25°C (APAT, 2006b). The series of three indices was obtained from minimum and maximum daily temperatures measured by 49 synoptic stations of the Air Force Meteorological Service well distributed throughout Italian territory. These data series are quality checked and satisfy the basic requirements of completeness and continuity (Toreti & Desiato, 2006a, 2006b).

Figure 7: Trend in summer days in Italy



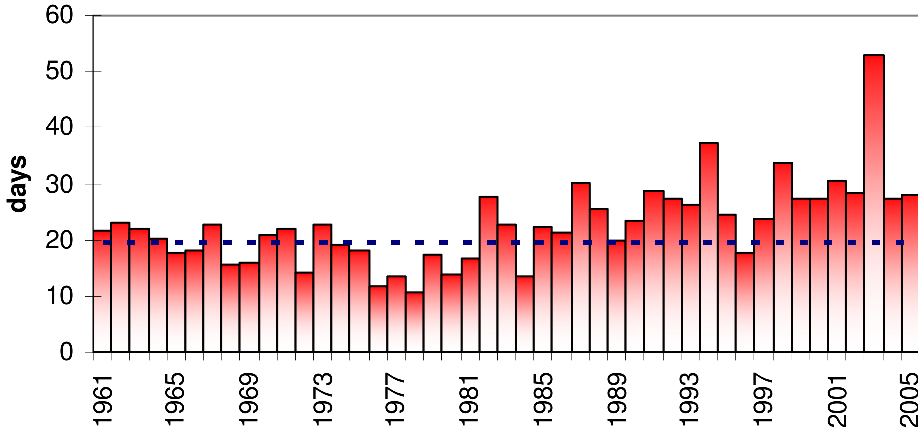
Source: APAT, 2007b.

Figure 7 shows the mean number of summer days in Italy from 1961 to 2005. The dashed line represents the normal value in the period 1961–1990. Based on a parametric statistical model for trend recognition, two trends may be distinguished. In the first, from 1961 until 1978, the number of summer days decreased, while from 1978 to 2004 it increased. Over the whole period, a net increase of about 14% of summer days is estimated.

Figure 8 shows the mean number of tropical nights in Italy from 1961 until 2005. The dashed line represents the normal value in the period 1961–1990. Based on a parametric statistical model for trend recognition, two trends may be distinguished. In the first, from 1961 till 1981, the number of tropical nights decreases, while from 1981 till 2004 it increases at a faster rate. In the whole period, a net increase of about 50% of tropical nights is estimated. Figure 9 shows the mean number of frost days in Italy from 1961 to 2005. The dashed line represents the average in the period 1961–1990. Based on a parametric statistical model for trend recognition, a variation of -0.25 frost days per year from 1961 to 2004 is estimated, corresponding to an average reduction of about 20% of the number of frost days over 43 years. These results show that the global trends observed in Europe also apply to Italy. This increases the probability that global and regional scenarios of climate change will be applicable to Italy as well.

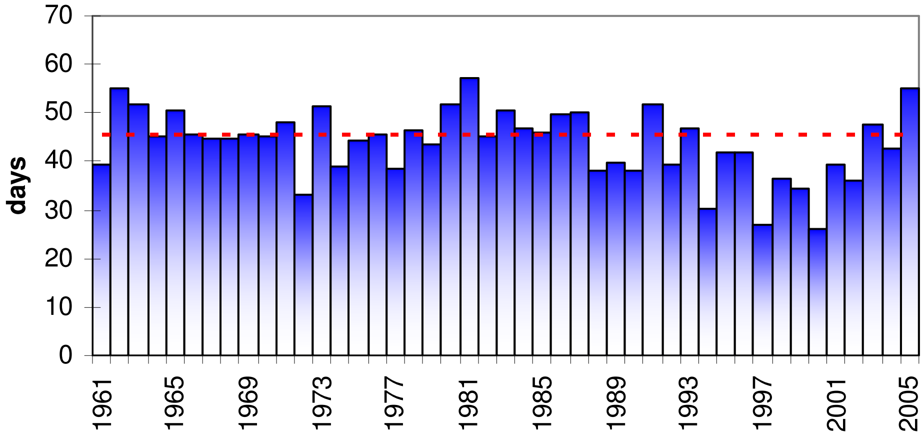
[1] Collected, calculated and diffused through the "Sistema nazionale per la raccolta, l'elaborazione e la diffusione di dati Climatologici di Interesse Ambientale" (SCIA) (www.scia.sinanet.apat.it), developed by APAT in collaboration with the Air Force Meteorological Service, the "Ufficio Centrale di Ecologia Agraria" and several regional environmental protection agencies (ARPA) (Desiato, Lena & Toreti, 2006).

Figure 8: Trend in tropical nights in Italy



Source: APAT, 2007b.

Figure 9: Trend in frost days in Italy



Source: APAT, 2007b.

2.3 Scenarios of climate change for Europe

For Europe, overall climate projections are mostly based on the IPCC-SRES[2] scenarios using the climate normal period (1961–1990) as a baseline and projecting to the year 2070. Box 2 explains some of the assumptions in these scenarios.

Box 2: The IPCC-SRES scenarios

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously

[2] SRES: special report on emission scenarios.

increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

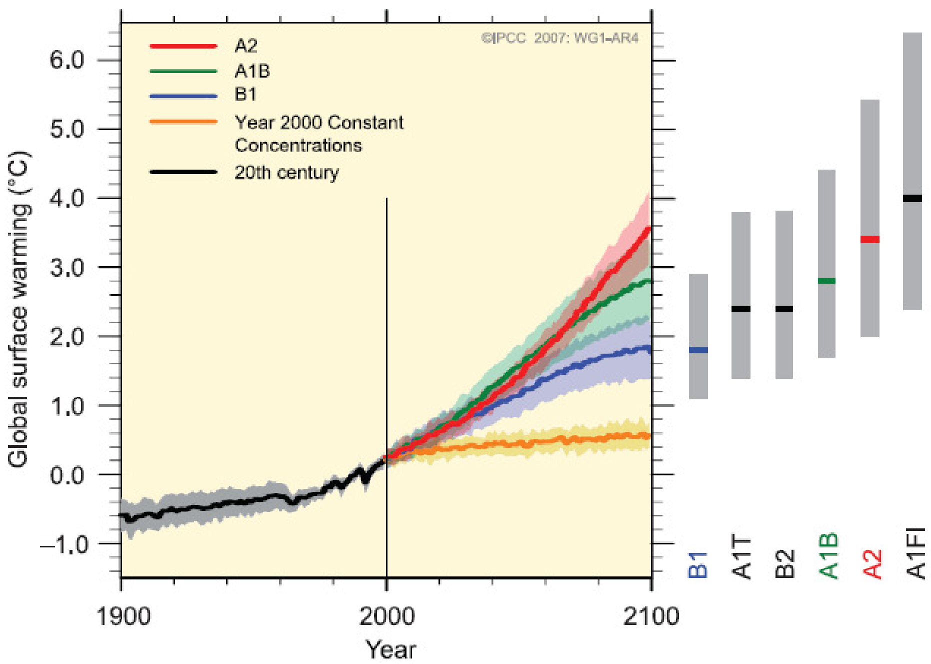
B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

All scenarios should be considered equally sound. The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

Source: IPCC, 2000

In the future, it is very likely that the following changes will occur within this century in the Mediterranean and Europe: a higher than average increase in the highest temperatures in southern Europe; an annual decrease in precipitation in most of the Mediterranean area; a decrease in the annual number of precipitation days in the Mediterranean area; and a decrease in snow season and depth. Following both the A2 and B2 scenarios, Europe will experience a warming in all seasons (in A2: 2.5% to 5.5°C; B2: 1% to 4°C; the range of change is related to emission scenarios and different climate modelling results). The warming is greatest over eastern Europe in December-January-February and over western and southern Europe in June/July/August (Giorgi, Bi & Pal, 2004). Results using two regional climate models under the PRUDENCE project show a greater warming in winter than in summer in northern Europe and the reverse in southern and central Europe. A very large increase in summer temperatures is shown to occur in the south-western parts of Europe (it exceeds 6°C in parts of France and the Iberian Peninsula) (Good et al., 2006; Kjellstrom, 2004; Räisänen et al., 2004).

Figure 10: Multi-model averages and assessed ranges for surface warming



Source: IPCC, 2001

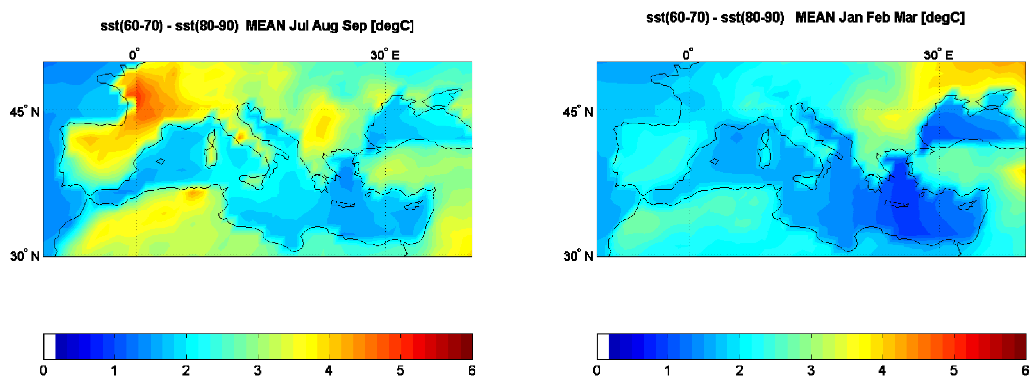
With regard to precipitation, for all scenarios the mean annual precipitation decreases in southern Europe. But the change in precipitation varies substantially from season to season and across regions in response to changes in large-scale circulation and water vapour loading. Giorgi, Bi & Pal (2004) found that increased Atlantic cyclonic activity in December/January/February leads to enhanced precipitation (up to 15–30%) over much of western, northern and central Europe. Precipitation during this period decreases over Mediterranean Europe in response to increased anticyclonic circulation. Räisänen et al. (2004) found that summer precipitation decreases substantially (in some areas up to 70% in scenario A2) in southern and central Europe, and to a smaller degree in northern Europe up to central Scandinavia. Giorgi, Bi & Pal (2004) identified enhanced anticyclonic circulation in June/July/August over the north-eastern Atlantic which induces a ridge over western Europe and a trough over eastern Europe. This blocking structure deflects storms northward, causing a substantial and widespread decrease in precipitation (up to 30–45%) over the Mediterranean basin as well as in western and central Europe.

Change in wind strength is highly sensitive to the differences in large-scale circulation that can result between different global models. From regional simulations based on ECHAM4,[3] mean annual windiness increases over northern Europe by about 8% and decreases in Mediterranean Europe (Pryor, 2005; Räisänen et al., 2004). The increase for northern Europe is largest in winter and early spring, when the increase in the average north-south pressure gradient is largest. From regional simulations based on HadAM3H,[4] change in windiness is small throughout Europe, and where it does occur it is mostly within the bounds of internal variability. For France and central Europe, all four of the simulations documented by Räisänen et al. (2004) indicate a slight increase in mean wind speeds in winter and some decrease in spring and autumn.

2.3.1 *Projected increases of temperature in Italy*

In addition to the regional projections for Europe, in Italy the Dynamic Climatology Group at the Istituto Nazionale di Geofisica developed a set of scenarios for the Mediterranean countries. The scenarios are based on the IPCC greenhouse gas emission scenarios SRES A2 and B2 (see Figure 10). The emission scenarios correspond to different assumptions about the socioeconomic evolution of the planet, but ultimately they are all based on the degree of concentration of greenhouse gases to be used in the climate model.

Figure 11: Temperature change under scenario A2



Source: Gualdi & Navarra, 2006

[3] Atmospheric general circulation model of the fourth generation, based on the weather forecast model of the European Centre for Medium-range Weather Forecasts (ECMWF)
[4] High resolution global atmosphere model from the Hadley Centre.

Figure 11 shows the expected surface temperature change in degrees under the scenario A2 for a reference period 2060–2070 in the 21st century with respect to a similar period in the 20th century (1980–1990) (Gualdi & Navarra, 2006). It is interesting to note that the pattern of warming in the summer in Figure 11 (left) has a strong resemblance to the warming pattern of the summer of 2003. It is, of course, impossible to attribute any single event to the general progressive evolution of the system, but the similarity is intriguing and it may bring some support to the speculation that the warming will manifest itself through an increase in the occurrence of events similar to those in the summer of 2003.

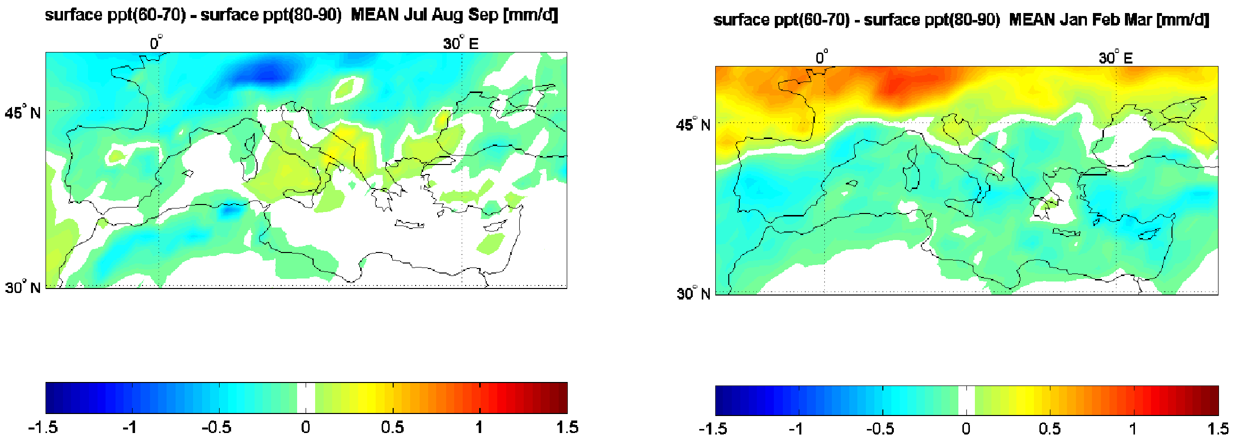
2.3.2 *Projected precipitation changes in Italy*

The changes in precipitation are shown in Figure 12 which visualizes the expected precipitation changes in mm/day under the scenario A2 for a reference period (2060–2070) in the 21st century with respect to a similar period in the 20th century (1980–1990). The differences between the scenario and the control are expressed in the same display format as in the previous picture. The differences are measured in mm/day of rain. There is a confused situation in summer when precipitation decreases everywhere except in a large area over the south of Italy and Albania. However, summer precipitation in the Mediterranean region is small and so we are looking at small differences in small numbers that are easily affected by chance or random variation. It is, instead, most interesting to inspect the winter precipitation in Figure 12, right. In this case we can see a definite and well-formed pattern. The precipitation decreases over the entire Mediterranean belt and we observe a corresponding increase in the precipitation in northern Europe. The magnitude is about 0.5 mm/day that corresponds to an accumulated amount over the 90 days of the season of 45 mm. The observed precipitation for winter in northern Italy is around 200 mm for the 90 days of winter. This means that we are facing a 25% possible decrease in precipitation by the late 21st century. B2 is a more optimistic scenario regarding the increase in the amount of CO_2 and it accordingly generates a weaker greenhouse forcing. The changes follow the same general pattern as in the A2 case, but in a weaker and more disorganized form. Still, it is possible to recognize the distinctive pattern of warming and precipitation reduction evidences under A2. The expected precipitation changes in mm/day under the scenario B2 for a reference period (2060–2070) in the 21st century with respect to a similar period in the 20th century (1980–1990) is shown in Figure 13.

The results obtained to date are certainly interesting, but the degree of reliability of the results of the simulations has to be evaluated. A reduction of 25% in winter precipitation is a major reason for concern. How can we believe this kind of result? It is, of course, a difficult and important question and there are no sure answers. In general, we can get a feel for the reliability of the model by checking the consistency of the simulation either internally or with other known results. The choice of the global model to perform the simulation offers an illuminating opportunity because we can investigate if the patterns that we have unveiled, and that we have inspected from a purely regional viewpoint, are part of something larger and more consistent.

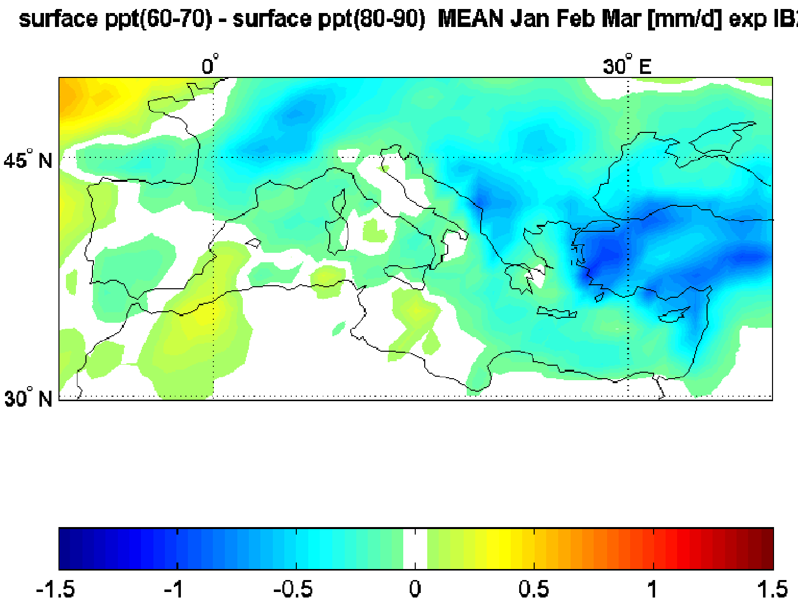
Figure 14 shows the expected global precipitation changes in mm/day under the scenario A2 for a reference period (2060–2070) in the 21st century with respect to a similar period in the 20th century (1980–1990). The differences are as discussed previously, but in this case we are showing them globally. Focusing on the winter precipitation (bottom panel) we can see several interesting patterns. The first observation is that the Mediterranean region is very small with respect to the Earth; very large changes are visible elsewhere and changes in the Mediterranean region do not particularly stand out. The second comment is that we can see that the changes we have discussed in the previous sections are indeed part of a larger system that extends from the Atlantic Ocean to Europe. It is composed of two parts: the northern branch is positive, indicating an increase in precipitation and the southern part is negative, indicating a decrease. It is the southern branch that ends up covering the entire Mediterranean region.

Figure 12: Precipitation changes under scenario A2



Source: Gualdi & Navarra, 2006

Figure 13: Precipitation changes under scenario B2



Source: Gualdi & Navarra, 2006

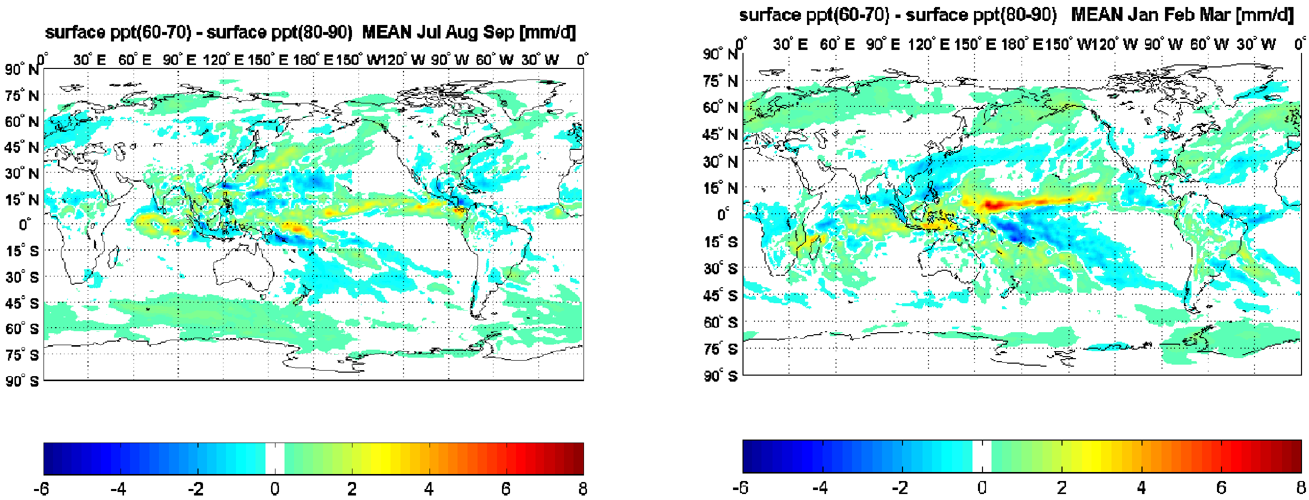
The parallel strips of opposing features are the sign of a shift in the dominant trend of precipitation. According to these scenarios, later in the 21st century, rainfall will move north, leaving a deficit behind and a surplus in the new area. The loss of precipitation over the Mediterranean is part of a much larger change that involves the hemisphere. It is the border between the Hadley[5] and the Ferrel cell[6] that has shifted north making the descending and dry branch of the Hadley circulation a more frequent visitor to the Mediterranean and reducing rainfall. The fortunate state of equilibrium of the Mediterranean between north and south appears to be in danger. The observation that the change in the Mediterranean region is part of a bigger change

[5] The **Hadley cell** is a circulation pattern that dominates the tropical atmosphere, with rising motion near the equator, poleward flow 10–15 km above the surface, descending motion in the subtropics, and a flow towards the equator near the surface.

[6] The **Ferrel cell** is a secondary circulation feature, dependent for its existence on the Hadley cell and the Polar cell.

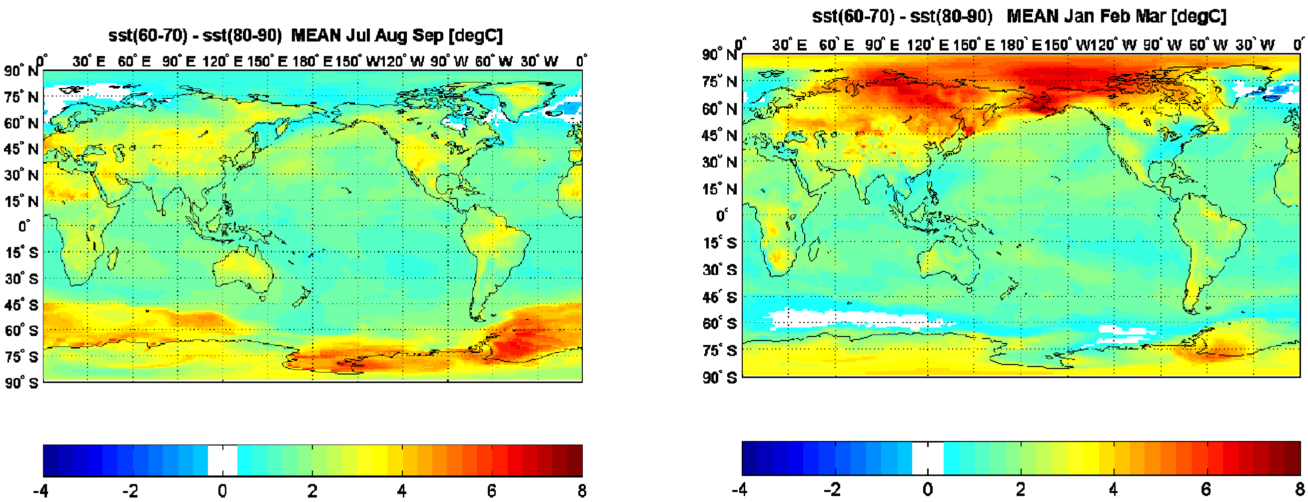
therefore increases the reliability of the result, because the models are usually very good when dealing with extensive data that relate to a large geographical area. A similar argument can also be made for temperature. Figure 15 shows the expected global temperature changes in degrees under the scenario A2 for a reference period (2060–2070) in the 21st century with respect to a similar period in the 20th century (1980–1990). In this case the dominant effect is a general warming of the poles in winter and a general warming of the landmass in the summer and Europe is not an exception.

Figure 14: Global precipitation changes under scenario A2



Source: Gualdi & Navarra, 2006

Figure 15: Global temperature changes under scenario A2

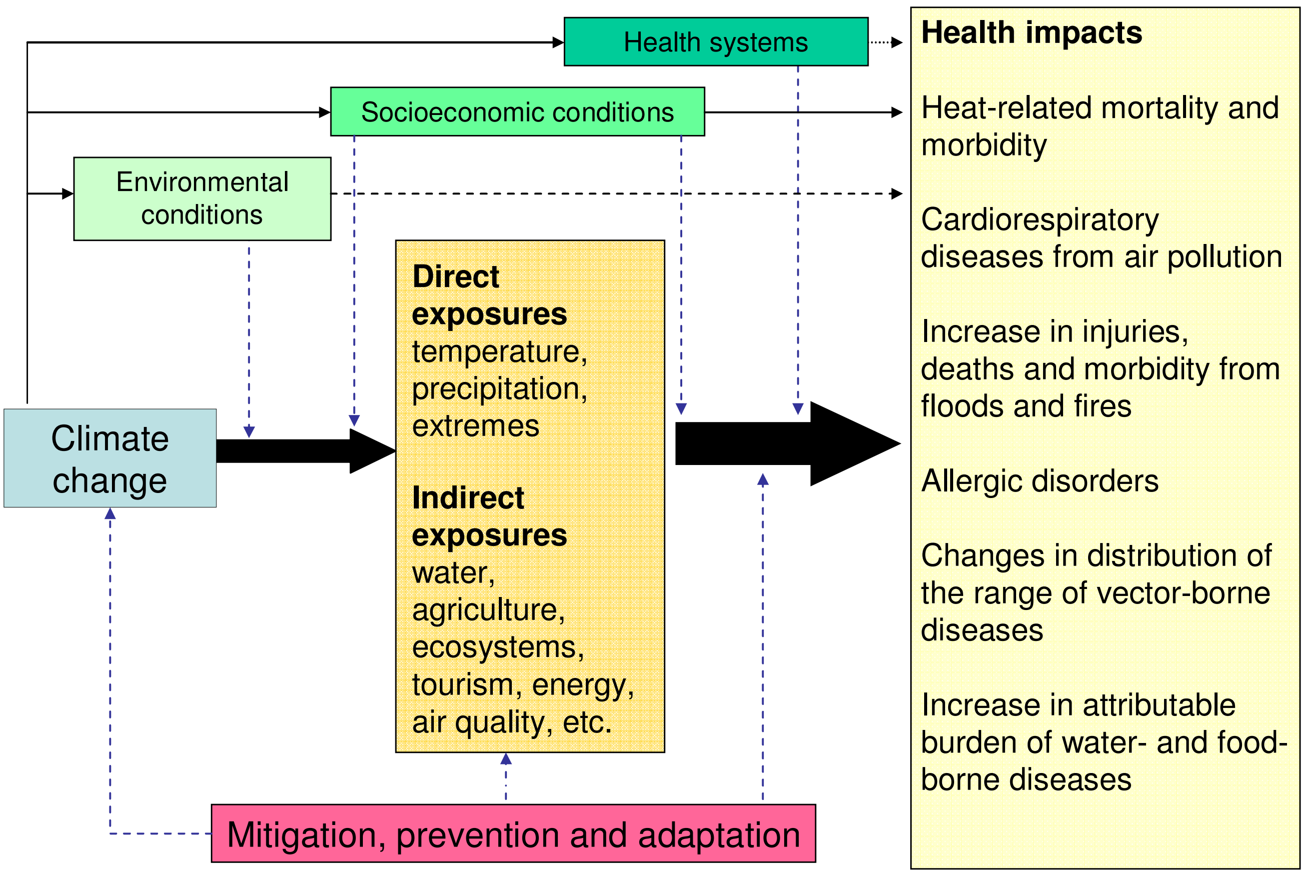


Source: Gualdi & Navarra, 2006

3. Observed and projected impacts of climate change and variability in Italy

The observed and projected changes in the climate system will affect the various sectors of the Earth's systems in different ways. To look at the impacts on the different sectors separately is rather artificial as they are interlinked. However, for the sake of a better structure and understanding, the impacts are distinguished using the IPCC nomenclature. Accordingly, section 3.1 describes the impacts related to water; section 3.2 looks at the impacts on ecosystems, forests and agriculture; while section 3.3 outlines the impacts on urban environments and socioeconomic sectors. These impacts are all relevant to human health, as they may change exposure or intensify exposure, as illustrated in Figure 16.

Figure 16: Direct and indirect exposure to climate change and human health



Source: adapted from Confalonieri et al., 2007

3.1 Water

– by Enzo Funari, Angiolo Martinelli, Monica Francesca Blasi, Mario Carere, Valentina Della Bella, Laura Mancini, Stefania Marcheggiani, Francesco Mattera, Mara Stefanelli

Key messages

- Water stress might increase by 25% in this century, leading to higher demand for irrigation water.
- Safe water supply is becoming a social and economic emergency in several regions.
- Rises in sea level will put coastal areas and plains at risk of sea flooding.
- Heavy precipitation events could increase inland flooding.
- Higher marine water temperatures have allowed the migration and settlement of toxic algal species close to the Italian coasts; several health-related problems have been observed in summer.

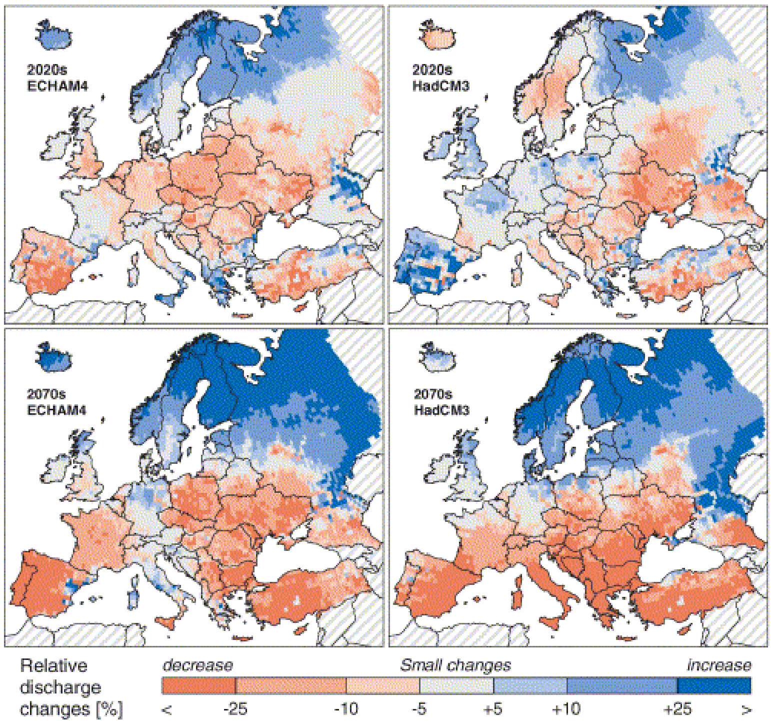
In this section on impacts related to water, several groups of impacts on systems are presented. They range from water stress to impacts on recreational waters, coastal flooding from sea level rise, river flooding and droughts.

3.1.1 *Water stress*

Observations and projections based on various scenarios and Global Circulation Models (GCMs) show that water flow is decreasing in some regions of Europe and will further decrease in the future (Chang et al., 2002; Etchevers et al., 2002; Iglesias, Estrela & Gallart, 2005; Menzel & Burger, 2002). Studies show a decrease in summer flows in the Alps (Schroter et al., 2005; Zierl & Bugmann, 2005). The volume of summer low flow may decrease by up to 50% in central Europe (Eckhardt & Ulbrich, 2003), and by up to 80% around the Mediterranean (Santos, Forbes & Moita, 2002). Therefore, the regions most prone to an increase in water stress are the Mediterranean (Portugal, Spain) and some parts of central and eastern Europe, where the 100-year deficit volumes may increase by 25% (Lehner et al., 2005) and the highest increase in irrigation water demand is forecast (Döll, 2002; Donevska & Dodeva, 2004; Santos, Forbes & Moita, 2002). Irrigation requirements are likely to become substantial in countries where they now hardly exist (Holden et al., 2003). Demand for water for irrigation may be influenced by changes in the amount and distribution of agricultural land as affected in the future by the EU Common Agricultural Policy (CAP). Groundwater recharge may also be reduced (Eitzinger et al., 2003), with a larger reduction in valleys (Krüger, Ulbrich & Speth, 2002) and lowlands (e.g. in the Hungarian steppes) (Somlyódi, 2002). Figure 17 shows the annual change in river basin discharge between the baseline period (1961–1990) and two future time slices (2020s) and (2070s) as computed by the ECHAM4 and HadCM3 global climate models and the Baseline-A water use scenario (Lehner et al., 2005).

In many parts of Italy, particularly in the south, it has become ever more difficult to meet demand for water. The recent years of drought and the constant increase of water demand for the civil sector have made irrigation supply more problematic. Wastewater reuse could represent a viable solution to meet water demand. Planned exploitation of municipal wastewater could help to meet the demand for irrigation water, particularly in southern Italy (e.g. Sicily) where farmers have been practising uncontrolled wastewater reuse for a long time. Reuse of wastewater, however, may have consequences for human health if strict guidance is not applied. In northern and central Italy, where available water resources generally meet water needs for different purposes, wastewater reuse could play an important role in controlling the pollution of bodies of water. Several projects on wastewater reuse are currently in progress (Barbagallo, Cirelli & Indelicato, 2001).

Figure 17: Annual change in river basin discharge



Source: Lehner et al., 2005

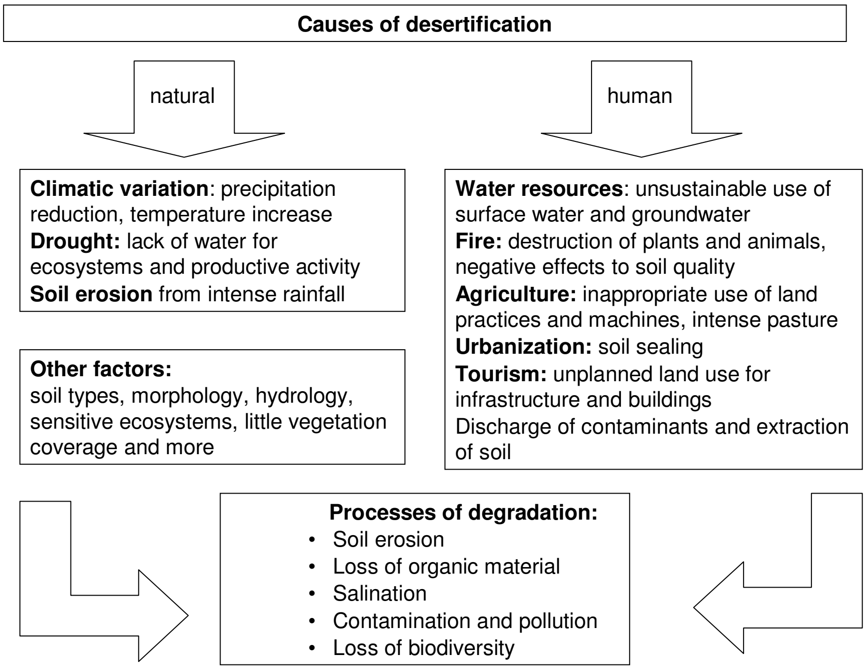
3.1.2 *Droughts and desertification*

Changes in the water cycle are likely to increase the risk of drought. Drought is defined as a period of below average precipitation that adversely affects gross primary productivity and causes water scarcity. The most important effect of drought is on agriculture and soil quality. Extended droughts in fact make soil more vulnerable to soil erosion and desertification. Food production may also be affected as demonstrated by the heat-wave which occurred in 2003. This was associated with annual precipitation deficits of up to 300 mm, and drought was a major contributor to the estimated 30% fall in gross primary land-related production in Europe (Ciais et al., 2005). This reduced agricultural productivity and increased production costs, with an estimated loss of more than € 11 billion (Olesen & Bindi, 2003). The risk of drought is likely to increase in southern and central Europe. Several model studies have indicated a decrease in the number of precipitation days (e.g. Semenov, Gelver &Yasyukevich, 2002; Voss, May & Roeckner, 2002; Räisänen et al., 2004; Frei et al., 2006) and an increase in the length of the longest dry spells in this area (Voss, May & Roeckner, 2002; Pal, Giorgi & Bi, 2004; Beniston, 2006; Tebaldi et al., 2006). The decrease in precipitation together with enhanced evaporation in spring and early summer is very likely to lead to reduced summer soil moisture in the Mediterranean region and parts of central Europe (e.g. Douville et al., 2002).

Drought can increase the risk of soil erosion and desertification. This is quite common in many countries since inappropriate land use and groundwater extraction increase the vulnerability of soils. Climate change is expected to affect the desertification process by increasing the intensity of rainfall, which will accentuate water loss due to run-off and erosion; by increasing evapotranspiration, causing soil salinization; by increasing aridity, which will contribute to reducing concentrations of organic matter in the soil; and by increasing droughts, which will jeopardize many anthropic activities (see Figure 18). However, scientists cannot yet predict how rising atmospheric levels of greenhouse gases will affect the global rate of desertification. What they can predict is that changes in temperature, evaporation and rainfall will vary from region to region. As a result, desertification is likely to be aggravated in some critical areas, in particular in the Mediterranean basin.[7]

In Italy, aridity has increased in the course of the 20th century in the southern and island regions both in terms of an increase in the number of areas involved and in terms of the index values. Arid, semi-arid and dry sub-humid areas currently include major regions in the south of Italy, such as Sicily, Sardinia, Apulia and Basilicata. At the same time, the mistaken conception and implementation of several policies intended to support agriculture – the use of inappropriate water resources for irrigation purposes, forest fires – and the increased urbanization of coastal areas have all contributed to a slow depletion of the soil resources, both quantitatively and qualitatively.

Figure 18: Logic framework for desertification



Source: adapted from Sciortino et al., 2000.

3.1.3 *Sea level rise and coastal flooding*

The vulnerability of coastal shelf waters and some stretches of coastline to sea level rise and coastal flooding are dependent on several local factors (Duffy & Devoy, 1998; EEA, 2004a, 2004b; Smith et al., 2000; Swift et al., 2005). For example, will low-lying coastlines with high population densities and small tidal ranges be most vulnerable to sea level rise (Kundzewicz & Parry, 2001)? Coastal flooding related to sea level rise could affect large populations in Europe overall (Arnell et al., 2004). Under the A1FI SRES scenario up to 2.5 million people each year might experience coastal flooding in Europe by 2080 (Nicholls, 2004). Approximately 20% of existing coastal wetlands may disappear by 2080 under SRES scenarios for sea level rise in Europe (Devoy, in press; Nicholls, 2004). Impacts of sea level rise and related climate warming on coastal marine ecosystems are also likely to intensify problems of eutrophication and stress on biological systems (EEA, 2003, 2004b, 2005a; Robinson et al., 2005). Furthermore, in areas of coastal subsidence or high tectonic activity, as in the low tidal range of the Mediterranean and Black Sea regions,

[7] In the context of the DISMED project, an index to assess vulnerability to desertification has been developed and applied to countries in the Mediterranean. A map of areas at risk of desertification can be viewed under http://www.ibimet.cnr.it/Case/dismed_products.php and indicates that southern Italy and the islands of Sicily and Sardinia are particularly at risk of desertification.

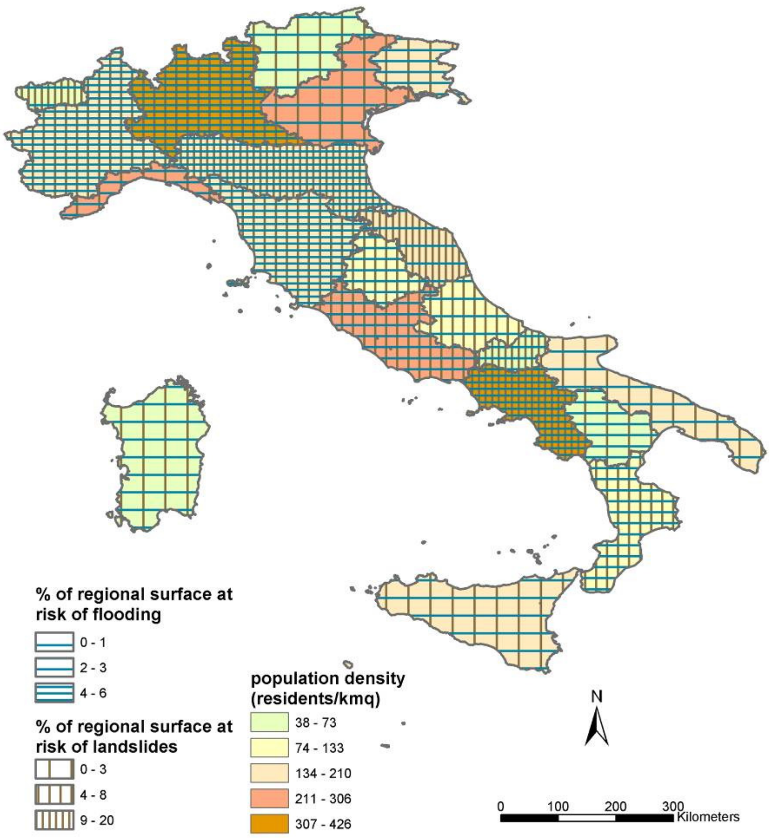
climate-related sea level rise could significantly increase potential damage from storm surges and tsunamis (Gregory et al., 2001). However, experiments indicate a decline in storminess and wind intensity eastwards into the Mediterranean (Busuioc, Chen & Hellstrom, 2001; Tomozeiu, Stefan & Busuioc, in press), but with localized increased storminess in parts of the Adriatic, Aegean and Black seas (Guedes Soares et al., 2002).

For the Italian coasts sea level rise will imply high risks. About 4500 km^2 of coastal areas and plains would be at risk of coastal flooding (according to a study carried out by NASA-GISS); floods might occur in northern Italy (Upper Adriatic Sea), central Italy (the coastline between Ancona and Pescara, the coasts near Rome and Naples) and in southern Italy (Gulf of Manfredonia, coasts between Taranto and Brindisi, eastern- southern Sicily).

3.1.4 *Heavy rainfall and river flooding*

Changes in the water cycle are likely to increase the risk of floods. An increase in intensive short-term precipitation in most of Europe is likely to lead to an increased risk of flash floods (EEA, 2004b), particularly in the Mediterranean and eastern Europe (Ludwig et al., 2003). Nevertheless, the flood risk from climate change could be magnified by an increasing impermeable surface due to urbanization (de Roo et al., 2003) and modified by changes in vegetation cover (Robinson et al., 2003) in small catchments.

Figure 19: Regions of Italy: risks of flooding and landslides



Source: WHO with data from APAT, 2004b

In Italy, records suggest that floods and droughts have been more frequent over the past 50 years. The flooding risk in Italy is high and widespread especially because of its peculiar geological and geomorphological formation with young orographical features. Some areas of Italy are subject to subsidence, which further increases this risk. Subsidence is a geological phenomenon characterized by the sinking of the land. In Italy, it has increased over recent years as a consequence of human activities, especially excessive groundwater withdrawal. In the eastern Po plain in northern Italy, the recent effects of human activities on subsidence have been judged to be as great as those resulting from long-term natural processes. A clear correlation between flood frequency and rapid subsidence can also be demonstrated (Carminati & Martinelli, 2002). A technical report by the Ministry of the Environment and Land Protection (Ministero dell'Ambiente, 2000) quantifies the areas with high risk of flooding: they cover an area of 7774 km^2, corresponding to 2.6% of the national territory. Floods can have severe consequences for human health, infrastructures and the environment. The most dramatic floods in Italy occurred in the Po (1951, 1994 and 2000) and Arno river basins (1966). Table 2 shows the main floods recorded in Italy from 1951 to 2003 as summarized by APAT.[8]

Heavy rainfall also causes landslides. Figure 19 summarizes information on percentages of regional surfaces at risk of flooding and at risk of landslides for the regions of Italy (APAT, 2004a, 2004b). Information on the regional population density is added. It shows that Lombardia and Campania have high average population densities of more than 300 persons per square kilometre and at the same time a relatively big share of land surface is at risk of flooding (4–6% of the regional surface) and landslides (9–20% for Campania, 4–8% for Lombardia).

Table 2: Main floods in Italy

Event period		Region	Loss of human lives	Estimated total damage	Estimated total damage /GDP*
			n	Million €	%
1951	16–22 October	Calabria, Sicily, Sardinia	110	15.49	0.2791
1951	8–12 November	Piedmont, Lombardia, Veneto, Liguria, Emilia Romagna	100	206.58	3.7216
1953	21 October	Calabria	100	-	-
1954	26 October	Campania	318	23.24	0.3295
1966	3–5 November	Piedmont, Lombardia, Trentino Alto Adige, Veneto, Friuli Venezia Giulia, Liguria, Tuscany ,Lazio, Sardinia	118	516.56	2.5107
1968	2–4 November	Piedmont	74	154.04	0.6418
1976	5 November	Sicily	18	51.65	0.0571
1978	6–10 August	Piedmont	18	51.65	0.0400
1983	3–11 September	Piedmont, Lombardia, Friuli Venezia Giulia	6	154.94	0.0474
1987	18 July – 28 August	Lombardia	53	1 549.37	0.3047
1991	12 October	Tuscany, Sicily	12	77.47	0.0104
1991	19 October	Lazio	3	-	-
1994	3–6 November	Piedmont	64	2 840.51	0.3326
1996	18–19 June	Tuscany	21	200.00	0.0204
1996	14 October	Calabria	6	113.62	0.0116
2000	14–16 October	Piedmont, Valle d'Aosta, Lombardia, Liguria	37	2 582.28	0.2214
2001	13–16 September	Campania	2	165.27	0.0136
2002	14 November, 7 December	Piedmont, Lombardia, Veneto, Friuli Venezia Giulia, Liguria, Emilia Romagna	2	850.00	0.0674
2003	23–26 January	Abruzzo, Molise, Campania, Puglia	1	810.00	0.0623

* Gross Domestic Product
Source: APAT, 2004b

[8] Based on information from ISTAT, GNR-GNDCI AVI Project, ARPA Piedmont, SICI, Benedettini and Gisotti "il dissesto idrogeologico", FLANET, Nimbuswd, EM-Dat: the OFDA/CRED International Disaster Database; Scienza e Tecnica, year LXVI – No. 393 – May 2003, Centro studi per la flora mediterranea-Borgo Val di taro (Parma), l'alluvione del fiume Taro nel November 1982; commissione interministeriale per lo studio della sistemazione idraulica e della difesa del suolo, l'evento alluvionale del novembre 1966; CONACEM.

3.1.5 *Recreational waters*

In this section on recreational waters, two impacts with health implications are outlined: first structural changes in lakes in Italy and second the problem of toxic marine algae. With regard to lakes, studies that have been conducted provide evidence that increased atmospheric temperature has had an impact on Italian lakes – those in the Alps but also those in the rest of Italy. Increased temperature causes a thermoenergetic increase in the surface waters and the deep water of the lakes and influences the annual and long-term circulation and mixing of water in the lakes, especially in late summer when the thermal inversion occurs. There is less mixing of water in the lakes and this decreases the availability of oxygen in the deep water. Under anoxic conditions the mineralization of organic substances is impaired or slowed down and the risk of anaerobic processes and the release of methane and CO_2 increases. A lack of oxygen in deep waters also enhances the mobilization of metals and of nutrients (e.g. phosphorous), which leads to an excessive growth of algae, cyanobacteria (see Chapter 4) and to eutrophic problems in the lake's ecosystem. The changes in water quality also affect human activity and human health as described in Chapter 4. These effects have been observed at Lake Maggiore, Lake Garda, Lake Orta, Lake Como (Ambrosetti & Barbanti, 1999), Lake Iseo (Garibaldi et al., 1999) and Lake Bolsena (Bruni, 1998). In order to monitor these changes, time series analysis of important indicators such as algae biomass and chlorophyll are necessary.

Regarding toxic marine algae, the observation of a rise in the Mediterranean Sea temperatures since the 1980s is relevant. In June and July 2003, sea surface temperatures reached particularly high values of 28°C with peaks of 32°C.[9] Some tropical species have colonized the Mediterranean Sea coming from other seas through the Suez Canal, the Strait of Gibraltar (www.ipsema.it) and ships' ballast water (Carlton & Geller, 1993). Several toxic algal species live in the Mediterranean Sea (Ade, Funari & Poletti, 2003). Recently, some tropical ichthyotoxic species have also been found in Italian marine environments. Some of them, *Heterosigma akashiwo, Chattonella antiqua, Chattonella marina, Fibrocapsa japonica* (all Raphidophyceae) produce toxins of the brevetoxin group (Mattei & Bruno, 2005). In addition, in recent years, several Italian coastal stretches have seen the occurrence of *Ostreopsis ovata*, a marine dinoflagellate species (Gallitelli et al., 2005; Sansoni et al., 2003). It is a benthic species which lives on red and brown macroalgae in tropical or subtropical regions. Some Ostreopsis strains produce palytoxin and analogues which can accumulate in fish and are implicated in clupeotoxism associated with eating clupeoid fish (Onuma et al., 1999). Palytoxin is one of the most potent non-peptidic marine toxins. It has a lethal dose in 50% of rats, mice, dogs and monkeys, when given intravenously, at ranges between 0.03 and 0.45μg/kg; palytoxin causes cytolysis as a result of the inhibition of Na+, K+-ATPase (Tosteson, 2000). It has been recognized as the causative agent of fatal human seafood poisoning (Onuma et al., 1999).

Furthermore, during summer 2005, about 200 people who spent time on or near beaches in a stretch of the north-west Italian coast around the city of Genoa sought medical treatment for symptoms such as rhinorrhoea, cough, fever, bronchoconstriction with mild breathing difficulties, wheezing and, in a few cases, conjunctivitis. For almost all of these people, the symptoms stopped after a few hours and only 20 people were hospitalized (Brescianini et al., 2005, 2006). *Ostreopsis ovata* was deemed the possible causative agent; indeed during these same period this species was blooming in that particular beach area. It was hypothesized that these symptoms might be due to inhalation of aerosolized *Ostreopsis ovata* fragments. Analysis of the content of marine samples showed the occurrence of palytoxin in these algae (Penna et al., 2005).

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[9] See details under http://www.ipsema.it/natutes/natutes24/indice24.htm: Tarelletto Alessio Il Mediterraneo nuovo paradiso tropicale.

On the basis of experience from 2005, an effective monitoring programme was conducted in 2006 in order to prevent dangerous exposure to *Ostreopsis ovata* blooms (see www.arpal.org). Similar but less intense episodes were observed in the Lazia and Puglia coasts in 2004 (Sansoni et al., 2003). This phenomenon is similar to that which occurs in the Gulf of Mexico where people exposed to marine aerosols during blooms of *Karenia brevis* suffer respiratory difficulty and irritation and burning of the throat and upper respiratory tract (Cheng et al., 2005). These examples show that the occurrence of new species in marine ecosystems is a health risk for humans.

3.2 Ecosystems, forests and agriculture

– by Lorenzo Cecchi, Simone Orlandini,
Marco Morabito, Marco Bindi, Marco Morindo

Key messages

- Climate changes alters characteristics of allergenic plants, biodiversity and mountainous ecosystems.
- Increased soil aridity and forest fires threaten Italian forests.
- Yield of summer crops might decrease due to development stages of extreme climate events.

There is strong evidence that the recent warming is noticeably affecting terrestrial biological systems, including such changes as the earlier timing of spring events. Also, satellite observations since the early 1980s show a trend in many regions towards earlier "greening" of vegetation in the spring linked to longer thermal growing seasons. There is also convincing evidence that observed changes in marine and freshwater biological systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation. These include shifts in ranges and changes in algal, plankton and fish abundance in high-latitude oceans, increases in algal and zooplankton abundance in high-latitude and high-altitude lakes and range changes and earlier migrations of fish in rivers (Alley et al., 2007). Some examples are given in the following sections.

3.2.1 *Phenology and allergenic plants*

The timing of life-cycle events such as leaf unfolding, bird migration and egg laying and poleward and upward shifts in ranges of plant and animal species, is very sensitive to several climate variables, such as ambient temperature (Ahas, Jaagus & Aasa, 2000) or water availability (Peñuelas, Filella & Comas, 2002). Accordingly, the chronology of plants' phenological phases is an indicator for checking if ecosystems are reacting to climate change. The analysis of historical data in the Mediterranean area shows that plant phenological development is more affected by temperature than rainfall (Gordo & Sanz, 2005). In general, in spring-flowering plants, the observed increasing temperature allows earlier leaf unfolding, flowering and fruit growing, while warmer autumn temperature conditions delay leaf fall, extending the leaf life-cycle (Frenguelli, 2002; Gordo & Sanz, 2005; Peñuelas, Filella & Comas, 2002). The increased plant-growing season is associated with a decreased probability of frost damage to young leaves and flowers since some long-term series analyses indicate a negative trend in the annual occurrence of frost days (Kostopoulou & Jones, 2005; Toreti & Desiato, 2006a, 2006b).

Furthermore, recent studies have demonstrated the potential impact of climate change on allergenic plants and their pollen, which in this context are also called aeroallergens. The pollen season, pollen amount, pollen allergenicity and plant and pollen distribution (Beggs, 2004) depend on the climate and react to changes in climate. First, the average length of the growing season in Europe has increased by 10 to 11 days over the last 30 years. Duration of the pollen season has also been extended, especially in summer and in late flowering species (Huynen et al., 2003). In addition, an earlier start and peak of the pollen season is more pronounced in species that start flowering earlier in the year (Corden, Millington & Mullins, 2003; Emberlin et al., 2002; Fitter & Fitter, 2002; Spieksma et al., 1995). Regarding the amount of pollen, there has been an increasing trend over the past decades which parallels local rises in temperature. Under experimental conditions substantial increases in pollen production resulted from exposure to increased CO_2 concentration (Rogers et al., 2006; Wayne et al., 2002; Ziska & Caulfield, 2000). There is some evidence of stronger allergenicity in pollen from trees grown at increased temperatures (Ahlholm, Helander & Savolainen, 1998; Hjelmroos, Schumacher & Van Hage-Hamsten, 1995). Besides these trends, the changes in climate appear to have altered the spatial distribution of pollens. New patterns of atmospheric circulation over Europe might contribute to episodes of long-distance transport of allergenic pollen, increasing the risk of new sensitizations among allergic populations (Cecchi et al., 2006). There is growing evidence that climate change might also facilitate the geographical spread of particular plant species to new areas which become climatically adapted (see section 3.2.3.). Table 3 summarizes the possible effects of climate change on the most important allergenic plants in Italy. Present data suggest an increase in the pollen count and an earlier onset for all species; however, effects on grass pollen concentration might be mitigated by a change in land use (i.e. urbanization). Changes in allergenic plants may have consequences for allergic diseases (Riotte-Flandrois & Dechamp, 1995; Zanon, Chiodini & Berra, 2000).

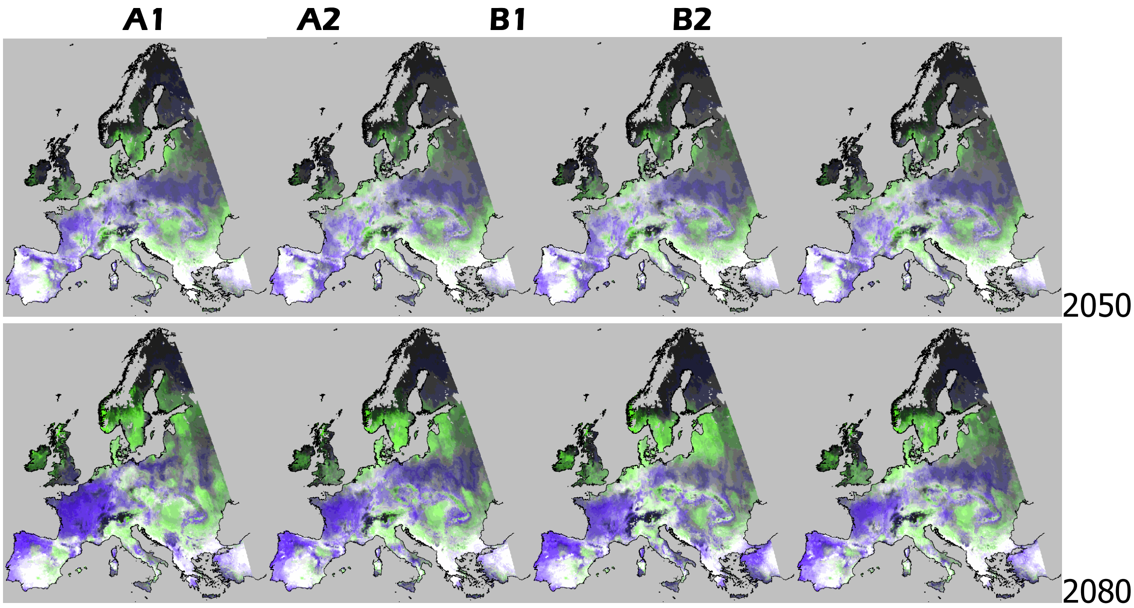
Table 3: Effect of warming on allergenic plants

Pollen	Concentration	Earlier onset
Birch	↑	yes
Grass	↔	yes
Pellitory	↑	yes
Ragweed	↑	yes

3.2.2 *Animal species*

Changing climate affects not only plants but also animals, and in particular species living in water. In general, the species richness in inland waters is highest in central Europe and declines towards the south and north because of periodic droughts and salinization (Declerck, 2005). In the future, higher temperatures may lead to further decreased species richness in freshwater ecosystems in parts of south-west Europe (Gutiérrez Teira, 2003) and invasive species may increase in the north (McKee et al., 2003). Woody plants and shrubs may encroach up bogs and fens (Weltzin et al., 2003). A reduction of periods of inundation in the south may favour amphibian over aquatic species (Álvarez Cobelas, Catalán & García de Jalón, 2005). Species adapted to the cold will be forced further north and upstream; some may eventually disappear from Europe altogether (Daufresne et al., 2003; Eisenreich, 2005). Figure 20 shows the change in combined amphibian and reptile species richness under climate change. Depicted is the change between baseline and future species richness projected for two time periods (2050 and 2080) using artificial neural networks, four SRES scenarios (A1, A2, B1, B2) (shown left to right), and based on climate scenarios from the HadCM3 global climate model. Increasing intensities of blue indicate increasing species richness in the baseline period (i.e. broad patterns of contraction) and increasing intensities of green represent increasing species richness in the future (i.e. broad patterns of range expansion). Black, white and grey cells indicate areas with stable species richness scores: black grid cells show low species richness in both periods; white cells show high species richness; grey cells show intermediate species richness (Araújo, Thuiller & Pearson, 2006).

Figure 20: Change in species richness under climate change



Source: Araújo, Thuiller & Pearson, 2006.

3.2.3 *Mountain areas*

Glaciers will experience a substantial further retreat during the 21st century (Haeberli & Burn, 2002). Small glaciers will disappear, while larger glaciers will suffer a volume reduction between 30% and 70% by 2050 (Paul et al., 2004; Schneeberger et al., 2003). During the retreat of glaciers, spring and summer discharge will decrease (Hagg & Braun, 2004). Rising temperatures and melting permafrost will destabilize mountain walls and increase the frequency of rockfalls, threatening mountain valleys (Gruber, Hoelzle & Haeberli, 2004). Changes in snowpack and glacial extent may also alter the likelihood of snow and ice avalanches, depending on the complex interaction of surface geometry, precipitation and temperature (Haeberli & Burn, 2002; Martin et al., 2001). Also Glacial Lake Outburst Floods (GLOFS) are a risk in the Alpine region (Chiarle et al., 2007).

It is virtually certain that European mountain flora will undergo major changes due to climate change (Theurillat & Guisan, 2001; Walter et al., 2004). Change in snow cover distribution and growing season length should have much more pronounced effects than effects on metabolism (Grace, Berninger & Nagy, 2002; Körner, 2003). Overall trends are, as mentioned before, towards an increased growing season, earlier phenology and shifts of species distribution towards higher elevations (Egli et al., 2004; Körner, 2003; Kullman, 2002; Sandvik et al., 2004; Walther, 2004). Similar shifts in elevation are also documented for animal species (Hughes, 2000). The tree line is predicted to shift upward by several hundred metres (Badeck et al., 2001) and there is evidence that this process has already begun in the Mediterranean (Camarero & Gutiérrez, 2004; Peñuelas & Boada, 2003). These changes, together with the effect of abandonment of traditional alpine pastures, will restrict the alpine zone to higher elevations (Dirnböck, Dullinger & Grabherr, 2003; Grace, Berninger & Nagy, 2002; Guisan & Theurillat, 2001) severely threatening nival flora (Gottfried et al., 2002). The composition and structure of alpine and nival communities will change

(Guisan & Theurillat, 2000; Walther, 2004) and local plant species losses of up to 62% are projected for Mediterranean and Lusitanian mountains by the 2080s under the A1 scenario (Thuiller et al., 2005). Similar extreme impacts are expected for habitat and animal diversity as well, making mountain ecosystems among the most threatened in Europe.

3.2.4 *Forests*

In Italy, forest are very important for landscape, biodiversity, the balance of the environment and for the economy. They occupy about 10 million ha (30% of the national area). The increased aridity observed in central-southern Italy makes the Italian forests vulnerable to biotic and abiotic disturbances reducing their resistance and resilience. For example oaks, which account for 26.5% of national forests. In fact, an oak deterioration, usually associated with a twenty-year-long water stress, has been observed. (Clini, 2003). Furthermore, in Italy every year thousands of hectares are also destroyed or damaged by forest fires. In the past 20 years 1 100 000 ha of forest have been burnt in Italy. Every year an average of 11 000 fires occur, destroying more than 50 000 ha of wood each year. Fires at any given location are the result of complex interactions between forest biomass, topography, ignitions, uncontrolled land use (increasing agricultural expansion, environmental mismanagement, including lack of adequate fire control, excessive logging and overgrazing) and weather (Mickler, Earnhardt & Moore, 2002). In many areas of the world fires are a seasonal problem aggravated during years of drought (Quah & Johnston, 2001). The consequences for the natural balance are grave and the recovery time is long. Today, as a result of a strong awareness-raising campaign and thanks to improved organization of the regional and national fire prevention system, the risk, though still high, has decreased. The surface burnt decreased from 190 640 ha in 1985 to 76 427 in 2001. Half of the total of about 10 000 fires every year occurs during July and August. During the hot year of 2003, regions affected by the highest numbers of fires were Calabria and Campania in the south-west of Italy, and when referring to the largest surfaces affected by the fires the most affected regions were in Sicily and Sardinia.[10]

Fires also have impacts on human health: deaths are the tip of the iceberg – fires also cause injuries related to burns and smoke inhalation. Big fires are also accompanied by an increased number of patients seeking help from the emergency services, including health-care providers affected by smoke and ash in hospital ventilation systems (Hoyt & Gerhart, 2004). Furthermore, toxic gaseous and particulate air pollutants are released into the atmosphere which significantly contribute to acute and chronic illnesses of the respiratory system, in particular in children, such as increases in cases of pneumonia, upper respiratory diseases, asthma and chronic obstructive pulmonary disease (WHO, 2002). For Italy, however, no quantitative assessment of health effects resulting from fires is available.

3.2.5 *Agriculture*

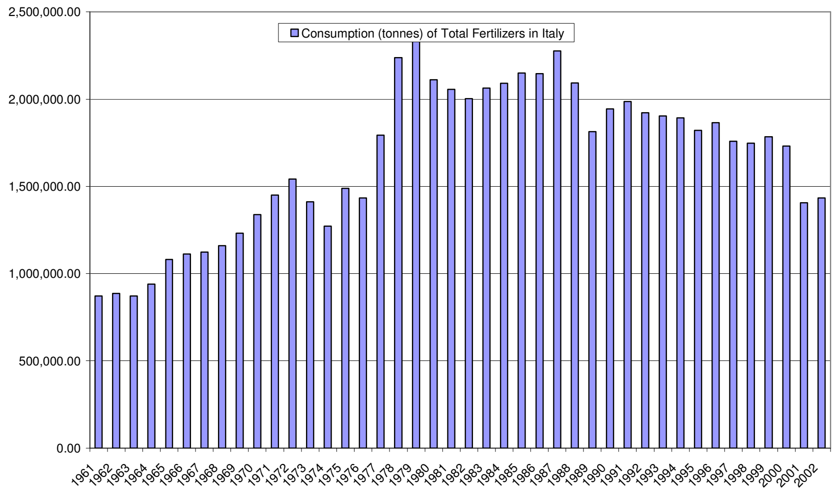
Both gradual climate change as well as extreme events have impacts on agriculture. Here the projected impacts in southern Europe are outlined. Climate change will modify processes on agricultural land, such as a decrease in nitrates leaching from the land (Olesen et al., 2006). Climate-related decreases in crop yields are expected in the Mediterranean and in the south-west Balkans (Maracchi, Sirotenko & Bindi, 2005; Olesen & Bindi, 2002). In southern Europe large decreases in yield are expected for spring-sown crops (e.g. maize, sunflower and soybeans) (Audsley et al., 2006) as well as for autumn-sown crops (e.g. winter and spring wheat) (Olesen et al., 2006; Santos, Forbes & Moita, 2002). In temperate climatic conditions, frosts, heat stress or prolonged drought events are the main weather hazards causing losses to agricultural crops and horticultural systems. The predicted increase in extreme weather events (e.g. spells of high

[10] Detailed information on forest fires in Italy available from APAT and also under http://www2.corpoforestaledellostato.it/portal/page/categoryItem?contentId=17198.

temperature and droughts) (Meehl & Tebaldi, 2004; Schar & Jendritzky, 2004) is expected to increase yield variability (Jones et al., 2003) and to reduce average yield (Trnka et al., 2004). In particular, in the European Mediterranean region increases in the frequency of extreme climate events during specific crop development stages (e.g. heat stress during flowering period, rainy days during sowing time), together with higher rainfall intensity and longer dry spells, is likely to reduce the yield of summer crops (e.g. sunflowers).

In addition to the effect of climate change on agriculture and soils, it also may interact with the use of pesticides and fertilizers in the environment. It may change the geographic range of pests and new plant pests might emerge, requiring an increase in currently used and new pesticides (see Figure 21). Furthermore, increased levels of ozone may lead to an increased tolerance to pesticides, leading to an increase in the amount of pesticides applied, with a series of negative effects. On the other hand, higher temperature can favour the degradation of pesticides. In addition, the altered pattern of rainfall and increased soil aridity could lead to an altered transport and persistence of pesticides. The extent and pattern of these changes in Italy need further investigation in view of the potential impact of this class of contaminants on human health.

Figure 21: Trend in the use of fertilizers in Italy



Source: FAOSTAT FAO Statistics Division 2006, 30 October 2006

Key messages

- Climate change may induce changes in air pollution concentrations, in particular an increase in ground-level ozone.
- Climate change is likely to have impacts on tourism: traditional beach resorts may become too hot in summer, and little snow in mountain sites may severely affect winter sport resorts.
- Energy demand might decrease in winter (from demand for heating) but will increase and peak in hot summers (from demand for cooling).

3.3 Urban environments and socioeconomic sectors

– Lorenzo Cecchi, Simone Orlandini, Francesco Forestiere, Marco Morabito

3.3.1 *Urban environments and air quality*

The impacts of climate change in urban areas concern, in principle, two main human health exposure factors. The first of these is the urban climate: everybody has noticed that, especially at night, temperatures are higher in urban areas compared to more rural surroundings. This is caused by many factors (e.g. lower wind speed, radiation, reflection, concrete mass, water balance) and is called the "urban heat island effect" (Gross, 1996, Jendritzky, 1993; Oke, 1997; Wagner, 1994). Increasing urbanization and associated changes in land use significantly modify the local and regional climate, but climate change could also exacerbate the urban heat island effect. The impacts of higher temperatures on health are explained in section 4.1. Certain weather patterns enhance the development of the urban heat island, whose intensity may be important for secondary reactions within the urban atmosphere, leading to elevated levels of some air pollutants (Jonsson et al., 2004; Junk, Helbig & Luers, 2003; Morris & Simmonds, 2000).

The second important impact of climate change in urban areas regards air pollution. Air pollutants arise from biomass burning, urban-industrial and natural sources (Jaffe et al., 2004; Jaffe et al., 2003; Koe, Arellano & McGregor, 2001; Moore et al., 2003; Murano et al., 2000). Under certain atmospheric circulation configurations, long-range or trans-boundary transport of pollutants, including aerosols, carbon monoxide, ozone, desert dust, mould spores and pesticide may occur over large distances and over time scales of typically four to six days (Ansmann et al., 2003; Buchanan, Beverland & Heal, 2002; Chan et al., 2002; Gangoiti et al., 2001; He et al., 2003; Helmis et al., 2003; Kato et al., 2004; Liang et al., 2004; Martin et al., 2002; Moore et al., 2003; Ryall et al., 2002; Shinn, Griffin & Seba, 2003; Stohl et al., 2001; Tu et al., 2004; Unsworth et al., 2003). Air pollution concentrations are the result of interaction among local weather patterns, atmospheric circulation features, wind, topography, human responses to weather changes (i.e., the onset of cold or warm spells may increase heating and cooling needs and therefore the requirement for electricity generation) and other factors (Hartley & Robinson, 2000). Thus, local conditions and emissions are more important than global concentrations of pollutants in determining human exposures. Some locations, because of their general climate and topographical setting, are predisposed to poor air quality because the climate is conducive to chemical reactions leading to the transformation of emissions, and the topography restricts the dispersion of pollutants (Kossmann & Sturman, 2004; Rappengluck et al., 2000). The state of the atmosphere at both the synoptic (large) and mesoscales determines the transport and diffusion of pollutants, with the passage of fronts, cyclonic and anticyclonic systems and their associated air masses of particular importance. Therefore, climate change also affects air pollution.

Some air pollutants demonstrate clear seasonal cycles (Eiguren-Fernandez et al., 2004; Hazenkamp-von Arx et al., 2004; Nagendra & Khare, 2003). Air quality is also influenced by variations in the physical and dynamic properties of the atmosphere on time scales from hours to days. The three-dimensional wind field, its related turbulence and vertical temperature are important for the dispersion, diffusion and deposit of pollutants (McGregor, 1999; Pal Arya, 2000). Meteorological conditions also influence the chemical and physical processes involved in the formation of secondary pollutants such as ozone (Nilsson, Paatero & Boy, 2001; Nilsson et al., 2001). Certain weather situations provide the requisite meteorological conditions for pollution episodes. Often air pollution events are associated with a stationary or slowly migrating anticyclonic or high-pressure system that reduces pollution dispersion and diffusion (Rao et al., 2003; Schichtel & Husar, 2001). Other high air pollution concentrations arise under other meteorological conditions. For example, airflow along the flanks of anticyclonic systems lying to the east or west of a location can transport ozone precursors, thus creating the conditions for an ozone event (Lennartson & Schwartz, 1999; Scott & Diab, 2000; Tanner & Law, 2002; Yarnal et al., 2001).

Background levels of pollutants on the global scale will moderate future air quality, especially at the local and also regional levels. For example, background levels of ozone have risen since pre-industrial times because of increasing emissions of methane, carbon monoxide and nitrogen oxides, and this trend is expected to continue over the next 50 years (Prather et al., 2003). As many major cities propose reducing vehicle-based emissions of pollutants, it is expected that urban levels of ozone will approach those of rural levels (Cifuentes et al., 2001; Metcalfe et al., 2002). For example, it has been estimated that for the United States, a 50% reduction of methane emissions would nearly halve the incidence of high ozone events (Fiore et al., 2002).

The expected trends in ozone have been supported by modelling studies designed to estimate the influence of the projected increase in emissions of methane, carbon monoxide and nitrogen oxides on the 2100 global distribution of ozone (Anderson, Derwent & Stedman, 2001; Derwent et al., 2001; Johnson et al., 2001; Stevenson et al., 2000). However, a major caveat of such studies is the uncertainty of future emissions (Syri et al., 2002; Webster et al., 2002). If 1990 is regarded as the reference period, then moderately high ozone concentrations of 60 ppb were found to be limited to central Europe, China, Brazil, South Africa, and eastern North America during summertime. By 2030, under the SRES A2 scenario, the area experiencing a background of 60 ppb was projected to expand significantly, especially in Europe and North America. By 2060, it was projected that most of the populated continental areas would experience ozone concentrations of at least 60 ppb. By 2100, much of the northern hemisphere was projected to have ozone levels of 60 ppb, as were most of the populated areas of the southern hemisphere (Anderson, Derwent & Stedman, 2001).

Assuming no change in the levels of ozone precursor emissions, the extent to which changing baseline levels of ozone are projected to have an impact on the frequency of "ozone episodes" will depend on the future occurrence of the requisite meteorological conditions (Jones & Davies, 2000; Laurila et al., 2004). Where climate change is predicted to result in an increased frequency of stable anticyclonic conditions with little boundary layer ventilation and associated high temperatures, cloud free conditions and large solar radiation inputs, it may be expected that exceedance of current air quality standards will likely occur (Hogrefe et al., 2004; Mickley et al., 2004). Taha (2001) estimated increases in ozone concentrations in two large cities in California based on model results that linked output from two global circulation models to future emission inventories and the air pollution models used to evaluate air quality compliance in these regions. Under assumptions of future controlled emissions, the modelling suggested significant increases in ozone concentrations in the Los Angeles Basin (up to 26 ppb, an approximate 24% increase) and in the Sacramento Valley (up to 12 ppb, an approximate 10% increase). Increases in peak ozone concentrations were smaller.

In comparison to ozone, assessments of the impact of climate change on other pollutants are few in number. However, these emphasize the role of local abatement strategies in determining the future levels of pollutants such as particulate matter (PM) and sulphur dioxide (Guttikunda et al., 2003; Jensen et al., 2001; Slanina & Zhang, 2004) and the need to make predictions of probability of exceedance as opposed to absolute concentrations (Hicks, 2003). Moreover, it is likely that the transboundary transport of pollutants will play a significant role in determining local to regional air quality and thus efforts to reduce the occurrence of critical exposures to health-damaging pollutants (Langmann, Bauer & Bey, 2003; Takemura et al., 2001). Accordingly, changing patterns of atmospheric circulation at the hemispheric to global level are likely to be equally important as regional patterns for future local air quality.

3.3.2 *Tourism*

Climate change is likely to have substantial impacts on tourism, especially regarding the choice of destination for seasonal activities. For example, traditional beach resorts may become too hot for summer holidays with a much higher frequency of severe climatic stress on tourists. On the other hand, insufficient snow precipitation on mountain sites may severely affect winter sport resorts.

Climatological scenarios were recently used in an Italian study (Morabito et al., 2004) to evaluate the future seasonal variations of extreme biometeorological discomfort (caused by hot and cold conditions) in three central Italian tourist sites: Florence, an important city for cultural and architectural tourism; Grosseto, a city involved in summer tourism and connected with environmental activities during all seasons, such as agro-tourism; and Monte Cimone, an important site for winter sports and mountain holidays in summer. The main results were a reduction of extreme discomfort caused by cold conditions with favourable winter thermal conditions for tourist activity. On the other hand, summer will show more frequent extreme discomfort conditions, especially in urban environments, with strong impact on summer tourist activities. These results confirm those pointed out by another study (Gawith, Downing & Karacostas, 1999) carried out in Thessaloniki, in northern Greece, which demonstrated that the temperature–humidity index will, by 2050, rise above a value where everyone feels uncomfortable, for more than twice as long as is presently the case. All these conditions are very dangerous for the health of tourists who tend to be more vulnerable than locals, as they are not acclimatized to the place they are visiting (de Freitas, 2003). If summer becomes warmer and/or drier, tourists might suffer great discomfort and health risks related to heat as outlined in section 4.1.

Tourism activity peaks in summer, coinciding with the time when natural water availability is at its lowest and this creates significant pressures on existing natural water resources (Karavitis & Kerkides, 2002) that lead to an increasing seasonal water deficit. The impact of global change on water quantity and quality is mainly observed in lakes and small islands. Hungarian researchers (Rátz & Vizi, 2004) showed the effects on tourism caused by the continuous decrease of water quantity during recent years in two important European lakes (Lake Balaton and Lake Tisza). Low water quantity allows algae to grow faster, mostly due to increased light and higher temperature, leading to poorer water quality. In small islands of the Mediterranean basin the groundwater is, in most cases, adequate to cover household demand, but this is only a small fraction of the peak summer demand. The timing of Mediterranean rainfall does not usually coincide with the time of major water demand. In this way tourism will make a major contribution to the degradation and destruction of water ecosystems. The availability of water supply could become a major constraint and the quantity and quality of water available may not be sufficient to satisfy future tourist demands. Large-scale expenditure on desalinization plants will be needed, especially in some island resorts if water supplies are to be guaranteed.

There is evidence that the drought of the early 1990s could make Mediterranean islands dependent on water being transported from the mainland with attendant political tensions (Wheeler, 1995). Small Mediterranean islands could be particularly affected if tourism is allowed to continue to grow. Several authors (Nicholls, Hoozemans & Marchand, 1999) have shown that in the Mediterranean area there are about 160 islands exceeding 10 square kilometres in size. Most have a low water resource base but significant tourist development. As a consequence of climate change, in the coming years a decline in rainfall (especially in the south of Italy) and water supply availability has been forecast, and, together with beach erosion, this could undermine their tourist industries and hence their local economies. For this reason, particularly in the vulnerable system of small islands, more effort should be addressed to finding water supply models linked to sustainable environmental policy options. The very short duration of peak demand for water has, in most cases, prohibited the development of solutions that require significant investment costs, such as desalination plants and surface storage reservoirs. However, in rapidly changing climatic conditions that could exacerbate shortfalls of water, new research needs to adopt innovative practice and solutions both for the supply and demand of the water system (Hofwagen van & Jaspers, 1999). In a study carried out for a small Mediterranean island (Voivontas et al., 2003) researchers have developed an optimization model for the identification of the lowest cost water sources able to cover the anticipated demand for water, with a long-term planning horizon until the year 2030. This model is able to estimate monthly water production as well as water supply cost. In many small islands traditional water supply options will become predominant, including water transfers from the mainland during the peak demand period, although this represents by far the most expensive solution owing to the high transportation cost.

The Italian study (Morabito et al., 2004) showed that tourists who visit cities in Tuscany during the seasons of transition, such as spring and autumn, generally characterized by mild weather, will more often find extreme and unexpectedly hot conditions. Several authors (Palutikof, Agnew & Hoar, 2004), in a recent preliminary study, have shown that the decisions of tourists are affected by weather fluctuations, especially with regard to short breaks in spring and autumn. Moreover, the autumn season, because mountain sites will experience an increasing number of days of precipitation, will be favourable for tourists who practise winter sports. On the other hand, the reduction in spring precipitation will anticipate the dry and hot summer season.

Further research is needed to quantify the climatic well-being of tourists by developing tourism climatic indices and beach comfort indices, which can be calibrated to include the effects of climate change. These surveys will be fundamental for the identification and evaluation of environmental information for business planning and decision making in the recreation and tourism industry (de Freitas, 2003).

3.3.3 *Energy consumption*

It is important that the implications of changing temperature regimes on heating and cooling needs are considered when looking for alternative energy sources. In the Mediterranean, by 2050, the need to heat homes will decrease by two to three weeks, but there will be a need for cooling for an additional two to three weeks along the coast and up to five weeks in inland areas (Giannakopoulos & Psiloglou, 2006). Cartalis et al. (2001) estimated an up to 10% decrease in energy heating requirements and an up to 28% increase in cooling requirements in 2030 for the south-east Mediterranean region. Summer cooling needs will particularly affect electricity demand (Giannakopoulos & Psiloglou, 2006; Valor, Meneu & Caselles, 2001) with up to 50% increases in Italy and Spain by the 2080s (Livermore, 2005). Peaks in electricity demand during summer heat-waves are very likely to equal or exceed peaks in demand during cold winter periods in Spain (López-Zafra, Sánchez de Tembleque & Meneu, 2005). At the same time the key renewable energy sources in Europe are currently hydropower (19.8% of the electricity generated) and wind. The shift to other renewable energy sources is important. More solar energy will be available in the Mediterranean region (Santos, Forbes & Moita, 2002) and the promotion of solar energy use has finally started in Italy in February 2007 (see www.casarinnovabile.it).

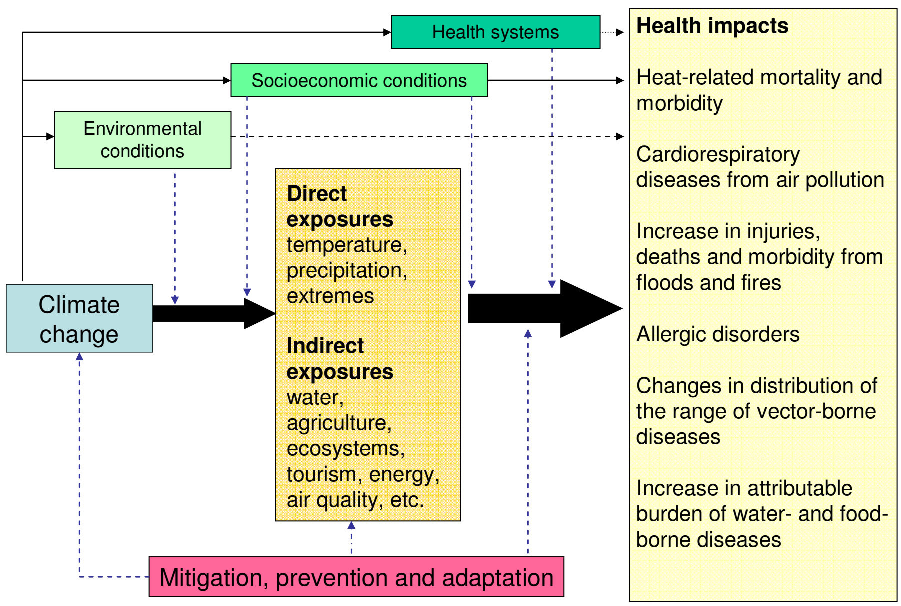
Regarding traditional energy sources, climate change could have a negative impact on the efficiency of thermal power production plants because water withdrawn for power plant cooling is expected to be somewhat warmer on average (Hansen, 2006). Furthermore, the availability of cooling water may be reduced at some locations in Europe because of climate-related decreases (Arnell et al., 2005) or seasonal shifts (Zierl & Bugmann, 2005) in river run-off. The distribution of energy is also vulnerable to climate change (Thomas, 2002). There is a small increase in transmission resistance with increasing mean temperatures (Santos, Forbes & Moita, 2002) coupled with negative effects on line sag and gas pipeline compressors' efficiency due to higher maximum temperatures (Colombo, Etkin & Karney, 1999; López-Zafra, Sánchez de Tembleque & Meneu, 2005). All these combined effects add to the overall uncertainty regarding the impacts of climate change on power grids.

4. Observed and projected health impacts of climate change and variability in Italy

As outlined in earlier chapters, Italy will likely face various changes in the climate system as well as changes in sectors and economic activities. These may present additional risks to human health, or enhance the present risks to human health. As in the earlier chapters, it can be concluded that people's health might be more exposed to:

- general warming of the Mediterranean, lakes and air masses;
- a decrease in mean precipitation but an increase in frequency of extreme precipitation (increased risk of floods);
- an increase in the frequency of hot and tropical days;
- a decrease in the number of cold/frost days;
- sea level rise (risk of sea flooding and salinization);
- decreases in water supply with associated higher costs and changes in water provision practices (wastewater reuse, desalinization etc.);
- increased risk of growth of algae and cyanobacteria in lakes and sea, in particular in late summer;
- increased risk of plant pests and associated changes in agricultural practices;
- lengthening and anticipation of plant flowering season with potential earlier arrival of some allergenic species, as well as changes in abundance of pollen types;
- changes in air pollution concentrations and air quality;
- prolonged persistence of ozone depleting substances, with a delay in the ozone hole repair and thus continuation of increased solar radiation reaching Earth's surface (although effects depend on many factors).

Figure 22: Pathways of health impacts of climate change



Source: adapted from Confalonieri et al., 2007

Figure 22 shows the observed and potential health impacts of climate change. Climate and weather represent important elements of the environment where human beings continuously adapt or acclimatize themselves to maintain healthy conditions.

The assessment of the literature on observed and potential impacts of climate variability and change in Italy found a paucity of information overall. Most of the studies available are on heat-waves, air pollution and health. For other climate-related health outcomes only general trends can be described and hypotheses developed; where applicable global scenarios were applied to Italy.

4.1 Heat and health

— by Paola Michelozzi, Francesca de Donato and Ursula Kirchmayer

> Key messages
>
> - In Mediterranean cities an average increase of 3% in daily mortality related to 1°C increase of apparent maximum temperature has been estimated.
> - Excess mortality from heat increases with age.
> - In Italy, heat-waves cause an average of 20–30% increase in daily mortality in the population over 75 years of age.
> - Prevention measures tailored to the high risk population can reduce the impacts on a short-term basis.
> - Long-term preventive actions, such as improved energy efficient housing are essential.
> - Public health preventive efforts are effective and could be further strengthened.

The association between temperature and mortality is typically described by a non-linear U-, J- or V-shaped function, with the lowest mortality rates recorded at moderate temperatures, rising progressively as temperatures increase or decrease (Curriero et al., 2002; Huynen et al., 2001; Kunst, Looman & Mackenbach, 1993). Different studies have provided evidence of the heterogeneity of the temperature-mortality relationship among different populations and settings.

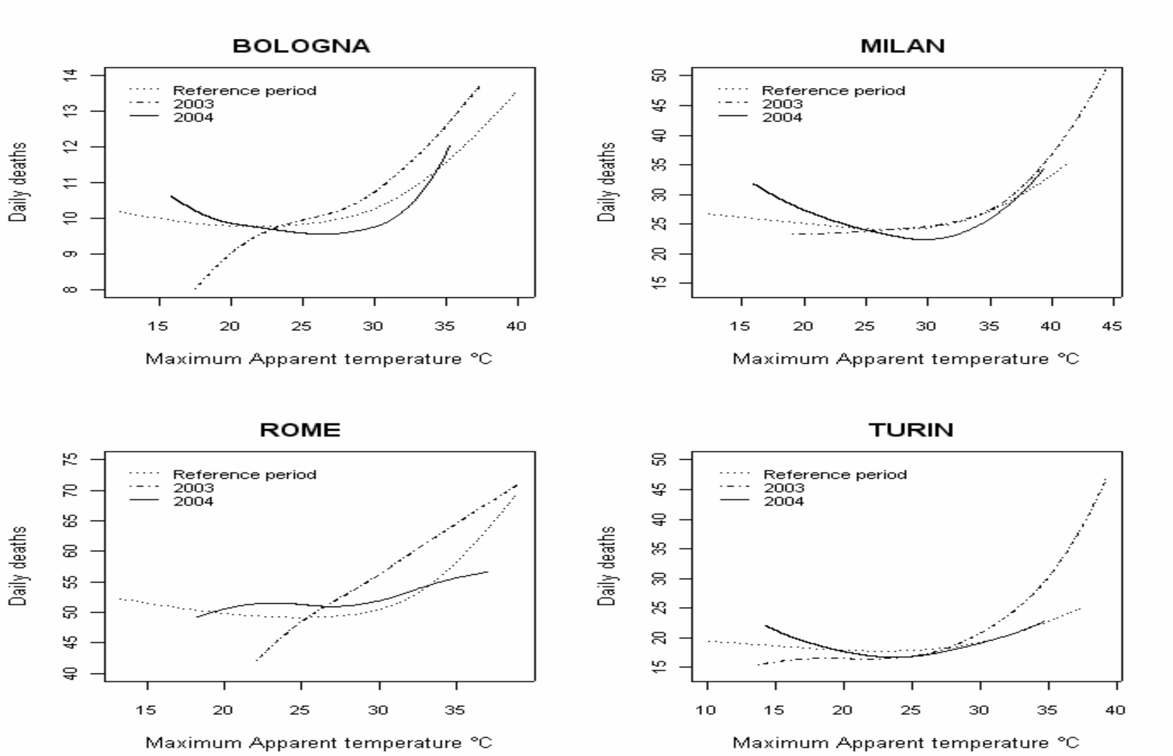
Geographical variations of the temperature–mortality curve have been documented in studies from the United States, Europe and other countries. A European collaborative study (Keatinge et al., 2000) and two multicity studies from the United States (Braga, Zanobetti & Schwartz, 2002; Curriero et al., 2002) suggest that at low latitudes populations are more adapted to high temperatures. Among the European countries, the minimum mortality is around a mean temperature of 16.5ºC in the Netherlands (Kunst, Looman & Mackenbach, 1993), 19ºC in London, United Kingdom (Haines, 2001), 23ºC in Valencia, Spain (Ballester et al., 1997) and 24°C in Rome, Italy (Michelozzi et al., 2000a).

A recently concluded European Union funded project on the "Assessment and prevention of acute health effects of weather conditions in Europe" (PHEWE), which involved 16 European cities (Athens, Barcelona, Budapest, Dublin, Helsinki, Krakow, Ljubljana, London, Milan, Paris, Prague, Rome, Stockholm, Turin, Valencia and Zurich) investigated the acute health effects of weather during the warm and cold seasons and provided further insights into the geographical heterogeneity of the relationship between temperature and mortality. An association between maximum apparent temperature and all-cause mortality in the summer season was detected in all cities, with a stronger effect in the Mediterranean area. The threshold level above which mortality increases showed a great heterogeneity, especially among Mediterranean cities. For the Italian cities, the estimated thresholds are 31.8°C in Milan, 30.3°C in Rome and 27°C in Turin. The temperature effect was found to be higher during the first period of summer. Some "harvesting" of up to 30 days was detected in Mediterranean cities (Biggeri et al., 2006). This "anticipation" of death in some population groups has also been documented in other studies

(Braga, Zanobetti & Schwartz et al., 2001; Huynen at al., 2001; Hajat et al., 2002; Kysely, 2005; Biggeri et al., 2006).

In Italy, a recent study conducted in the four Italian cities of Bologna, Milan, Rome and Turin, analysed the relationship between maximum apparent temperature and mortality during summer (June–September) in 2003, 2004 and in a previous reference period (Michelozzi et al., 2005a, 2005b). Results from this study show that during the summer of 2003 a dramatic increase in mortality was observed in the four Italian cities during the heat-wave. Figure 23 shows for 2003, compared to the other years, a change in the relation of temperature and mortality with a steeper J-shaped curve in Milan and Turin and a linear relationship in Bologna and Rome. In the summer of 2004, the Tappmax (maximum apparent temperature) mortality curves had a less steep right-hand slope. The effect of temperature on mortality was lower than in 2003 in all cities and the reduction occurred heterogeneously. Furthermore, the effect in 2004 was somewhat weaker than during the reference period in Bologna, Milan and Rome, while in Turin a similar reduction was not observed.

Figure 23: Temperature–mortality relationship in four Italian cities



Source: Michelozzi et al., 2005a

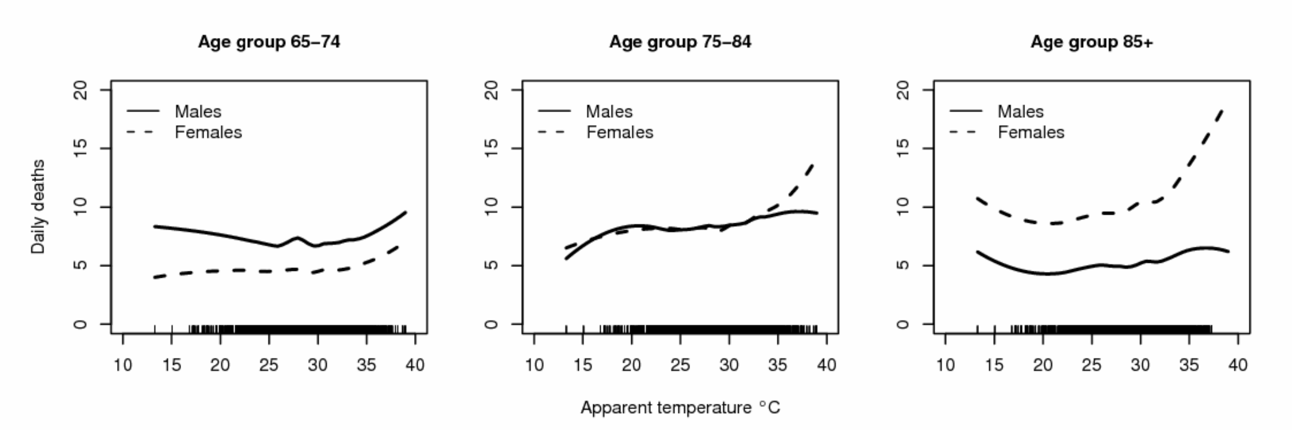
In Rome a recent study used the time series approach to describe the temperature–mortality relationship during the summer period (June–September) from 1995 to 2004 by age groups (65–74, 75–84 and >84 years old) and gender (Marino el al., 2006). Table 4 shows percentage change in daily mortality for an increase of 1°C of maximum apparent temperature below and above the threshold (31.9°C) in Rome during the summer period for 1995–2004. Above the threshold value the effects are stronger for females, especially in the old (75–84 years) and very old (over 85 years). An increase in mortality was also observed for temperatures below the threshold value in both very old females and males. Visual interpretation indicates differences by age and gender both in the strength of the relationship and in the shape of the curves (Figure 24).

Table 4: Change in daily mortality in Rome for a 1°C increase in temperature

Gender	Age group	Below threshold (95%CI)	Above threshold	Percentage increase in mortality (%)	(95%CI)
Male	65–74	-0.60	(-1.37, 0.17)	4.21	(1.95, 6.51)
	75–84	0.16	(-1.73, 2.10)	1.79	(1.06, 2.53)
	85+	1.58	(0.66, 2.51)	4.25	(1.55, 7.03)
Female	65–74	-0.02	(-0.88, 0.86)	5.19	(1.68, 8.81)
	75–84	0.45	(-0.31, 1.22)	5.73	(3.91, 7.59)
	85+	1.69	(1.05, 2.33)	9.09	(7.01, 11.21)

Source: Michelozzi et al., 2005a

Figure 24: Temperature–mortality relationship by gender and age group in Rome



Source: Michelozzi et al., 2005b

Descriptive analyses of individual heat-wave events have suggested that hot weather predominantly affects people with limited adaptive responses living in urban areas (Rooney et al., 1998; Smoyer, 1998), the elderly (Basu & Samet, 2002; Diaz et al., 2002), small children (Basu & Samet, 2002), people who live in deprived areas (Michelozzi et al., 2004b), the socially isolated (Naughton et al., 2002; Semenza et al., 1996) and also people who are chronically ill, for instance those with cardiovascular, respiratory and cerebrovascular diseases (Ballester et al., 1997; Braga, Zanobetti & Schwartz, 2002; Diaz et al., 2002;. Hajat et al., 2002; Huynen et al., 2001; Kunst, Looman & Mackenbach, 1993; Michelozzi et al., 2005a; Schwartz, 2005).

A case-crossover analysis carried out in four Italian cities identified some clinical conditions which increase the risk of dying during hot days; among them are psychiatric disorders, depression, heart disease and circulation problems, whereas a lower socioeconomic level has been found to be a weak modifier of risk. In the city analysis, diabetes and obesity have been found to be additional conditions that increase vulnerability (Stafoggia et al., 2006).

While all studies confirm age as an important modifier of the effect on mortality, the role of gender in influencing the risk of dying during heat-waves is more controversial. Several studies have shown a higher risk among women (Albertoni et al., 1984; Kysely, 2005; Michelozzi et al., 2004a, 2005a; Rooney et al., 1998; Stafoggia et al., 2006) which increases with age (Alberdi et al., 1998; Albertoni et al., 1984; Diaz et al., 2002; Michelozzi et al., 2005b). On the other hand, other studies have reported higher death rates among men (CDC, 1995; Marmor, 1978; Merchandani et al., 1993) or no gender differential (O'Neill, Zanobetti & Schwartz, 2003; Yan, 2000).

Few studies have analysed the effect of temperature on morbidity indicators. A study of 12 American cities (Schwartz, Samet & Patz, 2004) showed an increase in hospital admissions for heart diseases in response to hot weather. In the PHEWE project, increases in apparent maximum temperature were not associated with an increase in hospital admissions for cardiovascular and cerebrovascular causes in all age groups, while a weak effect was observed on hospital admissions for respiratory causes, especially in the age group over 75 years of age (Michelozzi et al., 2006).

The impact of heat on hospital admissions is, however, much weaker than the effect observed on mortality and this can be attributable to the fact people die before they reach medical attention.

Episodes of extreme temperature, the so-called heat-waves, have a specific impact on human health. Heat-waves have been documented for Europe since the 1970s. In Italy, the first well-documented episode occurred in 1983 in Rome (Albertoni et al., 1984) (Table 5). The heat-wave of 2003 presents the most dramatic event documented in Europe, causing probably more than 40 000 excess deaths. It remains, however, difficult to estimate the exact number of deaths due to the different methods applied in the affected countries.

The heat-wave of 2003 highlighted that Europe was not prepared to predict, detect and prevent the health impacts of heat-waves, nor did it expect a heat-wave of such magnitude to occur. Since the dramatic death toll of the 2003 heat-wave in Europe some effort has been directed towards the prevention of health impacts and research into the health impacts of heat. Generally it has to be considered that in the light of future climate change scenarios, the frequency and intensity of heat-waves is going to increase and may also occur in regions which usually are not prone to extreme heat in summer. The increase in mortality during episodes of extremely high temperature is a recurring phenomenon, but the estimated number of excess deaths related to these events depends very much on the definitions used and the characteristics of the event in terms of intensity and duration.

Table 5: Estimation of excess deaths in Europe during heat-waves

Place	Heat-wave event	Excess mortality (all causes)	References
Rome	1983	35% increase in deaths in July 1983 in the over 65+ age group.	Albertoni et al., 1984
Italy (21 capital cities)	2003 1 June – 15 August	General increase of 21.3% in the over 75 years age group, most significant increase in Turin (44.9%), Trento (35.2%), Milan (30.6%), Genoa (22.2%).	Conti et al., 2004
Bologna, Milan, Rome, Turin	2003	Increase by 33% in Turin, 23% in Milan, 19% in Rome, 14% in Bologna, with highest impacts in age groups 75 to 84 years and over 85 years.	Michelozzi et al., 2005a
Milan, Rome, Turin	2003	Strongest impact in age group 75 to 84 years related to diseases of the central nervous system, cardiovascular, respiratory, metabolic diseases, psychological disorders and at low socioeconomic levels.	Michelozzi et al., 2005b
EuroHEAT project: nine European cities, including Milan and Rome	1987–2004	Increase among men: 24.7% in Rome, 37.3% in Milan; increase among women: 32.2% in Rome, 40.9% in Milan. The effect was stronger for intense heat-waves and for those of a long duration.	Michelozzi et al., 2007

In Italy, several studies have evaluated the impact of the 2003 heat-wave: a national study in the Italian provinces (Conti et al., 2005), a study focusing on the causes of mortality in Milan, Rome and Turin (Michelozzi et al., 2005b) and a case-crossover analysis in the same cities with the aim of identifying individual risk factors associated with heat (Stafoggia et al., 2006).

During the three summer months of June, July and August of 2003, extremely high temperatures and humidity values were registered for prolonged periods of time causing a dramatic increase in mortality, especially among the elderly. The correlation between mortality and discomfort due to climate conditions on the one hand, and the short time lag between the onset of these weather conditions and the occurrence of an excess number of deaths on the other, gives clear information for public health intervention.

The Office of Statistics of the Istituto Superiore di Sanità assessed mortality in the 21 capitals of the provinces between 1 June and 31 August 2003. Compared to the summer of 2002, an excess of 3134 deaths was estimated. The highest increase was observed in people over 75 years old. The increase in mortality was not homogeneous. In terms of the spatial distribution, the highest increase was observed in the north-west, especially in Turin (44.9%), Trento (35.2%), Milan (30.6%) and Genoa (22.2%). The percentage values were higher in the most populated cities (39.8% for those cities with more than 500 000 inhabitants) and lower for the smaller towns (13.8% for towns with a population equal or less than 100 000 inhabitants and 29.2% for towns with a population of 100 001 up to 500 000 inhabitants) (Table 6).

One study (Conti et al., 2005) has analysed the impact of heat-waves on cause-specific mortality and the role of demographic characteristics and socioeconomic conditions that may have increased the risk of mortality during the 2003 summer (1 June – 31 August) heat-wave in Rome, Milan and Turin (Table 6). The analyses of cause-specific mortality illustrated how the greatest excess in mortality was observed for the central nervous system, cardiovascular, respiratory diseases, metabolic/endocrine gland and psychological illnesses (Table 7).

Table 6: Mortality in 2003 compared to 2002 in the 21 capitals during the summer period

City	All ages			75 years and older		
	2002	**2003**	**Difference (%)**	**2002**	**2003**	**Difference (%)**
Turin	1 780	3 241	31.5	1 134	1 643	44.9
Aosta	96	101	5.2	59	70	18.6
Genoa	1 829	2 136	16.8	1 295	1 575	22.2
Milan	2 438	2 953	21.1	1 612	2 105	30.6
Northwestern capitals	**6 143**	**7 531**	**22.6**	**4 100**	**5 393**	**31.5**
Trento	168	223	32.7	122	165	35.2
Bolzano	196	251	28.1	135	156	15.6
Venice	706	763	8.1	491	541	10.2
Trieste	795	835	5.0	571	606	6.1
Bologna	968	1 144	18.2	698	880	26.1
Northeastern capitals	**2 833**	**3 216**	**13.5**	**2 017**	**2 348**	**16.4**
Northern capitals	**8 976**	**10 747**	**19.7**	**6 117**	**7 741**	**26.5**
Ancona	271	309	14.0	187	227	21.4
Florence	941	1 015	7.9	707	790	11.7
Perugia	33	368	10.8	229	268	17.03
Rome	5 246	5 849	11.5	3 344	3 899	16.9
Central capitals	**6 790**	**7 541**	**11.1**	**4 457**	**5 184**	**16.3**
Naples	2 033	2 339	15.1	1 231	1 458	18.4
L'Aquila	125	138	10.4	77	96	24.7
Campobasso	71	78	9.9	42	54	28.6
Bari	535	675	26.2	340	455	33.8
Potenza	109	122	11.9	63	79	25.4
Catanzaro	135	142	5.2	86	76	11.6
Palermo	1 469	1 558	6.1	896	1 010	12.7
Cagliari	321	358	11.5	208	240	15.4
Southern capitals	**4 798**	**5 410**	**12.8**	**2 943**	**3 468**	**17.8**
All Italian capitals	20 564	23 698	15.2	13 517	16 393	21.3

A recent study called EuroHEAT, funded by the European Commission and coordinated by WHO, has estimated the effect of heat-waves in nine European cities (Athens, Barcelona, Budapest, London, Milan, Munich, Paris, Rome and Valencia) evaluating the heat-wave impact for several characteristics (intensity, duration, season) (Michelozzi et al., 2007). The health impact expressed as an increase in daily mortality during heat-waves ranges for males from 8% in London and 37% in Milan and for females from 8% in Munich to 40.9% in Milan. Comparing the results of analysis using different approaches to define heat-waves, the increase in risk is most prominent when the following meteorological parameters are considered in the heat-wave definition: maximum and minimum temperature and relative humidity. Examining the characteristics of the heat-wave regarding duration and intensity, it has been found that the effects are two to five times stronger for long heat-waves (more than 4–5 days) compared to shorter episodes.

Table 7: Mortality by cause of death in three Italian cities in summer 2003

Causes of death	Rome				Milan				Turin			
	Observed	Expected	Excess	%	Observed	Expected	Excess	%	Observed	Expected	Excess	%
Tumours	1921	1779	142	**8**	926	935	-9	**-1**	656	639	17	**3**
Circulatory	2328	1876	452	**24**	1044	832	212	**25**	892	631	261	**41**
Respiratory	327	236	91	**38**	282	155	127	**82**	201	128	73	**57**
Digestive System	227	253	-26	**-10**	121	103	18	**17**	97	85	12	**14**
Genitourinary	81	63	18	**29**	57	41	16	**39**	40	27	13	**48**
Mentabolic/disorders	307	247	60	**24**	111	66	45	**68**	103	42	61	**145**
Psychological illnesses	96	57	39	**70**	38	34	4	**12**	70	42	28	**67**
Central Nervous system	254	137	117	**86**	133	61	72	**118**	85	38	47	**124**
All causes	6009	5065	944	**19**	2968	2409	559	**23**	2332	1755	577	**33**

Some studies have indicated that the effects of heat-waves are more evident at the beginning of summer when vulnerable people have had little time to get used to the higher temperatures (Smoyer, 1998; Diaz et al., 2002; Hajat et al., 2002; Kyseley, 2004).

The impact of heat on health is a consequence of the levels of exposure, of the vulnerability of individuals and of their ability to cope with extreme temperatures (McCarthy et al., 2001). Demographic and social factors, as well as the level of urbanization, air pollution and the efficiency of social services and health-care units represent important local modifiers of the impact of heat-waves on health.

Several authors suggest that an effective heat response plan has to be based on a city-specific alarm system (Heat/Health Watch Warning System – HHWWS) which allows the forecasting of heat-waves and the expected health impacts in the population sufficiently early to allow interventions (Ebi, Teisburg & Kalkstein, 2004; Menne & Bertollini, 2005; Michelozzi et al., 2006). These integrated systems including specific prevention measures, tailored to the most vulnerable population groups, are able to reduce the impacts on population health. However, these interventions have to be based on the identification of high risk populations (*anagrafe dei suscettibili*), an efficient forecasting and alarm tool (HHWWS) and the identification of efficient prevention measures.

With regards to the long-term variations, different studies have shown a general decline in summer mortality which was explained by changes in adaptation strategies, such as the increased use of air conditioning and public health interventions (Davis et al., 2003; Donaldson, Keatinge & Nayha, 2003; Smoyer et al., 2000; Smoyer, Rainham & Hewko, 2000). A decline in heat-related mortality was also observed in studies comparing heat-wave episodes in different years; authors suggest that apart from the difference in exposure, this decline can be attributable to the variation in individual adaptation (Smoyer, 1998; Weisskopf et al., 2002).

As for future estimations, the IPCC fourth assessment report states that heat-related morbidity and mortality are projected to increase. The recent PESETA study estimated that in Europe more than 70 000 people could be dying annually in 2070 because of heat-waves if no preventive action is taken. Estimates of the burden of heat-related mortality attributable to climate change are reduced but not eliminated when assumptions about acclimatization and adaptation are included in models. On the other hand, increasing numbers of older adults will increase the size of the population at risk because a decreased ability to thermoregulate is a normal part of the ageing process. Overall, the health burden could be relatively small for moderate heat-waves in temperate countries because deaths occur primarily in susceptible persons (Confalonieri et al, 2007).

4.2 Cold and health

– by Paola Michelozzi, Francesca de Donato and Ursula Kirchmayer

Key message

- While Italy could theoretically experience a slight reduction in winter mortality; the extent of any reduction is unknown and very much depends on other socioeconomic and health-care factors.

Cold temperatures have been related to increases in mortality during winter in a number of studies in Europe (Alberdi et al., 1998; Carder et al., 2005; Diaz, Julio et al., 2005; Donaldson & Keatinge, 1997; Eurowinter Group, 1997; Huynen et al., 2001; Pattenden, Nikiforov & Armstrong, 2003; Wilkinson et al., 2004). Some diseases have been found to be associated to cold-related death. First of all, ischaemic heart disease can be considered the leading specific cause of excess mortality during winter, accounting for approximately half of all the excess deaths (Mackenbach, Kunst & Looman, 1992; Mercer, 2003). Then, cold stress has also been associated with an increase of cerebrovascular deaths (Donaldson & Keatinge, 1997; Eurowinter Group, 1997; Gemmell et al., 2000; Gorjanc et al., 1999) and the association was somewhat similar to that found for coronary heart disease. Finally, there is some evidence that the contribution of respiratory deaths to winter excess mortality is lower in comparison with cardiovascular diseases (Mackenbach, Kunst & Looman, 1992; Mercer, 2003), but their importance should not be underestimated since several studies have documented a significant effect of cold on these causes of death.

In the PHEWE project, the analysis of the effect of apparent temperature on mortality in the winter season showed a linear relationship with a negative slope. A decrease of apparent temperature by 1°C was associated with an increase in daily total mortality of 1%, which was stronger when analysing cardiovascular and respiratory causes of death. Between cities a significant heterogeneity was observed and a delay in the effect of up to 20 days was detected (Analitis et al., 2006). In the hospital admission analysis, cardiovascular causes showed a weak association with a decrease in Tappmax only for the 65–74 and 75+ age groups. City-specific results for cardiovascular admissions showed a significant effect only in Barcelona (all ages and 75+ age group), Budapest (all age groups considered) and London (all ages and 75+ age group). Cerebrovascular causes were not associated with a decrease in temperature in most cities; city-specific results showed a significant association only in Barcelona (75+ age group) and Budapest (all ages and 75+ age group). A linear, negative relationship was observed between winter temperatures and respiratory admissions. A significant effect was observed on respiratory admissions in all age groups in Budapest, Dublin, London, Paris, Rome, Stockholm and Valencia, while for Barcelona and Milan only for the total and the 75+ age group. It is worth noting a certain degree of heterogeneity between city-specific estimates for all the three outcomes.

Pooled results show a significant increase in hospital admission counts for a decrease in 1°C in Tappmax for cardiovascular causes in the 65–74 and 75+ age groups in all cities and only in the 75+ age group in northern/continental cities. Overall, no effect of low temperature was found for cerebrovascular admissions in all three groups of cities. With regards to respiratory admissions, a significant association with temperature was observed for all the age groups considered, even if higher in the 75+ age group in all cities as well as in continental/northern cities. In Mediterranean cities the only significant association was found in the 75+ age group (Michelozzi et al., 2006). In Italy, where extensive literature on the impact of heat and heat-waves on health is available, as outlined in section 4.1, there is limited evidence on the impact of cold. Therefore, little information on this topic can be provided here.

As stated in the IPCC fourth assessment report, cold days, cold nights and frost days have become rarer and explain only a small part of this reduction in winter mortality. Improved home heating, better general health and improved prevention and treatment of winter infections have played a more significant role (Carson et al., 2006). The sum of the reduction of cold-related mortality and heat-related mortality increases is unknown, and ultimately they cannot be compared with each other.

4.3 Flooding and health

– by Enzo Funari, Monica Francesca Blasi, Mario Carere, Valentina Della Bella, Laura Mancini, Stefania Marcheggiani, Francesco Mattera, Mara Stefanelli

Key messages

- Precipitation intensity could be increasing in Italy.
- Floods affect the sanitation service and are a social problem.
- In Italy more studies are needed to quantify the health impact of floods.

Floods can kill people and cause direct or indirect diseases. They can damage the environment, infrastructures and property. The frequency of great floods increased during the 20th century, although the total impact on mortality reduced significantly over the recent decades. Impacts can be short-term and long-term. In terms of loss of human lives, most of the alluvial events examined caused more than 10 deaths each and 5 of the events described caused more than 100 deaths each; this is especially true in the context of international disaster reporting (EM-DAT & Université Catholique de Louvain, 2007). The consequences of flooding were not always related to the intensity of meteorological events; other factors such as land-use, the anthropogenic pressures and the effectiveness of the structures of alerts and forecasting played an important role as well. Most of the flooding occurred in the autumn season.

It is generally recognized that high precipitation increases the density of microbiological agents in surface water and consequently the risk associated with its use (Eisenreich, 2005). For example, the incidence of gastrointestinal symptoms increased during floods in the United States (Wade et al., 2004) and there was a statistically significant association between rainfall and waterborne diseases from 1948 to 1994, as a result of surface water contamination (Curriero et al., 2001). Outbreaks of cryptosporidiosis, giardiasis, campylobacteriosis and other infections in the United Kingdom and United States were triggered by heavy rainfall events (Atherton, Newman & Casemore, 1995; Lisle & Rose, 1995; Rose et al., 2001). A limited number of short-term epidemiological studies have been undertaken to assess the health impacts of flooding, but there are not many studies of long-term health and economic impacts. Floods can also increase the chemical risk; in fact they have the capacity to re-mobilize and re-distribute large amounts of contaminants and cause the overflow of toxic waste sites (Eisenreich, 2005).

The adverse effects on human health can be summarized as follows:

- trauma deaths, mainly by drowning;
- injuries;
- enteric infections due to increased density of pathogenic micro-organisms in surface waters because of enhanced run-off of microbial pathogens from manure in the land, overburden of water treatment facilities and sewage systems, spill-overs of raw sewage and animal waste from farms, more re-suspension of pathogenic micro-organisms from sediments, shorter residence times hence less time for pathogen inactivation;
- groundwater contamination, resulting from an increase in wastewater leaking from sewage pipes or septic tanks;
- mental health problems such as post-traumatic stress disorder;
- vector-borne disease;
- rodent-borne disease, such as leptospirosis;
- poisoning caused by toxic substances;
- snake bites, as snakes tend to seek shelter in households to escape from flooding;
- the growth of moulds and spores in the aftermath of floods;
- other negative health outcomes, such as disruption of health-care services and population displacement.

Floods also represent a massive social problem: in 2003 the number of people involved with flood events in Italy was 319 900 and the resources needed for damage repair activities were estimated to be more than € 2180 million.

In the future and under conditions of a changing climate, an increasing intensity of heavy rainfall is likely to make extreme floods more frequent. The number of deaths can be particularly high during sudden flash floods. Flood events might cause increases in physical (e.g. injuries) as well as mental (stress and depression) disorders. Water- and foodborne diseases could increase under a changing climate, particularly when water availability decreases and high temperatures affect the quality of food.

There is a paucity of information available on how many people have died or been injured in natural disasters in Italy. According to the EM-DAT database almost 140 000 people have died in natural disasters since 1905. In order for a disaster to be entered into the database at least one of the following criteria has to be fulfilled: 10 or more people reported killed, 100 people reported affected, a call for international assistance and/or the declaration of a state of emergency. The entry criteria for the EM-DAT database ensure a good global overview of disasters. For a national analysis, however, the criteria are far too restrictive. Alternative sources reveal that between 1991 and 2001, about 12 000 landslides and more than 1000 floods occurred in Italy. Only the major flooding events in 2003 have affected more than 300 000 people and caused economic damage of more than € 2 million. Besides these, there were many smaller flooding events which damage agricultural areas and urban areas, causing significant damage but no human victims.

4.4 Air quality and health

– by Francesco Forestiere

Key messages

- Climate change may aggravate the effects of air pollution by:
  - – increased frequency and duration of extreme ozone events;
  - – increased toxicity of pollutants.
- Prevalence of respiratory diseases and allergies related to air pollution could increase as a result of climate change.
- Allergic disorders could be changing.

As illustrated in the fourth assessment report of the IPCC, concentrations of ground-level ozone are increasing in most regions. The concentrations of air pollutants in general and fine particulate matter may alter in response to climate change. In some regions, changes in the mean and variability of temperature and precipitation are projected to increase the frequency and severity of fire events and heat-waves and air pollution episodes can be aggravated during heat-waves. Under certain atmospheric circulation conditions, transport of pollutants may occur over large distances and for extended periods.

Air pollution has a significant impacts on health. There is extensive literature documenting the adverse health impacts of exposure to aeroallergens and elevated concentrations of air pollution, ozone, particulate matter with aerodynamic diameters under 10 µm and 2.5 µm, (PM_{10}, $PM_{2.5}$), sulphur dioxide, nitrogen dioxide, carbon monoxide and lead. In 2000, there were 0.8 million deaths and 7.9 million disability-adjusted life years lost from respiratory problems, lung disease and cancer that were attributed to urban air pollution, with the largest burden in developing countries in the Western Pacific region and South-East Asia (WHO, 2002). In addition, there were 1.6 million deaths attributed to indoor air pollution caused by burning biomass fuels.

Climate change could affect local and regional air quality through changes in the speed of chemical processes in the atmosphere, the altitude where pollutants mix and changes in air flow which affect the transport of pollutants. As meteorological conditions affect the transport, dispersion and deposit of air pollutants, there is concern that climate change affects the burden of illness and mortality associated with these gases and fine particles.

Ground-level (tropospheric) ozone adversely affects human health. Ozone is the primary constituent of urban smog and is formed as a secondary pollutant through photochemical reactions involving nitrogen oxides and volatile organic compounds in the presence of bright sunshine with high temperatures. Temperature, wind, solar radiation and atmospheric moisture influence both the production of ozone as well as emissions of ozone precursors. Petrol-burning engines are major sources of volatile organic compounds and nitrogen oxides are produced whenever fossil fuels are burned. Because ozone formation depends on sunlight, concentrations typically are highest during the summer months. Outdoor ozone concentrations, activity patterns and housing characteristics are the primary determinants of ozone exposure (Suh et al., 2000).

Increased emissions of ozone precursors under warmer conditions will tend to increase concentrations of tropospheric ozone. Current concentrations of tropospheric ozone are approximately 36% higher than pre-industrial concentrations. Ozone is a known pulmonary irritant that affects the respiratory mucous membranes, other lung tissues and respiratory function. Exposure to elevated concentrations impairs the normal mechanical function of the lung. Although small changes in lung function may not interfere with normal activities in healthy individuals, such changes in individuals with pre-existing disease could result in clinically significant adverse effects. Exposure to elevated concentrations of ozone has been shown to be associated with increased hospital admissions for pneumonia, chronic obstructive pulmonary disease, asthma and other respiratory diseases, and also with premature mortality.

Various studies have observed increased morbidity and mortality during hot weather and under conditions of elevated air pollution. Ye et al. (2001) have shown for Tokyo that concentrations of nitrogen dioxide or particulate matter <10 µm were associated with daily hospital emergency admissions for angina, cardiac insufficiency, myocardial infarction, asthma, acute and chronic bronchitis and pneumonia. Pneumonia was also associated with daily maximum temperature. Another study in Belgium concluded from the observation of data before, during and after a heat-wave (the definition of a heat-wave is missing however!) that elevated outdoor temperatures in combination with high ozone concentrations were the causes of the observed excess mortality during the heat-wave (Sartor et al., 1995). Recent studies have shown that during the heat-wave of the summer of 2003, air pollution had an impact on mortality (Fischer, Brunekreef & Lebret, 2004; Stedman, 2004).

Epidemiological studies conducted in different countries have observed associations between increases in PM concentration and increases in morbidity and mortality, particularly among those people with respiratory or cardiovascular diseases. However, there are still important unanswered questions concerning potential biological mechanisms of PM effects, the identification of the factors responsible for the adverse health effects (size and/or chemical composition) and the groups of people that may be particularly sensitive to the effects of PM. The most recent hypotheses indicate that ultra-fine particles (<0.1 µm) and transition metals (like iron – Fe) may play an important role in the induction of toxic effects. Results obtained during recent years at some sites located in the city centre of Rome, showed mean annual levels of PM_{10} and $PM_{2.5}$, with peak values during winter months. Ultra-fine particle concentrations showed similar seasonal trends, and daily trends correlated with increasing traffic flows (Marconi, 2003).

In the MISA project a meta-analysis of short-term effects of air pollution on health in eight Italian cities from 1990 to 1999 was conducted. Each pollutant (sulphur dioxide ($SO_{2)}$, nitrogen oxide (NO_2), carbon monoxide (CO), PM_{10}, ozone (O_3)) was significantly associated with mortality for natural causes. The effect of PM_{10} on mortality was greater during the warm season and for the elderly. A north-south gradient in risk was observed for total natural mortality. The excess risks of hospital admission were modified by the deprivation score and by the NO_2/PM_{10} ratio. Results add evidence for an association between air pollution and early mortality or morbidity and support the hypothesis of a synergism between meteorological variables and air pollution (Biggeri et al., 2005). Mean yearly concentration of PM_{10} in the major Italian cities exceeded 40 µm/m^3 (range 30 µm/m^3 to less than 70 µm/m^3. Very few data are available on $PM_{2.5}$, with the exception of Rome where mean annual levels approached 28 µm/m^3, with 24-hour averages ranging from 5 µm/m^3 to 101 µm/m^3 (Zapponi & Marconi, 2003).

Two time-series studies among Rome inhabitants found that daily total mortality was associated with average concentration of particles on that day and with NO_2 levels of one or two days before. Hospital admissions for cardiovascular disease were positively correlated to PM, SO_2, NO_2 and CO. Hospital admissions for respiratory disease were associated with NO_2 and CO levels of the same day and of two days before among children (0–14 years) and adults (15–64 years). Increments of ozone were associated with increments of total respiratory and of acute respiratory diseases in children (0–14 years) (Michelozzi et al., 2000b).

Regarding the long-term effects of air pollution, studies of respiratory disorders in adults and children can be considered. Chronic respiratory diseases are an important factor when evaluating effects of climate change. The burden of chronic obstructive pulmonary disease is very high for the Italian community. Prevalence data for Italy indicate that self-reported chronic obstructive pulmonary disease is in the range of 3.9% (females) and 4.8% (males), with higher values when the 64+ age group is considered (18.3% males, 11.2% females). However, more detailed epidemiological investigations, using objective measurements of lung function, have suggested that the disease is often under-diagnosed and treated only at advanced stages, while it is a substantial health problem even among young adults. It has been estimated that the true prevalence of chronic bronchial obstruction in people aged above 25 years is in the range of 11–18%, depending on the clinical criteria used (Viegi et al., 2001). Mortality data from chronic obstructive pulmonary disease indicate a slow downward trend in the recent decades, with about 18 and 5 deaths per 100 000 inhabitants, for males and females, respectively (Avino et al., 2004).

Ciccone (2000) assessed exposure to traffic by using questiong about the density of truck traffic in the street of residence and evaluated the association with respiratory disorders among children participating in the first SIDRIA study. A high frequency of truck traffic in the street of residence was associated with significantly increased risks of wheeze, recurrent bronchitis, bronchiolitis and pneumonia. In the metropolitan areas (Turin, Milan, Rome) there was also an association with current respiratory symptoms, such as asthma, attacks of wheeze, speech-limiting wheeze, persistent cough and persistent phlegm. After extensive evaluations, the authors felt that reporting bias seemed unlikely. In a recent longitudinal study which followed children for several years with regards to hospital admissions for respiratory diseases (Farchi et al., 2006), a clear association was seen between NO_2 concentration measured in the area of residence and the subsequent incidence of lower respiratory infections.

Table 8: Average excess risk attributed to ozone and temperature

City	Mortality of all ages			Mortality of 65+ age group		
	Excess risk ozone and temperature (%)	Ozone part (%)	Temperature part (%)	Excess risk ozone and temperature (%)	Ozone part (%)	Temperature part (%)
Bordeaux	25.00	2.46	97.54	26.66	1.31	98.69
Le Havre	10.58	58.00	42.00	10.87	82.43	17.57
Lille	13.97	44.61	55.39	15.28	48.50	51.50
Lyon	87.74	2.57	97.43	95.07	0.18	99.82
Marseilles	11.19	50.30	49.70	9.99	49.48	50.82
Paris	174.68	7.33	92.67	203.22	6.46	93.54
Rouen	35.24	32.60	67.40	36.01	31.48	68.52
Strasbourg	11.75	75.95	24.05	11.21	74.27	25.73
Toulouse	17.98	85.34	14.66	22.96	92.14	7.86

When considering possible effects of climate change in Italy, studies on the effects of heat-waves and air pollution are relevant. Observation and analysis of the health impacts of the heat-wave and the ambient ozone levels in the United Kingdom during the summer of 2003 led to an estimation that 21–38% of the excess deaths in the United Kingdom could be associated with elevated ozone levels (Stedman, 2004). Even higher is the proportion of excess deaths attributable to elevated ozone levels and particulate matter (PM_{10}) during the 2003 heat-wave in the Netherlands. Calculations show that 400–600 excess deaths related to air pollution may have occurred compared to an average summer. This is almost half of the observed 1000 to 1400 total excess deaths during the heat-wave in the Netherlands (Fischer, Brunekreef & Lebret, 2004). In France, a more complex study on mortality in relation to heat and air pollution has been undertaken, involving nine French cities. Table 8 shows the average excess risk (%) attributed to ozone and temperature, share of ozone and share of temperature in nine French cities between 3 August and 17 August 2003, with astonishing results: the higher the total excess mortality during the heat-wave, the lower is the share of the ozone (Paris, Lyon). In cities where the overall excess mortality is relatively low, the contribution of ozone to this is much higher (Toulouse, Le Havre) (INVS, 2004).

An interesting study has been published on the relationship between climate, air pollution and prevalence of respiratory disorders among young adults (De Marco et al., 2002). The specific aim was to evaluate to what extent climate and outdoor NO_2 pollution can explain the geographical variation in the prevalence of asthma and allergic rhinitis in Italy. The data were collected in the cross-sectional study carried out during 1998–2000 on young adults aged 20 to 44 years living in 13 areas from 2 different Italian climatic regions (sub-continental and Mediterranean). Mediterranean areas had a significantly higher prevalence of asthma-like symptoms, higher annual mean temperature, lower temperature range and lower NO_2 levels (31.46 $\mu m/m^3$ vs. 57.99 $\mu m/m^3$) than sub-continental ones. Mediterranean climate was associated with an increased risk of wheeze, asthma attacks and other respiratory symptoms. After adjusting for climate, an increase of NO_2 levels moderately increased the risk of asthma and asthma-like symptoms. When the levels of outdoor NO_2 exposure rose, the prevalence of allergic rhinitis increased significantly in the Mediterranean region, but not in the sub-continental one. In sum, the prevalence of asthma increases when annual mean temperature increases and temperature range decreases. Furthermore, climate interacts with NO_2 outdoor exposure, increasing the risk of allergic rhinitis in people exposed to high stable temperatures. The study also suggests a long-term link for the effect of traffic pollution on asthma.

The possible effects of changes in climate and associated changes of temperature ranges and air pollution call for future research into several aspects.

- Most studies into the short-term effects of air pollution in Italy indicate that the largest effect is found during the warm season. These findings call for further research into the constituents and size of the airborne particulate mass.
- The potential synergism between air pollution exposure and extreme weather events should be examined in more detail, with particular emphasis on the effects of PM, ozone and increases in temperature and humidity.
- Long-term studies into air pollution and respiratory diseases in various climatic areas should be designed.
- Monitoring the prevalence of and mortality from respiratory diseases should continue.

4.5 Vector-borne diseases

– by Giancarlo Majori

Key messages

- Cases of West Nile fever, leishmania and boutonneuse fever could increase.
- Vigilance for malaria and dengue fever must continue, as potential risks exist.
- Vector control and early case detection will be essential in avoiding the spread of vector-borne disease.

It is well known that climatic factors can influence the appearance or the reappearance of infectious diseases in a particular area when there are other biological, ecological and socioeconomic factors favourable to the event (Patz et al., 1996). Vector-borne diseases affect over 700 million people every year and are considered most susceptible to climatic and environmental changes. Since 1990, the World Health Organization has launched a warning about the effects that the climatic changes could have on the spread of vector-borne diseases (WHO, 1990; WHO Regional Office for Europe, 2004). Italy, representing one of the countries located in the most southern part of the

European continent and being an ideal bridge to the African continent, could be particularly affected by this phenomenon. Bearing in mind the above-mentioned increase in temperature, we report here and discuss its possible impact on vector-borne diseases in Italy. These effects can be summarized in the following six processes:

- amplification of the area of distribution of the indigenous vectors;
- reduction of the duration of the life-cycles of the indigenous vectors;
- reduction of the duration of reproduction of the pathogens inside the arthropod;
- prolongation of the reproduction season of the pathogens;
- importation and adaptation of new arthropod vectors;
- importation and adaptation of new pathogens through vectors or reservoirs.

4.5.1 *The malaria vectors*

The importance of mosquitoes as disease vectors is linked above all to the transmission of malaria, an illness that still today causes millions of deaths every year in the world (WHO, 2005a). In Italy, malaria was eradicated at the end of the 1940s. However, the mosquito species responsible for its transmission is still present in remarkable density in southern regions of Italy, for example in Sicily and Sardinia (Romi et al., 1997). Today, most of the annually notified cases of malaria in Italy are imported and only very few cases are locally contracted, usually following accidental events (transfusions, contaminations, importation of infected vectors) (Romi, Boccolini & Majori, 1999, 2001). Nevertheless, the occurrence of autochthonous malaria in 1997 in Italy (Balderi et al., 1998) has shown the persistent risk of resurgence of malaria through *Anopheles labranchiae* and *An. superpictus*, two of the vectors responsible for previous transmission. A recent study carried out in Tuscany (Romi, Sabatinelli & Majori, 2001) has appraised the parameters that define the so-called "malariogenic potential" of a country: the receptivity, infectability and vulnerability. The first refers to the presence of potential vectors, the second to the possibility that the native vectors become infected with the plasmodial species and the third is the number of subjects carrying the gametocytes. The malariogenic potential for Italy is not very high, but it does not exclude the possibility that autochthonous malaria cases could occur in areas "at risk", especially in the south and in the islands.

Under conditions of climate change, within the next decade, the constant increase in mean temperature could widen the area of distribution of the vectors. Also, the accidental importation of infected vectors from endemic areas (for instance through intercontinental flights) could happen again. This would, however, possibly cause only isolated cases of malaria. Furthermore, the distribution of the vectors is dependent on the presence of larval breeding sites during the seasonal activity of the vectors between July and September. Therefore, the possibility that a tropical vector may settle in Italy following an increase in temperature appears highly unlikely because of the complexity of ecological factors linked to the different anopheline species.

4.5.2 *Vectors of arbovirus*

Several species of Culicidae present in Italy are potential vectors of arbovirus. The isolation of arbovirus from Italian Culicidae occurred more than 40 years ago in two mixed samples of Aedes mosquitoes (*Aedes caspius* and *Aedes vexans*) collected in the Friuli region; the virus was found to belong to the Tahyna strain (Saccà et al., 1968). In the same period a low prevalence of anti-Tahyna antibodies was found in samples of human serum collected in some regions (Friuli, Campania, Sardinia, Emilia). Furthermore, human and domestic animal sera were found to be positive in the haemoagglutination test against West Nile virus (WNV) and against western equine encephalitis (WEE), demonstrating that a circulation of these arboviruses, although at a low level, must have occurred in those areas (Verani et al., 1977). Among the potential Culicidae vectors of arbovirus in Italy, at least three species deserve particular attention: the first, *Culex pipiens*, a native species that is the major component of the local entomofauna; the second, *Aedes albopictus*, introduced into Italy in the early 1990s and at present solidly rooted in the country (Romi, 1999); and the third, *Aedes aegypti*, currently not present in the Mediterranean basin but, as mentioned above, climatic changes within the next decade could favour its reintroduction into the countries of southern Europe. In Italy, as in other European countries, the increase in the mean temperature could lead to a greater circulation of the virus, amplifying the density of the vectors, extending the favourable season for the transmission of the virus and also prolonging the presence of the migratory birds that act as reservoirs.

Potentially, *Aedes albopictus* is able to become infected with over 20 arboviruses (Shroyer, 1986; Boromisa, Rai & Grimstad, 1987; Mitchell, 1991). In its countries of origin, that stretch from southern China to South-East Asia, *Aedes albopictus* is the proven vector of dengue fever (DEN), yellow fever and Japanese encephalitis. In Europe, the increase in temperature would favour its expansion towards northern regions, but in Italy, where the species is already present up to the Alpine regions (Romi, 2001), its expansion toward the north has already reached its maximum; on the other hand, the species could see a reduction in its presence in the southern regions if the increase in temperature was not accompanied by abundant rainfall during the warmest months.

Until the end of the Second World War, the presence of *Aedes aegypti* in the countries of southern Europe was reported quite frequently. In 1930, the species reached its maximum expansion in the Mediterranean basin, being seasonally present from the Atlantic coasts of France, Portugal and Morocco to the west, as far as to Turkey, the Middle East and the Arabic peninsula to the west (Mitchell, 1995). In the 19th and 20th centuries the species was certainly responsible for cases of yellow fever which occurred in the French port cities of Brest, Bordeaux and Marseilles (Rageau, Mouchet & Abonnec, 1970), and perhaps also in Italy, in Livorno (Piras, 1917). In Italy, particularly, *Aedes aegypti* has been reported many times, from 1889 up to 1944, almost exclusively in the port cities (Ficalbi, 1899; Piras, 1917, 1918 and 1928). The species did not succeed in surviving the winter months, however, as it was not able to hibernate at any stage of its development and it did not succeed, therefore, in taking root in the territory. Certainly, the species was responsible for the epidemic of dengue fever that occurred in Greece between 1927 and 1928, with a million clinical cases and around 1000 deaths (Halstead & Papaevangelolou, 1980). In Italy the last reported case was in the city of Genoa, in 1944. The species probably disappeared definitively from Italy immediately after the Second World War, due to the Malaria Eradication Programme based on DDT residual spraying (1947–1951). Since *Aedes aegypti* survives more easily than *Aedes albopictus* in arid environments (Christophers, 1960), the increase in mean temperature could also lead in the near future to the reintroduction and the re-establishment of huge populations of this powerful vector in the countries bordering the Mediterranean Sea, Italy included.

4.5.3 *Sandflies*

The vectors of the endemic leishmaniasis in Italy are sandflies (Diptera: Psychodidae) belonging to the genus *Phlebotomus*, sub-genus *Larroussius* (Maroli and Khoury, 1998). In Italy, the human disease is present in two different epidemiological and clinical forms (Gramiccia, 1997): zoonotic visceral leishmaniasis (ZVL) and sporadic cutaneous leishmaniasis (SCL).

The etiological agents of ZVL are viscerotropic strains of *L. infantum*. The most common reservoir is the dog; the principal vector is *Phlebotomus perniciosus* (Bettini, Gramicchia & Gradoni, 1986; Maroli et al., 1988, 1994). The ZVL is a typical rural and periurban disease, present in patchy spots along areas of the Tyrrhenian Coast, the low Adriatic Coast and in the islands, according to the biological characteristics of the vectors. Cases of ZVL have been reported in many regions of the centre-south, but the most affected areas are in Campania and Sicily (Ascione, Gradoni & Maroli, 1996; Gramiccia, 1997).

SCL is caused by dermotropic strains of *L. infantum*. The dog plays an important role in the maintenance of SCL and the vectors involved in transmission are *P. perniciosus* and *P. perfilievi* (Maroli, Gramicchia & Gradoni, 1987; Maroli et al., 1988, 1994). The distribution of SCL in Italy is more or less similar to that of ZVL but the "historical" areas are located along the coast of Abruzzi and in some areas of Calabria (Gramiccia, 1997). The mean increase in atmospheric temperature could, in general, favour the diffusion of ZVL and its vectors into regions of northern Italy till now untouched, where sporadic cases of canine leishmaniasis have been reported (Maroli et al., 1995; Ferroglio et al., 2000) and increase its incidence in the regions where it is already endemic.

In Italy sandflies are also vectors of arbovirus belonging to the genus *Phlebovirus*, family Bunyaviridae (Nicoletti, Ciufolini & Verani, 1996). During the Second World War in Italy, Sabin, Philip & Paul (1944) described two phleboviruses antigenically correlated. The main sign of the infection was fever, and therefore the light feverish illness was named "three day fever" or "phlebotomus fever", transmitted to humans by *P. papatasi* (Sabin, 1951). Since the end of the 1940s these viruses have not been found in Italy. The distribution and the density of the endophilic vector were probably drastically reduced by the DDT employed for the residual spraying treatments conducted during the malaria eradication campaign in Italy and in the other countries of southern Europe (Tesh & Papaevangelolou, 1977). In the 1970s and 1980s two other phleboviruses were isolated in Italy: the Toscana virus (Verani, Nicoletti & Ciufolini, 1980), an agent of acute infections of the central nervous system, present in at least three regions of central Italy (Tuscany, Marche and Abruzzo) and of which more than 100 strains have been identified in *P. perfilievi* and *P. perniciosus* (Verani, Ciufolini & Nicoletti, 1995); and the Arbia virus, isolated in Tuscany and Marche from the same vectors (Verani et al., 1988) and until now never found in human cases.

4.5.4 *Ticks*

Ixodids (hard ticks) are vectors of a great variety of infectious agents pathogenic to livestock and to humans. In Italy there are two ticks of great medical importance: the dog tick (*Rhipicephalus sanguineus*) and the "tick of the woods" (*Ixodes ricinus*), the so-called sheep tick, that inhabits relatively humid, cool, shrubby and wooded pastures, gardens, windbreaks, floodplains and forest through much of Europe. *R. sanguineus* is ubiquitous, present in all the warm-moderate zones of the world and broadly present throughout Italy (Maroli et al., 1996). The dog is the specific host of this tick that, however, frequently parasitizes other pets and occasionally human beings. *R. sanguineus* lives in urban and periurban sites. The peak of activity generally occurs in the warmest months of the year and the tick can live very well at high temperatures and overcome periods of drought.

In Italy, *R. sanguineus* is a vector of rickettsiae, particularly *Rickettsia conorii*, agent of boutonneuse fever. This disease is endemic in Italy except in the Valle d'Aosta region. The regions with a greater incidence are Lazio, Sardinia and Sicily (Maroli et al., 1996). In Italy, *I. ricinus* is the vector of the virus TBE, agent of the tick-borne encephalitis (Verani, Ciufolini & Nicoletti, 1995) and of *Borrelia burgdorferi s.l.*, agent of Lyme disease. The main areas where tick-borne encephalitis is present are Veneto, Tuscany and Trentino (Verani, Ciufolini & Nicoletti, 1995; Ciufolini et al., 1999). Sporadic cases of Lyme disease have been reported in various Italian regions, but the endemic foci of borreliosis are located especially in Veneto, Friuli and Trentino. The increase in mean temperature could have different impacts on the two principal ixodid vectors and on the spread of the pathogenic agents transmitted.

In the case of *R. sanguineus* and transmitted boutonneuse fever, a warmer climate could theoretically increase the incidence of rickettiosis where it is endemic and favour its diffusion into new areas, increasing the density of the vector populations. It is well known that the diffusion of ticks in our cities and domestic environments has increased in the recent decades as a consequence of different factors, such as uncontrolled urbanization and the increased habit of keeping pets in the house. In the case of *I. ricinus*, the vector of TBE and Lyme disease, just the increase in average atmospheric temperature could be an unfavourable factor in Italy. In fact, in the countries of northern Europe a milder climate could allow the increase of the vector populations and lengthen the favourable season for the transmission of the pathogenic agent (Lindgren & Gustafson, 2001), whereas in the warmest countries it could subsequently limit the already low number of endemic zones and reduce the presence and density of the vector in the most southern regions.

4.5.5 *Future estimations*

Table 9: Main vector-borne diseases and vectors that could increase in Italy

Disease	Vectors	Pathogens	Present situation in Italy	Events causing the cases	Risk level
Malaria	Anopheline mosquitoes	Plasmodia (mainly *P. vivax*)	Malaria cases only imported. About 700 cases/year, decreasing trend since 2001. Rare cases of malaria transfusion, baggage malaria; one autochthonous vivax malaria in 1997, in Tuscany region	Imported cases from endemic areas (gametocyte carriers)	LOW Only rural areas of central/ southern Italy at risk
Dengue fever	*Aedes albopictus* (tiger mosquito)	Flavivirus DEN 1, 2, 3, 4	Imported cases only. About 40 cases/year. Rising trend	Imported cases from endemic areas (virus carriers)	LOW Urban areas more at risk
Dirofilariasis	*Aedes albopictus* (and other mosquito species)	*Dirofilaria immitis* and *D. repens*	Rare cases in rural areas		MODERATE Urban areas more at risk
West Nile Disease	*Culex pipiens* (and other mosquito species)	Flavivirus WNV	In 1998, epidemics of equine encephalitis in Tuscany region (14 cases). No human cases	Arrival of infected reservoirs (migratory birds)	HIGH In all humid areas of the country
Visceral leishmaniasis	Sandflies (*P. pernicious*)	Leishmania (*L. infantum*)	Endemic mainly in central/southern Italy. About 500 cases/year. Rising trend		HIGH Spreading towards northern Italy
Toscana virus Meningitis	Sandflies (*Phlebotomus* spp.)	Phlebovirus Toscana virus	Endemic, mainly in Tuscany and Marche regions. Few cases/year. Rising trend		MODERATE Virus present in central regions
Boutonneuse fever	Ixodid tick *(R. sanguineus)*	Rickettsiae (*R. conorii*)	Endemic, mainly in central/southern Italy. About 1000 cases/year. Decreasing trend		HIGH Moving towards northern Italy
Lyme disease	Ixodid tick (*Ixodes ricinus*)	Borreliae (*B. burgdorferi*)	Endemic, mainly in northern/eastern regions of Italy. Few cases/year. Rising trend	Increasing temperature accompanied by heavy rainfall	VERY LOW
Tick-borne encephalitis	Ixodid ticks *(Ixodes ricinus)*	Flavivirus TBE	Endemic, mainly in northern/eastern regions of Italy. <10 cases/year. Rising trend		VERY LOW

As the IPCC fourth assessment report states, there is greater confidence in projected changes in the geographic range of vectors than in changes in disease incidence, because of uncertainties about trends in factors other than climate that influence human cases and deaths, including the status of the public health infrastructure. Future estimates are available globally for malaria, dengue fever and a few other infectious diseases. Unfortunately, these models often use incomplete parameterization of biological relationships between temperature, vector and parasite and often over-emphasize relative changes in risk, even when the absolute risk is small.

Few models project the impact of climate change on malaria outside Africa. An assessment in Portugal projected an increase in the number of days per year suitable for malaria transmission; however, the risk of actual transmission would be low or negligible if infected vectors are not present (Casimiro et al., 2006). For the United Kingdom an increase in risk of local malaria transmission was estimated at 8–15% but it was judged highly unlikely that indigenous malaria would be re-established. As for dengue fever, an empirical model based on vapour pressure projected increases in latitudinal expansion, with the population at risk increasing to 3.5 billion people by 2085; the population at risk is projected to be 5–6 billion people allowing for population growth projections (Hales et al., 2002). Table 9 shows the potential of vector-borne diseases in Italy, based on observations and expert judgement.

4.6 Food and health

– by Marina Miraglia, Luciana Croci

Key messages

- Risks of fungi growth and insect attack depend on climate.
- Effects of temperature on foodborne infectious disease (e.g. salmonella) can be assumed, but evidence is lacking for Italy.

Foodborne diseases are defined as any disease of an infectious or toxic nature caused by the consumption of food or water, therefore strictly linked to food safety. Foodborne diseases can be related to extrinsic (chemical or biological) or to intrinsic hazards, as in the case of natural toxins or anti-nutritional factors. However, in this section the emphasis is on those diseases related to food alone, as the diseases related to water are tackled separately in section 4.7.

Many of the existing issues ragarding food safety are directly or indirectly related to climate, with parameters such as drought, dryness of soil, temperature, ozone, rainfall and related groundwater level greatly influencing the extent of risk. The predicted altered climate conditions in Italy will probably cause changes in many of those parameters, and this represents a potential source of emerging/re-emerging/new risks. Unfortunately, the influence of the climatic parameters on specific issues is very complex and peculiar to each geographical area, food product and source of risk, with knowledge of the interaction between these often lacking. Climate change can affect food quantity, quality and health in various ways: it can influence the world's food supply system, and can affect food safety, such as through contamination by viruses, bacteria, chemicals and fungi and through direct influence of climate variability on foodborne diseases.

4.6.1 *Climate change impacts on food quantity*

First, climate change can affect food quantity. In temperate regions, moderate to medium local increases in temperature (1–3ºC), along with associated CO_2 increase and rainfall changes can have small beneficial impacts on crops, including wheat, maize and rice. General warming and increased frequency of heat-waves and droughts in the Mediterranean, semi-arid and arid pastures will reduce livestock productivity. Regional changes in the distribution and productivity of particular fish species will continue and local extinctions will occur at the edges of ranges, particularly in freshwater and diadromous species (e.g. salmon, sturgeon). In some cases, ranges and productivity will increase. Secondly, climate changes can have a substantial impact on food safety in Italy, as well as in other parts of the planet, among other things through its influence on chemical and biological contamination. The IPCC states that it has observed a poleward spread of diseases and pests which were previously found at lower latitudes and this is predicted to continue. The magnitude of the overall effect is unknown, but it is likely to be highly regionalized. Food can be contaminated by chemical and biological agents and some of the biological contaminations are outlined below.

Fungi and mycotoxins, for example, can contaminate plants. Microscopic filamentous fungi can develop on a wide variety of plants and can lead to the production of highly toxic chemical substances, commonly known as mycotoxins. The most widespread and studied mycotoxins are metabolites of some genera of moulds such as *Aspergillus, Penicillium* and *Fusarium*. Fungi contamination can occur in almost all stages of the food chain (field, storage and transport). The colonization and diffusion of the fungi are driven by environmental conditions and nutritional components (Magan et al., 2003), as well as by other factors such as insect or pest attacks. Quite peculiar conditions influence mycotoxin biosynthesis, such as climate and geographical location of crops, cultivation practices, storage and type of substrate (Brera et al., 2004).

The effect of climate change on the colonization of fungi and production of mycotoxins should be evaluated on a case-by-case basis since every species of fungi has its own optimum conditions of temperature and water activity for growth and formation of toxic metabolites, also depending on the host plant. No systematic study of the influence of climatic changes on mycotoxigenic fungi foreseen in Italy has so far been published. Only estimates can therefore be made based mainly on the knowledge of key environmental conditions affecting the production of the main fungi/toxins. An increase in *Aspergillus flavus* contamination could be particularly relevant for maize, a major Italian crop affected by these toxins.

In 2003, due to the high temperature and extreme drought, an exceptional peak in aflatoxin contamination in maize was registered. Tons of maize were destroyed due to an unacceptable level of the toxins in food and animal feed, and the impact on human and animal health was minimized due to the rapid alert system of the control authorities. The optimum temperature for formation of the toxins is 15–30°C; production of fumonisins has been associated with dry weather during grain fill and late-season rains (Munkvold & Desjardins, 1997), therefore the production of the toxins is favoured by the foreseen climate change in Italy. *Penicillium* species are more frequently associated with storage therefore the extreme climate conditions do not directly influence their occurrence and the formation of the related toxins.

The influence of insect attack on mycotoxin contamination is relevant and depends on several parameters, such as the necessary level of inoculum (versus airborne inoculum), the ability of fungi to attack on its own under other conditions and the characteristics of the insect population and of the plant, including its stress and resistance (Dowd et al., 1992). As for insect storage pests, their respiration can increase moisture conditions which may favour fungal growth (Magan & Olsen, 2004). Vice versa, examples have been reported of the ability of insects to protect plants from fungi attack (Dowd et al., 1992). Climate change can influence insect attack on plants by influencing their capacity for overwintering, their distribution over cultivated land and the ranges of insects as discussed in the previous sections. A few examples of a relation between fungi/mycotoxins and insect attack on agricultural plants can be given. In almonds and pistachios high aflatoxin contamination is associated with damage by the navel orange worm larvae, while high levels of aflatoxins in maize are almost always associated with insect injury, especially by the European corn borer, Ostrinia nubilalis (Widstrom, 1996).

4.6.2 *Climate change impacts on foodborne diseases*

Epidemiological studies were undertaken within the cCASHh study to describe and quantify the effect of environmental temperature on foodborne diseases. Surveillance data from laboratory confirmed cases of S*almonella* were obtained from several European countries (Italy did not participate). In general, cases of *Salmonella* increase by 5–10% for each degree increase in weekly temperatures, for temperatures above about 5°C. The effect of temperature is most apparent in the week before illness, indicating that inappropriate food preparation and storage around the time of consumption is most important. Rates of salmonellosis are declining in most countries in Europe and rates of campylobacteriosis are, in general, also decreasing. There was no good evidence of a strong role of temperature in the transmission of campylobacteriosis (Kovats et al., 2005).

4.7 Water and health

– Enzo Funari, Monica Francesca Blasi, Mario Carere, Valentina Della Bella, Laura Mancini, Stefania Marcheggiani, Francesco Mattera and Mara Stefanelli

Key messages

- Waterborne disease outbreaks could occur due to intense rainfall or drought via contamination of coastal, recreational or surface waters.
- There is also a direct relationship between some diarrhoeal diseases during spring and summer seasons.
- Algal bloom and possible toxic cyanobacteria have been observed to be potentially associated with climatic changes and there is a potential for them to increase in the future.

Climate change and variability can affect both water availability and water quality, with different severe consequences for human health through water-related diseases. Distinguished by route of transmission, *waterborne* diseases are defined as those infectious diseases transmitted through drinking water but also through food, for instance via irrigation, shellfish and aquaculture. However, these infectious diseases related to food have been tackled in the previous section, while those related directly to water are the focus of this section. A second category are *water-washed* diseases, which include infectious diseases transmitted through recreational exposure (see also section 3.1) as well as sanitation-related diseases transmitted through direct or indirect human contact with human excreta. They result in infections and infestations, skin and other reactions through water contact. A third category are water-related accidents such as drowning and physical injury, misadventure during water-based recreation and flood events. There are four main considerations when evaluating current climate and health outcomes (primarily diarrhoeal disease):

- the role of extreme rainfall (intense rainfall or drought) in facilitating waterborne outbreaks of diseases through either the piped water supplies or surface water;
- effects of temperature and run-off on microbiological contamination of coastal, recreational or surface waters;
- direct effects of temperature on diarrhoeal diseases;
- water stress and measures to reuse wastewater.

More than 100 types of pathogenic bacteria, viruses and protozoa can be found in contaminated water. Many of these have been implicated in a variety of illnesses via waterborne and foodborne transmission. Changes in precipitation, pH, water temperature, wind dissolved CO_2 and salinity can strongly influence the survival or the behaviour of marine organisms. The water–food connection is apparent, as the above-mentioned microbial agents can contaminate food and can affect people by direct contact or by the consumption of seafood or of fresh fruit and vegetables contaminated via irrigation waters (Tauxe, 1997). Fish and shellfish from contaminated waters have been recognized worldwide as major sources of foodborne diseases. For many bacterial or viral diseases there is a clear seasonal trend in the detection or isolation of a pathogen and prevalence of disease.

4.7.1 *Bacterial water- and foodborne diseases*

Among marine bacteria, the presence of pathogenic *Vibrio* spp, including *V.cholerae*, shows a clear seasonal trend in the environment, where high numbers of bacteria can be observed during times of warm water temperatures and zooplankton blooms. Abiotic factors both affect and are affected by the biotic environment. Sunlight, temperature and nutrients influence the plants and phytoplankton, altering the dissolved O_2, CO_2 and therefore the pH of the surrounding water, subsequently influencing the population of bacteria, including Vibrios. *V.cholerae*, responsible for outbreaks of cholera around the world, has been found in plankton and fish in ponds and coastal waters of pandemic areas (Colwell, 1996). Also in Italy outbreaks of cholera occurred in 1973 in the Puglia region and Naples, in 1979 in the Sardinia region and again in Puglia in 1994. To date about 200 serogroups of *V.cholerae* have been recorded, of which only two (O1 and O139) have been associated with major epidemics. While environmental and clinical strains are now known to represent a single species, there is significant genetic diversity among environmental and non-O1, non-O139 strains of *V.cholerae*. However, some evidence suggests that both O139 and clinical strain O1 may have arisen by genetic exchange with non-O1 strains (Lipp, Huq & Colwell, 2002).

Evidence indicates that toxigenic strains may arise from environmental, nontoxigenic progenitors in coastal areas (Chakraborty et al., 2000). Most *V.cholerae* strains, especially those from the environment, lack the genes required to produce cholera toxin, but the genetic exchange in the environment allows the potential emergence of the new toxigenic clones. Although further studies are necessary, it appears that seasonal environmental factors may affect the acquisition of virulence genes to a significant degree (Lipp, Huq & Colwell, 2002).

Vibrio parahaemolyticus and *Vibrio vulnificus* are responsible for a majority of the non-viral infections related to shellfish consumption in the United States, Japan and South-East Asia (Wittman & Flick, 1995), though they occur occasionally in other parts of the world. The number of cases which have occurred in Europe to this date is extremely low, but recently a large outbreak (64 cases), caused by consumption of *V. parahaemolyticus* contaminated shellfish harvested in Galicia, was registered in Spain (Lozano-Leon et al., 2003). It is known that pathogenic Vibrios, such as *V.parahemolyticus* and *V.vulnificus*, occur in estuarine waters throughout the world, are present in a variety of seafood (Croci et al., 2001; de Sousa et al., 2004; DePaola et al., 1990, 2003) and are part of the natural flora of zooplankton and coastal fish and shellfish. Their number is dependent on the salinity and temperature of the water, and cannot be detected in water with a temperature below 15°C. These micro-organisms have also been detected throughout the Mediterranean coasts. Manciàn et al. (2000) reported on a study conducted on natural marine samples (seawater and shellfish) from the coast of Spain and, among 284 strains isolated, 14 (5%) were identified as *V.parahaemolyticus*. In Italy, various studies report the isolation of pathogenic Vibrios from seawater and seafood (Barbieri et al., 1999; Croci et al., 2007; Ripabelli, Sammarco & Grasso, 1999). With the possibility of acquisition of virulence genes by environmental strains and with a changing climate, the geographic range of these pathogens may also change, potentially resulting in increased exposure and risk of infection for humans. Furthermore, changes in plankton populations and other hosts for which Vibrios are commensals or symbionts would similarly alter their ecology. Increased international trade, more consumption of raw seafood, and an increasing number of susceptible people, along with changing climatic conditions that can also favour the survival of these micro-organisms, are causing concern that the number of infections due to pathogenic Vibrios may increase in Europe and also in Italy.

4.7.2 *Viral water- and foodborne diseases*

The viruses are abundant in marine systems and survive longer in seawater and sewage treatment processes than bacteria (Gerba & Goyal, 1988). Therefore, contamination of marine waters with viruses has been, and will continue to be, an important public health issue. The spread of viral diseases through recreational water exposure and ingestion of contaminated shellfish is a primary public health concern. Shellfish are known as an important source of food for humans, but they are also recognized as a potential cause of foodborne diseases, especially when they are consumed raw or partially cooked (Lees, 2000; Lipp & Rose, 1997; Potasman, Paz & Odeh, 2002). Bivalve shellfish, in fact, are filter-feeding animals that can filter several litres of seawater daily and, if pathogenic micro-organisms are present in the water, the pathogens may accumulate to considerable levels (Burkhardt & Calci, 2000; Metcalf et al., 1979; Rippey, 1994). In accordance with the European Commission Regulation (EC) No. 2073/2005 on microbiological criteria for foodstuffs, only the presence of salmonella and the number of *Escherichia coli* (*E. coli*) are routinely used to test for microbiological quality of the live bivalve molluscs. However, it is known that bacteria are not reliable indicators of viral contamination in shellfish (Croci et al., 2000; Lees, 2000), as enteric viruses are generally more resistant to inactivation in water sources and are removed slowly from bivalves by depuration processes (Croci et al., 1992; De Medici et al., 2001; Schwab et al., 1998).

A large number of shellfish-associated outbreaks, indeed, have been attributed to enteric viruses, particularly Norovirus (NoV) (Hamano et al., 2005; Koopmans & Duizer, 2004; Prato et al., 2004; Sugieda, Nakajima & Nakajima, 1996) and hepatitis A virus (HAV), which have caused outbreaks in several countries such as the United States, China and Spain (Boccia & Working Group, 2004; Chironna et al., 2003; Chironna et al., 2004; Potasman, Paz & Odeh, 2002; Sanchez et al., 2002). In Europe, NoV infections are among the most important causes of gastroenteritis in adults. In the Netherlands, approximately 80% of outbreaks of gastroenteritis reported to municipal health services are caused by NoV. In the United Kingdom it has been estimated that a substantial proportion of foodborne infections may be caused by NoV (Koopmans & Duizer, 2004), which has long been recognized as a cause of relatively mild gastroenteritis, often referred to as "winter vomiting disease". Surveillance carried out in England and Wales from 1995 to 2002 changed this view, showing a summertime peak in NoV reports in 2002 (Lopman et al., 2003).

In Italy, the data from the National Surveillance System for Acute Viral Hepatitis (referred to as SEIEVA) show low annual incidence rates (around 5/100 000 inhabitants) of HAV cases and a shift in the average age of infection towards adulthood, when the clinical illness is more frequent and more severe. The country is considered at low endemicity (Mele et al., 1997), but the statutory notification system suggests that the epidemiological pattern is not homogenous across the country: in southern Italy, especially in the Campania and Puglia regions, HAV infection still shows an intermediate level of endemicity with annual incidence rates up to 30/100 000 (Germinario et al., 2000). Seroprevalence rates among adolescents are still 40% among 18 year-olds and more than 30% among 20–30 year-olds in this part of the country, while in northern Italy it has rapidly decreased over recent years to around 10%. A large percentage (60–65%) of the new cases reported each year correlate with bivalve mollusc consumption (http://www.iss.it/engl/goal/seie/index.html).

Consistently with this, southern Italy also experienced outbreaks of HAV presenting a very similar pattern: the last episode reported lasted over two years and, respectively, caused 5673 cases in 1996 and 5382 in 1997 in the Puglia region, accounting for an annual incidence rate of 138 and 132 cases per 100 000, respectively. According to the two case-control studies implemented, this large outbreak was caused by the consumption of raw (or improperly cooked) shellfish and sustained over time through person to person transmission. Shellfish is a rather common food habit in this part of Italy, where it is traditionally eaten raw or slightly cooked. During 2004 a large outbreak of HAV occurred in Campania, a region of southern Italy, with 882 cases reported between 1 January and 1 August. A case-control study among residents and a microbiological investigation in sera patients and mussels sold in the area were conducted. Both the analytical study and the microbiological investigation identified the seafood as the most important infection source (Boccia et al., 2005).

Regarding gastroenteritis caused by NoV in Italy, the real incidence of this kind of disease is not known, because of the lack of a surveillance system. The first reported outbreak of NoV gastroenteritis occurred in July 2000 at a tourist resort in the Gulf of Taranto in southern Italy. Illness in 344 people, 69 of whom were staff members, met the case definition. Norwalk-like virus (NLV) was found in 22 of 28 stool specimens tested. The source of illness was probably contaminated drinking water, as environmental inspection identified a breakdown in the resort water system and tap water samples were contaminated with faecal bacteria (Boccia et al., 2002). In December 2002, several clusters of NoV gastroenteritis outbreaks were reported in different parts of France and Italy. Epidemiological investigations rapidly implicated oysters produced in the south of France (Parnaudeau et al., 2004). In April 2002 an outbreak of NoV gastroenteritis, involving 103 people, which occurred in the province of Bari (south-east Italy), was related to seafood consumption (Prato et al., 2004).

Different papers have been published about the incidence of viral contamination on shellfish sold in different parts of Italy or harvested from the Adriatic Sea coast. A study conducted on 180 mussels collected from the markets of five big cities in the south of Italy, where a high incidence of HAV infection is reported every year, resulted in 15.6% of the samples being found to be contaminated by infectious HAV (Croci & Suffredini, 2003). Incidence and circulation of different strains of HAV and NoV in shellfish were studied on 235 shellfish samples obtained from different sites representing the shellfish production areas of the northern Adriatic Sea and analysed after depuration. Viral contamination was present on average in 22% of samples: specifically, 6% of samples tested positive for HAV, 14% for NoV and 2% for both viruses. None of the samples revealed the presence of salmonella, and in most of them (93%) the number of E. coli was below the European legislation limit of 230 MPN/100g (Croci et al., 2007).

Key climatic variables, particularly precipitation and temperature, have direct and indirect effects (storms can increase transport from faecal and wastewater sources) on enteric viruses too. Run-off from rainfall is also a key factor in contamination of coastal waters and consequently shellfish harvesting areas. Temperature and ultraviolet radiation are the most detrimental to stability and function of the virus particle while salinity has been found to have little direct effect on virus survival (Wetz et al., 2004).

4.7.3 *Toxic cyanobacteria and cyanobacteria*

Cyanobacteria have a high degree of evolutionary adaptability, which is in part facilitated by short life-cycles. Also a large number of species have the capacity to form akinetes, which are a resting stage where they can tolerate a great deal of environmental variation and remain viable for periods even longer than 60 years (Livingstone & Jaworski, 1980). A number of mechanisms can facilitate their movements: large-scale flooding can carry organisms to new locations, waterbirds can be vectors, and even in very dry conditions dried scum can become aerosolized by the wind and transported, so it is unlikely that lack of migration will restrict the distribution of cyanobacteria, if climatic conditions result in habit shifts (Garnett et al., 2003).

A possible relationship mediated by cyanobacteria between human health and increased temperature is the increase in the frequency of their blooms (Hunter, 2003). Indeed most of the cyanobacterial blooms occur during the summer season (Jacoby et al., 2000; Maier & Dandy, 1997; Saker & Griffiths, 2001).

Cylindrospermopsis raciborskii (Woloszynska) Seenayya and Subba Raja, a species of (sub)tropical origin, is a cyanobacterium found principally in fresh water. It belongs to the order of Nostocales, is filamentous, with a variable length and 1-5 mm wide. The extremities of its trichomes are sharp, due to the shape of the terminal heterocystis (Shafik, 2001). Due to the senescence or environmental stresses (such as thermal shock or water purifying processes), *C. raciborskii* releases a toxin, cylindrospermopsin; but it can also produce saxitoxin (Pomati et al., 2004). Cylindrospermopsin is hepatotoxic but can also affect the kidneys, thymus and heart. Finally, it has shown some genotoxic properties in vitro studies (Rao et al., 2002). In Italy, massive blooms of *C. raciborskii* were first noted in the summer (June to September) of 1995, in the lakes of Albano and Trasimeno, then in 2002 in Lake Albano and finally in 2003 in Lake Cedrino; unfortunately no toxicity analyses were performed. Its occurrence was observed in the same three Italian lakes in 2004. In this study the phytoplankton analysis revealed that the maximum density of *C. raciborskii* in Lake Albano (July 2004) was 6 x 106 cell/L; in Lake Trasimeno (September 2004) it was 9 x 106 cell/L; and in Lake Cedrino (October 2004) it was 81 x 106 cell/L. The chemical analysis revealed a concentration of cylindrospermopsin of 15 and 0.46 ng ml-1 in Albano and Trasimeno lakes respectively, whereas no toxin was found in Lake Cedrino. The maximum density of *C. raciborskii* was found in Lake Cedrino, but the maximum toxin concentration was registered in Lake Albano: this demonstrates that wild populations of cyanobacteria species do not necessarily or always produce the toxin (Manti et al., 2005; Ohtani, More & Runnegar, 1992).

C. raciborskii is a highly adaptable species able to invade mid-latitudes. There are three possible explanations for the recent expansion of this cyanobacterium towards northern latitudes. Firstly, some strains of *C. raciborskii* particularly adapted to a temperate climate may have been selected during the northward movement. Secondly, the high physiological tolerance of this species may enable it to grow in a wide range of conditions, including tropical to temperate climates. Thirdly, changes in climate (global warming) may now allow the originally tropical species to develop at mid-latitudes during the summer period (Briand et al., 2004).

The increase in water temperature in temperate lakes, which is the third hypothesis, therefore seems to be the key factor in the expanding growth area of *C. raciborskii*. Global warming is now a recognized phenomenon with biological consequences, including effects on the physiology, distribution and adaptation of species (Hughes, 2000). In the water bodies of Europe, climatic changes are linked to the North Atlantic Oscillation (NAO), and in particular there are correlations between surface water temperatures and NAO (Straile et al., 2003). The influence of the NAO on the lake temperatures particularly in winter and early spring could be more significant (Anneville et al., 2002; Livingston & Dokulil, 2001; Scheffer et al., 2001; Straile et al., 2003). This warming of the water in spring could be related to the potential germination of *C. raciborskii* akinetes, which appears to play a key role in temperate countries. They allow this cyanobacterium to survive in the cold months, and germinate when the temperature of the water or sediment reaches 22–23°C (Padisak, 1997). An increase in spring temperatures could induce germination and growth earlier in the season, giving them a competitive advantage over other summer phytoplankton populations (Istvànovics, Somlyòdy & Clement, 2002).

Table 10: Main risks from changes in water and food quality in Italy

Disease	Pathogens	Present situation in Italy	Climate sensitivity	Mean	Risk level
Hepatitis	Hepatitis A	Hepatitis A is endemic in Italy, with around 3/100 000 inhabitants Water-related outbreaks occur regularly: in the period 1998–2005, 33 outbreaks occurred due to shellfish and drinking water consumption	Moderate	Food: infected sea food and water	HIGH
Diarrhoeal diseases	*Salmonella*	Salmonella is endemic. It reduced from 41/100000 in 1992 to 6/100000 in 2005 Regular outbreaks occur. An epidemiological study from 1998 to 2005 identified 63 cases originating from drinking water consumption and 232 cases from shellfish consumption	High	Infected food, drinking water and shellfish	HIGH, depending on behaviour and food handling practices and processes
Diarrhoeal diseases	*Campylobacter*	Outbreaks occur	Low	Shellfish	MODERATE
Diarrhoeal diseases	*Cryptosporidium*	Outbreaks occur	High	Drinking water	MODERATE
Diarrhoeal diseases	*V.cholerae*	Outbreaks occurred in the past	Moderate	Water, food, particularly seafood	LOW
Acute intoxication	*Vibrio parahaemolyticus*	Outbreaks occur	Moderate	Shellfish consumption	MODERATE
Systemic diseases	*Leptospira*	Outbreaks occur every year	High, when related to extreme precipitation events	Water	MODERATE
Allergic reaction	*Aspergillus, Penicillium* and *Fusarium*		Moderate		
Acute intoxications	Mycotoxins		Moderate		
Intoxication	Cyanobacteria	Growing number of species; few human attributable causes	High; water temperature	Drinking and recreational waters, fresh water fish	MODERATE
Cutaneous, systemic reactions and Guillaum Barre	*Pelagia noctiluca*	Bloom in 1980 report on jellyfish envenomation in the Mediterranean Sea	High; sea water temperature and alterations of ecosystems	Bathing waters	LOW
Cutaneous reaction	*Chrysaora hysoscella*	Spring coastal blooms of *C. hysoscella* were observed in 1989	Moderate	Bathing waters	LOW

A new study (Gugger et al., 2005) suggests that the recent invasion of Europe and Central and North America by *C. raciborskii* did not result from recent colonization events by African or Australian isolates as proposed by Padisàk (1997). In view of the history of the Earth's climatic changes and of bio-geographic evidence for numerous plant and animal models (Mayr & Ohara, 1986; Stuart, 1991), it seems possible to propose the following hypothesis. The multiple glaciations or dry climatic conditions during the Pleistocene age could have led to the extinction of *Cylindrospermopsis* in most of its geographical distribution areas and allowed it to survive only in warm refuge areas on each continent. Recently, the elevation of temperature has allowed the colonization of more and more northern areas from these warm refuge areas on the European and American continents. This hypothesis is in agreement with other ecophysiological studies, showing that the optimal conditions for growth of European isolates are the same as the tropical ones (Briand et al., 2002, 2004). Hence, these European strains could have originated in a warm area located on the Eurasian continent.

A very few cases of outbreaks were published in Italy in order to correlate infectious diseases to water, and they are principally related to microbiological and chemical agents as well as envenomation produced by jellyfish stings. Cnidarians may be encountered during recreational use of coastal environments. Jellyfish are pelagic cnidarians found worldwide and over recent decades new blooms of jellyfishes are occurring in response to the cumulative effects of human impact. The pathogenesis of cnidarian stings depends on many factors influencing the variability of reactions. The main risks discussed in this section are summarized in Table 10. The risk level is a result of a qualitative expert estimation based on probability, area and population affected and potential severity of the impact (detectable, curable).

5. Strategies to reduce the environmental and health impacts of climate change and variability

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5.1 Introduction

The Principles of the Ethical Practice of Public Health (Thomas, 2004) begins with a statement that directs attention to climate change: "Public health should address principally the fundamental causes of disease and requirements for health, aiming to prevent adverse health outcomes". Thus, attention to climate change is dictated by the traditions of both medical and public health ethics and dealing with the causes and effects of climate change is a fundamental task for public health. Mitigation and adaptation are measures to ultimately reduce the health impacts of climate change. Mitigation is the reduction of greenhouse gases and adaptation is the avoidance of impacts or the reduction of impacts. Health adaptation and mitigation to climate change are addressed in different frameworks, such as the prevention framework and the risk management framework.

In public health, primary prevention aims to prevent the onset of injury or illness; clinical examples include immunization, smoking cessation efforts and the use of bicycle helmets. Secondary prevention aims to diagnose disease early in order to control its advance and reduce the resulting health burden; clinical examples include screening for hypertension, hyperlipidaemia and breast cancer. Tertiary prevention occurs once disease is diagnosed; it aims to reduce morbidity, avoid complications and restore function.

There are clear analogies in the approach to climate change. Primary prevention corresponds to mitigation – efforts to slow, stabilize or reverse climate change by reducing greenhouse gas emissions. Although some measures have been taken in Italy to reduce greenhouse gases (mitigation), these are not enough. The recent fourth assessment report of the IPCC clearly states that the costs of mitigation of greenhouse gases can be offset by the benefits it will have for human health through the reduction of air pollution. Integrating air pollution abatement and climate change mitigation policies offers further potentially large cost reductions compared to treating those policies in isolation. Mitigation efforts will largely occur in other sectors other than health, such as energy, transportation and construction, although the health sciences can contribute useful information. Today, the knowledge on how to reduce greenhouse gas emissions is available, but until now it has not been widely implemented.

Secondary and tertiary prevention correspond to adaptation – efforts to anticipate and prepare for the effects of climate change, and thereby to reduce the associated health burden (Ebi, Burton & Menne, 2006; Menne & Ebi, 2006). Adaptation efforts correspond closely to conventional medical and public health practices. The latter will be more effective if integrated, for example, with long-term actions in the building sector and in structural flood protection.

Several well-established principles point to the need for vigorous, proactive public health approaches to climate change. Preparedness often occurs in the face of scientific uncertainty. Events such as an influenza pandemic, a terrorist attack or a hurricane cannot be predicted with precision, but protecting public health remains essential. The precautionary principle, as articulated at the 1998 Wingspread Conference, holds that: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically". The notion that steps to protect the public from the threats of climate change cannot await full scientific certainty is consistent with prevailing public health practice.

Public health can address a range of relevant activities, such as energy production and transportation, providing data from health impact assessments, decision support, and when appropriate, direct action to protect health. Economic considerations are critical in public health planning. The mandate to maximize health protection at the lowest short-term and long-term cost is highly relevant to climate change. The Stern Review, published by the United Kingdom HM Treasury in October 2006, estimated that annual flood losses in the United Kingdom could increase from 0.1% of gross domestic product today to 0.2–0.4%, and climate change could reduce global per capita consumption by 11% (HM Treasury, 2006).

5.2 Reduction of greenhouse gases: mitigation

Key messages

- The measures taken to reduce greenhouse gas emissions in Italy are not adequate.
- If human health were included in policy planning, the costs of greehouse gas mitigation could be offset by the benefits it will have for human health through the reduction of air pollution.
- Integrating air pollution abatement and climate change mitigation policies offers potentially large cost reductions compared to treating those policies in isolation.
- Lessons learned in other countries showed that combined examples of measures to reduce greenhouse gas emissions and air pollution are also reducing the use of resources through energy conservation, increasing energy efficiency, fuel switching, demand management and behavioural change.

The IPCC suggests a portfolio of measures to further reduce greenhouse gases. This includes changes in lifestyle towards reducing individual and collective ecologic footprints; upgrading energy infrastructure; investment into energy security; energy efficiency measures for vehicles, buildings and the electricity sector; renewable energy; biofuels; and a model shift in transport and carbon storage. Not all of them have the same potential for greenhouse gas reduction or growth. Some of them also have possible health impacts (nuclear energy and carbon storage) – but most of them combined in the long term would have multiple benefits for health.

Lifestyle changes can reduce greenhouse gas emissions. Changes in lifestyle and consumption patterns that emphasize resource conservation can contribute to developing a low-carbon economy that is both equitable and sustainable. Education and training programmes can help overcome barriers to the market acceptance of energy efficiency, particularly in combination with other measures. Changes in occupant behaviour, cultural patterns and consumer choice and use of technologies can result in considerable reduction in CO_2 emissions related to energy use in buildings. Transport Demand Management, which includes urban planning (that can reduce the demand for travel) and provision of information and educational techniques (that can reduce car usage and lead to an efficient driving style) can support greenhouse gas mitigation. In industry, management tools that include staff training, reward systems, regular feedback and documentation of existing practices can help overcome industrial organization barriers and reduce energy use and greenhouse gas emissions.

Upgrades of energy infrastructure in industrialized countries and policies that promote energy security can, in many cases, create opportunities to achieve greenhouse gas emission reductions compared to baseline scenarios. Additional co-benefits are country-specific but often include air pollution abatement, balance of trade improvement, provision of modern energy services to rural areas and employment. The widespread diffusion of low-carbon technologies may take many decades, even if early investments in these technologies are made attractive. Initial estimates show that returning global energy-related CO_2 missions to 2005 levels by 2030 would require a large shift in the pattern of investment, although the net additional investment required ranges from negligible to 5–10%. It is often more cost-effective to invest in end-use energy efficiency improvement than in increasing energy supply to satisfy demand for energy services. Efficiency improvement has a positive effect on energy security, local and regional air pollution abatement and employment.

Renewable energy generally has a positive effect on energy security, employment and on air quality. Given costs relative to other supply options, renewable electricity, which accounted for 18% of the electricity supply in 2005, can have a 30–35% share of the total electricity supply in 2030 at carbon prices up to US$ 50 per (metric) ton of CO_2 equivalent (US$ 50/tCO_2-eq). The higher the market prices of fossil fuels, the more low-carbon alternatives will be competitive, although price volatility will be a disincentive for investors. Higher priced conventional oil resources, on the other hand, may be replaced by high carbon alternatives such as from oil sands, oil shales, heavy oils and synthetic fuels from coal and gas, leading to increasing greenhouse gas emissions, unless production plants are equipped with carbon dioxide capture and storage (CCS). Given costs relative to other supply options, nuclear power, which accounted for 16% of the electricity supply in 2005, can have an 18% share of the total electricity supply in 2030 at carbon prices up to US$ 50/tCO_2-eq, but safety, weapons proliferation and waste remain a high constraint, in particular for human health. Carbon storage in underground geological formations is a new technology with the potential to make an important contribution to mitigation by 2030. Technical, economic and regulatory developments will affect the actual contribution. Carbon storage is not free of health effects – such as the effects of accidental release of CO_2 through leakages.

There are multiple mitigation options in the transport sector, but their effect may be counteracted by growth in the sector. Mitigation options are faced with many barriers, such as consumer preferences and lack of policy frameworks. Improved vehicle efficiency measures leading to fuel savings in many cases have net benefits (at least for light-duty vehicles), but the market potential is much lower than the economic potential due to the influence of other consumer considerations, such as performance and size. There is not enough information to assess the mitigation potential for heavy-duty vehicles. Market forces alone, including rising fuel costs, are therefore not expected to lead to significant emission reductions.

Biofuels might play an important role in addressing greenhouse gas emissions in the transport sector, depending on their production pathway. Biofuels used as gasoline and diesel fuel additives/substitutes are projected to grow to 3% of the baseline of total transport energy demand in 2030. This could increase to about 5-10%, depending on future oil and carbon prices, improvements in vehicle efficiency and the success of technologies to utilize cellulose biomass.

Modal shifts from road to rail and inland waterway shipping and from low-occupancy to high-occupancy passenger transportation, as well as land use, urban planning and non-motorized transport, offer opportunities for greenhouse gas mitigation, depending on local conditions and policies. Medium-term mitigation potential for CO_2 emissions from the aviation sector can come from improved fuel efficiency, which can be achieved through a variety of means, including technology, operations and air traffic management. However, such improvements are expected to only partially offset the growth of aviation emissions. Total mitigation potential in the sector would also need to account for non-CO_2 climate impacts of aviation emissions. Realizing emissions reductions in the transport sector is often a co-benefit of addressing traffic congestion, air quality and energy security.

Energy efficiency options for new and existing buildings could considerably reduce CO_2 emissions with net economic benefit. Many barriers exist against tapping this potential, but there are also large co-benefits (high agreement, much evidence). By 2030, about 30% of the projected greenhouse gas emissions in the building sector can be avoided, with net economic benefit. Energy efficient buildings, while limiting the growth of CO_2 emissions, can also improve indoor and outdoor air quality, improve social welfare and enhance energy security. Opportunities for realizing greenhouse gas reductions in the building sector exist worldwide. However, multiple barriers make it difficult to realize this potential. These barriers include availability of technology, financing, poverty, higher costs of reliable information, limitations inherent in building designs and an appropriate portfolio of policies and programmes. The magnitude of the above barriers is higher in the developing countries and this makes it more difficult for them to achieve the greenhouse gas reduction potential of the building sector.

The economic potential in the industrial sector is predominantly located in energy intensive industries. Full use of available mitigation options is not being made in either industrialized or developing nations (high agreement, much evidence). Many industrial facilities in developing countries are new and include the latest technology with the lowest specific emissions. However, many older, inefficient facilities remain in both industrialized and developing countries. Upgrading these facilities can deliver significant emission reductions. The slow rate of capital stock turnover, lack of financial and technical resources and limitations in the ability of firms, particularly small and medium-sized enterprises, to access and absorb technological information are key barriers to the full use of available mitigation options.

5.2.1 *Italy and action under the UNFCCC and the Kyoto Protocol*

The United Nations Framework Convention on Climate Change (UNFCCC) was ratified by Italy through Law No. 65 of 15 January 1994. As a party to the convention, Italy is committed to developing, publishing and regularly updating national emission inventories of greenhouse gases as well as to formulating, implementing, publishing and regularly updating programmes addressing anthropogenic greenhouse gas emissions. The Kyoto Protocol, adopted in December 1997, has established emission reduction objectives for Annex B parties (i.e. industrialized countries and countries with economies in transition). In particular, the European Union as a whole is committed to an 8% reduction within the period 2008–2012, relative to 1990 levels. For Italy, the EU burden sharing has established a reduction objective of 6.5% in the commitment period, in comparison with 1990 levels (Romano et al., 2005).

Subsequently, on 1 June 2002, the Italian Government ratified the Kyoto Protocol with Law No. 120. The ratification law prescribed also the preparation of a National Action Plan to reduce greenhouse gas emissions, which was adopted by the Interministerial Committee for Economic Planning (*Comitato Interministeriale per la Programmazione Economica* – CIPE) on 19 December 2002. The Kyoto Protocol finally entered into force in February 2005. In order to establish compliance with national and international commitments, the national greenhouse gas emission inventory is compiled and communicated annually to the competent institutions through compilation of the Common Reporting Format (CRF), according to the guidelines provided by the UNFCCC and the European Union’s Greenhouse Gas Monitoring Mechanism. Detailed information on emission figures, as well as estimation procedures, including all the basic data needed to carry out the final estimates, is requested in order to improve the transparency, consistency, comparability, accuracy and completeness of the inventory provided. The national inventory is updated annually in order to reflect revisions and improvements in the methodology and availability of new information (Romano et al., 2005).

Emission estimates include the six direct greenhouse gases under the Kyoto Protocol (carbon dioxide, methane, nitrous oxide, hydro fluorocarbons, perfluorocarbons, sulphur hexafluoride) which contribute directly to climate change owing to their positive radioactive forcing effect, and four indirect greenhouse gases (nitrogen oxides, carbon monoxide, non-methane volatile organic compounds, sulphur dioxide). The CRF files and other related documents can be found at the website www.sinanet.apat.it/aree/atmosfera/emissioni/emissioni.asp.

In order to comply with the targets set, Italy has to achieve a 6.5% reduction of greenhouse gas emissions by 2008–2012 relative to 1990 emissions. In other words, emissions should decrease from 519.5 million (metric) tons of CO_2 equivalent emissions ($MtCO_2eq$) of 1990 to 485.7 $MtCO_2eq$, so the "gap" to be filled amounts to 33.8 $MtCO_2eq$ by 2012. However, 2005 emissions amounted to 582.2 $MtCO_2eq$ (12.1 % more than in 1990) and projected emissions for 2010, under the "with measures" scenario, correspond to 587.3 $MtCO_2eq$. In other words, the overall "gap" to be filled in 2010 is 101.6 $MtCO_2eq$ (MATTM, 2006).

The general approach to achieving the Kyoto Protocol target comprises in the implementation of domestic policies and measures for at least 80% of the reduction effort and in the use of the Kyoto mechanisms such as credits from Joint Implementation (JI) and Clean Development Mechanisms (CDM) for not more than 20%. Considering that Italy has already bought credits of about 4 $MtCO_2eq$, the actual reduction effort of Italy is only 97.6 $MtCO_2eq$. Domestic policy and measures have to result in a reduction to at least 78 $MtCO_2eq$. The new government plans a revision of the CIPE 2002 plan with the aim of supplying operational indicators for coherent intervention measures.

Concerninig the implementation in Italy of EU Directive 2003/87/EC, which establishes a European exchange system of greenhouse gas emission allowances, the allocation decision for the period 2008–2012, which coincides with the first Kyoto commitment period, will set emission caps for the energy intensive sectors of the Italian economy. The basis for the 2008–2012 allocation decision is the National Allocation Plan which was finalized by the Ministry for the Environment, Land and Sea and by the Ministry of Economic Development and has recently (15 May 2007) been approved. It requires a further cut in emissions of 13.2 $MtCO_2eq$. This means that those sectors included in the EU Emission Trading Scheme (ETS) have to reduce their emissions by 37.4 $MtCO_2eq$ compared to the reference scenario, while other sectors have to apply a reduction of 29 $MtCO_2eq$.

The reference scenario includes, in particular, the effects of restructuring measures since 1999 in the context of the liberalization and privatization of the electric energy market. Regarding the production of electric energy from fossil fuels, a reduction of 8–9% in 1996 to 2005 has been achieved. This is mainly due to the introduction of Combined Heat and Power (CHP) plants using natural gas or gas derivates since 1999. These electric plants have an efficiency of up to 57% compared to the traditional ones (maximum 38%). Another 20 000 megawatts of electric capacity could derive from combined plants: out of these, 14 000 megawatts could be gained substituting old plants and 6 thousand MW by constructing new combined plants. Among the additional measures, the higher efficiency of the new plants has also been considered with another 3200 MW. For the production of electricity from renewable energy, Law No. 79/1999 establishes that 2% of electric energy (imported or produced from conventional sources) must stem from renewable sources. This equals more than 100 gigawatts per hour last year.

The additional policies and measures identified in the draft national strategy affect all economic sectors and all greenhouse gases. Examples of policies and measures in different sectors are the promotion of CHP and renewable energy (energy sector – supply), measures aimed at improving energy saving and energy efficiency (energy sector – industry, tertiary and residential), measures aimed at improving vehicle efficiency and the use of biofuels (energy sector – transport sector).

As concerns energy efficiency, the 2007 Budget Law includes measures aimed at supporting higher deductions from income tax for the expenses for building renovations, promoting the construction of buildings with very low energy consumption, providing incentives for refrigerators with A+ and A++ energy class labels and for high efficiency or variable-speed electric engines.

As concerns renewables, EU Directive 2001/77/EC establishes for the EU a target of 22.1% of total electricity consumption to be provided by renewable energy sources in 2010, and requests Member States to define their own targets. For Italy the share of electric energy produced by renewable sources should be at 25%. But despite several support measures (including a renewable energy obligation), it will be very difficult for Italy to reach this goal. Until now, the incentive system has not worked or has rewarded pseudo-renewables (co-generation, waste-to-energy schemes and electricity from oil tars). Only recently have the Minister for Economic Development and the Minister for the Environment, Land and Sea agreed to restrict incentives to real renewables. In addition to this, the very long and bureaucratic procedures to install alternative and decentralized plants have delayed the use of the wind and sun (photovoltaic and thermal energy) and this still remains marginal.

In the transport sector, which has several specific characteristics that do not favour the implementation of any measure aimed at reducing greenhouse gas emissions, an annual fund of € 100 million has been established for the period 2007–2009 by the 2007 Budget Law for the purchase of LPG- or CNG-fuelled vehicles and the conversion of old cars. A share of the consumption of biofuels will be exempted from excise taxes, in order to reach the target set by EU Directive 2003/30/EC, which requests Member States to replace, by 2010, at least 5.75% of their petrol and gas consumption with biofuels.

Measures in the agricultural and forestry sectors include the implementation of programmes and initiatives aimed at increasing the quantity and improving the management of forest areas and woodlands, reclaiming abandoned territories and the protection of territories that face instability or risk of desertification. These include:

- management of existing forests;
- re-vegetation of farmlands and grazing lands;
- natural reforestation;
- afforestation and reforestation in existing woodlands, in new areas and in areas subject to risk of hydro-geological instability.

As regards the implementation of these measures, it is worth noting that the political power related to energy questions has been transferred to the regions, which creates new conflicts and uncertainty regarding competences. For instance, the use of the wind and sun still remains marginal, mainly as a result of the very long and bureaucratic procedures to install alternative and decentralized plants. In order to develop an effective strategy, regional and local communities will have to take on board their responsibilities for the achievement of the Kyoto target, rather than focusing only on regional autonomy.

5.2.2 *International cooperation, clean development mechanisms and transfer of technology (CDM/TT)*

Italy has contributed US$ 90.5 million to the Global Environment Facility (GEF), ranking sixth among all contributors. Italy has recently responded to the third GEF call for funds, confirming its 4.39% share of total contributions. The so-called carbon tax law establishes that all national actions to reduce greenhouse gas emissions must be accompanied by a series of international cooperation programmes. One example is the cooperation programme with China. It aims to stimulate multilateral funding for environmental protection and renewable energy. Italian bilateral and multilateral official development assistance (ODA) in the environmental sector has been supporting the environmental institutions of developing countries and economies in transition in the transfer of know-how and capacity building through ad hoc co-financing schemes implemented with the World Bank, the GEF, and the multilateral regional development banks.

As regards scientific cooperation for the transfer of know-how, the Italian Ministry of Foreign Affairs, in cooperation with the Ministry of Education, University and Scientific Research, is supporting bilateral agreements with 43 developing countries and transition economy countries. Many of them include environment-related issues, such as climate change, terrestrial, coastal and marine ecosystems and clean energies, and are aimed at the exchange of information, researchers, methodologies and research approaches. No estimation of the ODA share of this contribution was available. At the private sector level, various Italian industrial and service companies are actively transferring low impact technologies and implementing projects aimed at the integrated management of natural resources and/or waste, also through co-financing schemes supported by national and local public institutions.

5.2.3 *Co-benefits for human health of greenhouse gas reductions*

A report from the EEA shows that action to combat climate change would deliver considerable ancillary benefits in air pollution abatement by 2030 (EEA, 2006). The ancillary benefits would be:

- lower overall costs of controlling air pollutant emissions, to the order of €10 billion per year;
- reduced air pollutant emissions, leading to less damage to public health (e.g. more than 20 000 fewer premature deaths/year) and to ecosystems.

In the Italian cities (Milan and Rome) taken into consideration in the EEA report, climate policies alone would not eliminate the exceeding of air quality targets, in particular as concerns PM_{10}. However, policies aimed at achieving long-term climate goals make it easier and significantly cheaper to reach long-term air quality goals.

There is plenty of low-cost mitigation potential between now and 2030 in the various sectors. Many local authorities have voluntarily set themselves targets to reduce local emissions of greenhouse gases. In many European countries, there is likely to be a decrease in emissions of most air quality pollutants and their precursors over the next 20–30 years, not because of a decrease in our use of fossil fuels, but because of improved technology. These improvements are driven by legislation and local regional actions.

The magnitude of the current health impact of air pollution estimated for 13 Italian cities in Italy underscores the need for urgent action to reduce its burden at urban level in particular. Compliance with EU legislation results in substantial savings by avoiding ill health, and it is important that the limits on PM_{10} introduced in Directive 1999/30/EC (EU, 1999) are met and that they should not be relaxed (a position recently taken by a large group of researchers in the field (Brunekreef & Forsberg, 2005).

Italy, however, is one of the EU Member States where this is still a challenge. In 2005, in Italy, many of the major cities had reached the allowed 35 days in excess of 50 µg/m3 of PM_{10} by the end of March; only some cities are in compliance with the annual average of 40 µg/m3 of PM_{10}; none is in compliance with the average value of 20 µg/m3 of PM_{10}, which is the limit to be reached in 2010. Within Europe, in general, the concentrations of PM_{10} decreased substantially between 1997 and 1999, but this decline has stopped in more recent years. Instead, there was a steady increase between 2001 and 2003. However, on average, levels in 2004 were lower than in 2003.

Substantial gains can be achieved through policies aimed mainly at reducing emissions from two sources: urban transport and energy production. A recent report prepared by APAT (2006a) showed that PM_{10} from road transport (excluding resuspended dust) represents the main source of total primary pollution.

The contribution of road transport is between 40% and 60% (average 51%) in all metropolitan areas, except Venice-Mestre, Trieste and Genoa, where there are large industries or harbours (or both) and where industrial activities account for most (from 66% to 81%) of total emissions.

On average, about 48% of PM_{10} primary emissions originate from industrial activities in northern metropolitan areas (Turin, Genoa, Milan, Venice-Mestre and Trieste), as compared with 15% in central and southern areas (Florence, Bologna, Rome, Naples, Catania and Palermo). Within the general policy goal of reducing emissions, attention should be given to local circumstances. In particular, PM_{10} concentrations observed in a WHO study were high in northern cities (50 ug/m3), compared with urban areas in central (43 ug/m3) and southern Italy (35 ug/m3). These differences are likely to be due mainly to differences in transport, industrial activities and heating-related emissions at the city level and also at the regional level, together with climatic factors. For example, the cities of the Po-Venetian Plain (Verona, Milan and Padua) have high concentrations of PM_{10} (59 ug/m3 annual average for the period 2002–2004), due to intense local urban traffic, intense regional traffic and intense industrial activities, combined with climatic conditions that limit the dispersion of pollutants. Under these circumstances, action taken by one municipality to reduce, for example, emissions from motor vehicles is likely to have modest results. Instead policy action at the regional level may be needed to achieve substantial gains in reducing concentrations of air pollutants and in improving health.

A recent review by the United Kingdom Department for Environment, Food and Rural Affairs (DEFRA) on climate change and air pollution pointed out that combined measures are essential to reduce both health effects and the effects on the climate system. Combined measures can be grouped under the following headings:

- conservation – reducing the use of resources through energy conservation, for example by improving the insulation in our houses;
- efficiency – carrying out the same activity, but doing so more efficiently, and so reducing the use of resources and emissions of air quality and climate active pollutants, for example by improving the efficiency of car engines;
- fuel switching – substituting a higher emission fuel with a lower emission fuel; the switch from coal to natural gas in power stations led to significant reductions in carbon dioxide emissions;
- demand management – implementation of policies or measures which serve to control or influence demand, for example the congestion charge in central London; and
- incentives and disincentives as tools for behavioural shifts – changes in the habits of individuals or organizations that result in reduced emissions, for example travelling by train instead of by air.

5.2.4 Action towards sustainable development

Closely related to the activities aimed at combating climate change are those linked to sustainable development. In February 2000, 51 local authorities signed up to the Aalborg Charter – the European Sustainable Cities and Towns Campaign. Through this adhesion, the 51 local authorities have acknowledged the existence of general environmental sustainability-related issues, such as social equity, adoption of sustainable land-use models, conservation of biodiversity, awareness of citizens and other stakeholders in environmental issues, and have assumed responsibility with respect to climate issues at the planetary level. A series of measures aimed at preventing pollution at the ecosystem level have been also adopted. However, there have been many difficulties and problems in the diffusion of Agenda 21 in many Italian central and southern regions. The information network is not available to all municipalities, which have no direct access to the European circuit and cannot show their interest in the issues in question. Many Italian municipalities have a combination of different views, but these are quite homogeneous from the economic-environmental point of view. A national plan for sustainable development was developed with the aim of providing a series of guidelines on sustainable development. Even if the plan does not directly mention climate change-related issues, it deals with many sectors directly or indirectly connected to climate vulnerability, through the analysis of some major environmental gaps at the national level.

There are a number of initiatives by APAT and the Italian National Agency for New Technologies, Energy and the Environment (ENEA). For example, APAT has established the GELSO Database for the local management of environmental sustainability. GELSO is an online database on good practices of local sustainability, which should serve as an effective working tool for public administrations, business enterprises, environmental associations, technical experts, environmental consultants and citizens interested in the latest innovations in the field of sustainable development. GELSO is designed to promote good practices by serving as an incentive for a process leading towards sustainable local development through the support of exchange of information, participation in projects, integration and planning, as well as the publicizing of innovative projects that have reached objectives of sustainability.

5.3 Adaptation to climate change

Key messages

- It is necessary to evaluate future risks to human health from climate change.
- It is necessary to create and enforce collaboration among health scientists and stakeholders, experts on the environment and civil protection, central and local government and health services.
- Multidisciplinary expert groups on health and the environment should be set up to contribute to the process of validation of priority action and adaptation options.
- Local case studies could be planned to assess examples of policy integration with the aim of strengthening public health and minimizing the costs of inaction.

Adaptation will be increasingly necessary. Even if atmospheric greenhouse gas concentrations remain at 2000 levels, past emissions are estimated to generate warming of about a further 0.6°C by the end of the century.

Although a broad range of adaptation options is available, there is a need for more systematic adaptation. As the IPCC states in its most recent assessment, although many early impacts of climate change can be effectively addressed through adaptation, the options for successful adaptation diminish and the associated costs increase with increasing climate change.

At the moment, some European countries have taken adaptation measures, for example in infrastructure planning, such as coastal defence in the Netherlands. In other countries, response systems to heat-waves and early warning systems have been developed.

At present we do not have a clear picture of the limits to adaptation, or the cost, partly because effective adaptation measures are highly dependent on specific, geographical and climate risk factors as well as institutional, political and financial constraints.

The array of potential adaptive responses available to human societies is very large, ranging from the purely technological (e.g. sea defences), through behavioural (e.g. altered food and recreational choices), to managerial (e.g. altered farm practices) and policy practices (e.g. planning regulations).

There has been growing interest in adaptation to projected climate change and associated impacts in Europe, such as the development of national adaptation plans (United Kingdom and Finland). Even though an explicit national adaptation policy framework is absent, adaptation measures and activities are taking place in many countries, often in the contexts of natural hazard prevention, environmental protection and sustainable resource management. These measures are often initiated on an ad hoc basis from a sectoral viewpoint (e.g. water resource management) and implemented by different sectors and organizations (e.g. local authorities), often prompted by the impacts of recent extreme weather events. This represents the situation in most European countries, such as Austria, France, Sweden, the Netherlands, Belgium, Italy and Switzerland. Proactive policies and measures designed to address long-term climate change and its impacts are still to be developed in many countries (EEA, 2005b).

5.4 Public health adaptation actions to address climate change

Before looking at adaptation actions in the field of public health, four questions have to be considered.

1. What is the observed effect of climate change on health?
2. Which of the measures currently available are effective?
3. What are the expected impacts on health in Italy?
4. What additional measures and infrastructure are needed in the face of climate-related health risks?

In this report we have achieved a preliminary evaluation of the problem and identified some risks. Table 11 therefore summarizes the threats from the different climate change scenarios as described in Chapter 2, the effects on the environment (Chapter 3) and health (Chapter 4) and points out the high risk populations, potential further damage to health and necessary adaptation measures.

This report, limited by the scarcity of data available, briefly describes what would be necessary in theory. A more complex reflection not only needs a more comprehensive analysis of the available interventions, but also a more systematic approach at the national level. In order to achieve this, it is important to strengthen the network of collaboration between health professionals along with other stakeholders, experts on climate change and environmental and civil protection, and central and local authorities dealing with health and environmental information systems.

A multidisciplinary working group could use the model of integrated risk management developed by the Treasury Board of Canada Secretariat 2001. This includes nine steps:

1. identifying issues and setting the context
2. assessing key risk areas
3. measuring likelihood and impacts
4. prioritizing risks
5. agreeing on desired results
6. developing options
7. selecting a strategy
8. implementing the strategy
9. monitoring, evaluation and adjustment.

One of the weaknesses in applying this approach is the lack of a systematic and comprehensive evaluation of future health risks. This makes the prioritization of action and the assessment of the results of inaction and co-benefits of prevention a more complex issue.

Table 11: Health effects and adaptation proposals

Climate change effect	Health effect	Areas and populations most affected	Additional risk to Italy	Adaptation (not in the health sector)	Adaptation (in the health sector)
Increase in the frequency, duration and intensity of heat-waves	Mortality and morbidity	The elderly and frail	3000 more deaths/year by 2030	Early warning for heat-waves	Heat/health action plans; public health preparedness; awareness raising; information for different groups (physicians, vulnerable populations, media); revision of urban infrastructure and architecture
Intense precipitation events (risk of floods)	Respiratory and infectious diseases; post-traumatic stress disorders	Coastal populations; populations living along rivers, e.g. Po	4500 km_2 of coastal areas are at risk, half of the Italian population	Structural and non-structural measures	Flood health action plans; awareness raising; simulation exercises; surveillance system and monitoring
Droughts	Water- and foodborne diseases	In particular southern Italy and islands	Water stress increases by 25%	Wastewater reuse; desalinization	Water and food quality control; surveillance and monitoring
Reduction of frost days	Potential of survival and reproduction of tropical vector species	In particular in southern Italy	-	-	-
Increase in sea and lake temperature	Algal bloom and cyanobacteria	Along Italian coasts and major lakes	Algal bloom outbreaks in summer		Surveillance and monitoring; early warning; public information; summer preparedness planning
Sea level rise	Same as floods – depending on rapidity	In the upper Adriatic Sea, the coastline between Ancona and Pescara; the coasts near Rome and Naples; Gulf of Manfredonia, coasts between Taranto and Brindisi, eastern-southern Sicily – 6.6% of coast in Sardinia.	4500 km_2 of coastal areas are at risk	Relocation of settlements; coastal reinforcements	Flood health action plans; awareness raising; surveillance system and monitoring
Increase of water stress	Water- and foodborne diseases	All		Wastewater reuse; desalinization	Summer preparedness planning; surveillance and monitoring
Increase of wild fire risk	Burning injuries; respiratory diseases	All	55 000 ha of woodlands	Population awareness-raising; civil protection services	Preparedness of emergency medical services
Lengthening of plant growing season and pollen season	Anticipation in season of allergic disorders	All	Northern Italy	-	Early warning; pollen forecasting
Altitudinal and latitudinal shift of ecosystems, plants and animals	Potential invasion by new allergenic plants, pests and movement of vectors	Northern Italy and Appenines	Leishmania; West Nile fever; boutonneuse fever; dengue fever, malaria, TBE and others	Vector control	Vector control and early detection of diseases; surveillance

Increase in electricity demand in summertime	Potential cut-offs in hospitals	All	Potential cut-offs	Summer preparedness planning	Hospital and retirement homes to have electricity generators
Changes in air pollution concentrations in cities in summertime	Mortality and cardiorespiratory diseases	All major cities	All Italian cities	Conservation; efficiency; fuel switching; demand management; education	Emergency medical services
Delay in ozone recovery	Potential increase in number of skin cancer and cataract problems	All	All Italy	Greenhouse gas reduction	Avoid sun; use of sunscreens; medical and public education

The cCASHh project (Climate Change and Adaptation Strategies for Human Health) identified specific areas of public health services which need to be revised, strengthened or developed namely: **early warning, assessment (research and monitoring), policy development and service assurance**. This section analyses what would theoretically be necessary and what is currently available in Italy.

5.4.1 *Early disaster warning systems*

Gradually, there has been a growing global awareness of the importance of early warning systems. During the Second World Conference on Disaster Reduction (Hyogo, Kobe, Japan, January 2005) 168 countries adopted the Hyogo Framework for Action 2005-2015 (HFA) and identified five high priority areas, of which the second stressed the need for "identifying, assessing and monitoring disaster risks and enhancing early warnings", as a critical component of disaster risk reduction. Furthermore, the HFA stressed that disaster risk reduction must be addressed through an integrated and multi-hazard approach.

At the United Nations World Summit, held in New York in September 2005, governments requested the establishment of early warning systems for all natural hazards, building on existing national and regional capacities to complement broader disaster preparedness and mitigation initiatives. Opportunely, the preliminary report of the Global Survey of Early Warning Systems, which was requested by the United Nations Secretary-General, has confirmed that while there has been substantial progress, many gaps and challenges still remain. At European level few early warning systems are available, most of them generated by the national weather services. For example the German weather service produces pollen, wind and heat forecasting and a number of other services.

In Italy, since 2003, the Italian Department for Civil Protection has implemented a network of alarm systems for the prevention of the effects of heat on health during the summer in major urban areas. These are able to predict dangerous weather and the public health impact up to three days in advance (HHWWS – www.protezionecivile.it). They are accompanied by "real time" surveillance systems for monitoring the impact of heat on mortality and evaluating the performance of warning systems and the introduction of national and local prevention programmes. At the moment the systems cover 31 cities: in 17 the system is in operation and in 14 it is in the experimental phase.

At a national level, the National Centre for the Prevention of Heat Health Effects (NCC) coordinates the project and is responsible for data collection, the running of surveillance systems, as well as the development and production of daily warning bulletins. Warnings are distributed throughout the network to all the local centres, where the local organization in charge (civil protection, municipality, etc.) coordinates the local information network and activates prevention programmes. Alongside the national project and the warning systems each city is free to develop and adopt local warning systems, as has been done in Turin and the Piedmont region, Florence and the hinterland of the Bologna and Reggio-Emilia region as well as in other cities in which the warning system is being run experimentally.

Since 2005 the Ministry of Health has launched the "Piano Operativo Nazionale per la Prevenzione degli Effetti del Caldo sulla Salute". Its main objectives are the definition of national prevention guidelines and methods of identification of susceptible populations, the creation of a network for the distribution of heat warnings to health workers and the general population as well as the evaluation of the effectiveness of existing interventions.

The efficiency of these interventions will be evaluated over time and changes will be made according to risk management principles. Therefore, it will be necessary not only to assess the process but also to define criteria to assess the efficiency of the action taken. An information service for special groups such as physicians, managers of hospitals, care homes, social services and vulnerable populations is planned.

Furthermore, it would be interesting to look at examples from other European countries and to complete a review on the feasibility of other alarm systems (pollen, intense rainfall, storms, fires) for the benefit of public health in Italy. In this context it has to be highlighted that at European level there is also a lack of action plans and information on how to avoid health risk from flooding and fire.

5.4.1.1 Early detection of health impacts

Early detection of the health impacts of extreme weather events and climate change is important to plan interventions. In Italy there are two initiatives, which are described here.

Italy has activated a real-time daily heat-related mortality surveillance system whose aim is to provide real-time mortality data in order to identify increases in mortality associated with heat-waves very rapidly. Mortality surveillance systems are activated in all cities which have a warning system for the period 15 May to the 30 September. Anonymized information on gender, age, place of residence and death are collected from the local mortality registry offices. A city-specific mortality baseline is defined on the basis of a time series of registered deaths, taking into account the month and day of the week.

The difference between the baseline and daily mortality is calculated by gender and age group (0–64, 65–74, 75+) to estimate the potential daily excess of deaths associated with high temperatures. In most cases, mortality counts are complete within 72 hours, providing a high quality database which is readily usable. Since the implementation of the system in 2004, daily excess mortality has been observed mainly in the population over 75 years of age.

Results from the HHWWS and data from the daily mortality surveillance system allow the identification of real peaks in mortality occurring in the resident population. The immediate identification of excess mortality during the summer allows for the detection of summer health emergencies and the activation of rapid health care response plans. Furthermore, daily mortality data are included in forecasting models to predict expected mortality associated with temperature taking into account the death counts of previous days. Moreover, the daily mortality trend is useful to validate HHWWS and in the evaluation of prevention programmes.

The Italian Ministry of Health manages an information system on communicable diseases governed by the Ministerial Decree of 15 December 1990, which is currently under review. The decree identifies five classes of priority diseases, each defined by the timing and method of reporting

(Table 12). The main source of information on the incidence of communicable diseases is the statutory notification system, which provides for the immediate notification of any new cases of communicable diseases in class I, even if only suspected, by the physician to the Local Health Unit (LHU). Each of the 197 LHUs is responsible for preparing cumulative tables and forwarding, by ordinary mail, the case report forms (CRFs) every month to the regional health authority, which in turn is responsible for forwarding the data, using the same procedures, to several central-level institutions (the Ministry of Health, the National Institute of Statistics (ISTAT), and the National Institute of Health).

Table 12: Communicable diseases according to the Italian Decree (1990)

AGENT	ITALIAN DECREE (1990) DISEASE	WATER-BORNE REPORTING (WHO)
	CLASS I	
Vibrio Cholerae	1) cholera	primary importance
Flavivirus	2) yellow fever	
Borrelia recurrentis	3) epidemic recurrent fever	
arenaviruses, filoviruses, bunyaviruses, and flaviviruses	4) viral haemorrhagic fever	symptoms of diseases of unknown aetiology
Lassa virus	Lassa	symptoms of diseases of unknown aetiology
Marburg virus	Marburg	symptoms of diseases of unknown aetiology
Ebola-virus	Ebola	
Yersinia pestis	5) bubonic plague	
Poliovirus 1-2-3	6) poliomyelitis	symptoms of diseases of unknown aetiology
Rickettsia prowazekii	7) Epidemic typhus	primary importance
Clostridium botulinum	8) botulism	symptoms of diseases of unknown aetiology
Corynebacterium diphtheriae	9) Diphtheria	
Orthomixovirus (types A, B, and C)	10) viral flu	
Lyssavirus	11) rabies	
Clostridium tetani	12) tetanus	
Trichinella spiralis	13) trichinosis	
	CLASS II	
Neisseria gonorrhoeae	14) gonorrhoea	
Brucella melitentis, Brucella abortus suis	15) brucellosis	symptoms of diseases of unknown aetiology
Escherichia coli	16) diarrhea	primary or secondary importance
Giardia lamblia	Giardiasi	secondary importance
Cryptosporidium	Cryptosporidiosis	secondary importance for WHO
Escherichia coli (ETEC, EPEC, EIEC, EHEC)	Enteric E. coli or Diarrheal diseases	primary importance for WHO
Enterovirus Hepatitis A	17) hepatitis A	primary importance for WHO
Hepatitis B virus (HBV)	18) hepatitis B	symptoms of diseases of unknown aetiology
Hepatitis C virus (HCV	19) hepatitis C	
hepatitis E virus (HEV), Hepatitis G	20) hepatitis not specified	symptoms of diseases of unknown aetiology
Salmonella typhi, Salmonella paratyphi A-B-C	21) thypoid fever	primary importance for WHO
Legionella pneumophila	22) legionellosis	symptoms of diseases of unknown aetiology
Protozoa Leishmania	23) leishmaniasis cutaneus	symptoms of diseases of unknown aetiology
Leishmania	24) leishmaniasi visceral	symptoms of diseases of unknown aetiology
Leptospira interrogans	25) leptospirosis	symptoms of diseases of unknown aetiology
Listeria monocytogenes	26) listeriosis	symptoms of diseases of unknown aetiology
herpes simplex viruses, arboviruses and enteroviruses	27) brain fever	symptoms of diseases of unknown aetiology
Neisseria meningitidis	28) bacterial meningitis	
Paramixovirus (Morbillivirus)	29) measles (rubeola)	
Paramixovirus (Mumps virus)	30) mumps (epidemic parotitis)	
Bordetella pertussis	31) pertussis (whooping cough)	
proteobacteria Rickettsia	32) rickettsioses	
Rubivirus	33) rubella (german measles)	
Enterobacteriaceae	34) nontyphoid salmonella	symptoms of diseases of unknown aetiology
Group A streptococcal infection	35) scarlet fever	
Treponema pallidum	36) syphilis	
Pasteurella tularensis	37) tularemia	symptoms of diseases of unknown aetiology
Varicella-zoster virus (VZV)	38) Chickenpox	
	CLASS III	
H.I.V. 1 e 2	39) AIDS	
Mycobacterium laprae	40) hansen's disease	
Plasmodium vivax, Plasmodium falciparum, Plasmodium malariae	41) malaria	
M. avium complex, M. kansasii, M. absussus, etc.	42) Mycobacteria other than tuberculosis	
Mycobacterium tuberculosis, M. bovis e M. leprae	43) tuberculosis	
	CLASS IV	
Microsporum, Trichophyton and Epidermophyton.	44) dermatophytosis	
Campylobacter, Salmonella, E. coli O157:H7, Norwalk-like viruses	45) food illness and infections	symptoms of diseases of unknown aetiology
Pediculus humanus capitis	46) pediculosis	
Sarcoptes scabiei	47) scabies	
	CLASS V	
	ZOONOSIS (DPR 1954, n. 320)	secondary importance
Campylobacter	Camphylobacteriosis	secondary importance
Caliciviridae (Norwalk-like viruses)	Calicivirus infections	secondary importance

The Communicable Diseases Unit of the Ministry of Health collects, from every Italian region, the reports of transmissible diseases according to the reporting system provided by the body of laws on health and by the 1990 decree. The Ministry of Health reports to ISTAT only the confirmed cases. Classes IV and V of infectious diseases should be reported to the local health authorities only when the outbreak occurs. Action is taken immediately the report is received through direct contact with the public health organizations verifying that inclusion criteria are respected and that the case is really part of a potential outbreak. At the same time the completeness and correctness of the information is verified (completion of relevant CRFs).

Several problems have been identified: the reporting forms for each class of disease indicated in the Italian decree (1990) include only health data as well as the aetiology of the disease (agent, incubation period, duration of the illness), the specimens examined from patients and the history of the exposed persons. Environmental data (type of exposure and source, characteristics of the exposure and source) are not indicated on the reporting forms. Although most relevant data from CRFs are eventually entered into a computerized database at ISTAT, the national database (Ministry of Health) is only available 3–4 years later and no data quality control is performed at that time.

During the years 1997–2001 between two and twelve outbreaks were detected annually but due to the high level of heterogeneity in information collection between regions data are likely to have been underestimated. The Italian decree (1990) identifies the source and vehicle of infection only in the case of epidemics. Data have not been used to plan preventive measures involving all the institutional actors. In most regions, all data are recorded manually on hard copy. Non-notifiable waterborne diseases are not monitored in Italy. A project is currently under way to create a national observatory on water and health to rationalize and integrate information systems at a national level (Italian Water and Health Observatory). The project should contribute to the rationalization and integration of the whole waterborne disease surveillance system.

The new International Health Regulations which will come into force in June of this year (2007) will require mandatory reporting of certain diseases and syndromes across Europe and beyond and may well provide the much needed surveillance input. Additionally, integrating data from various sources is important, such as, for instance, from environmental, satellite remote sensing data and health.

Box 3: International Health Regulations (2005)

In May 2005, the 192 member states of WHO unanimously adopted a significantly revised and modernized version of the International Health Regulations (WHO, 2005b), which constitute the only legal framework governing the reporting of outbreaks and prevention of their international spread. The revised regulations recognize 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. The scope has been expanded accordingly, and now encompasses all public health emergencies of international concern, including those caused by chemical agents and radionuclear materials. Second, reporting requirements and time frames have been tightened, reflecting the heightened sense of urgency and the greater speed allowed by electronic communications. Third, 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 recognized. 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 recognize 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. The IHR (WHO, 2005b) has come into force in June 2007.

5.4.2 *Assessment*

Assessing the impacts of global warming includes researching and understanding the effects and monitoring of trends over time.

5.4.2.1 Research

Research into the present and future effects of climate change on human health is not well developed. These are a few examples of research activities at the European level.

- The European Commission funded a research programme, cCASHh, under its Fifth Framework Programme (FP5) to systematically investigate the ways climate change affects human health, and to identify policies and strategies for adaptation in Europe.
- The PHEWE project, coordinated by the ASL3 group in Rome, assessed the health effects of heat and cold in European cities, including three Italian cities.
- The EDEN project, with the participation of the Italian National Health Authority (Istituto Superiore della Sanità) is evaluating the effects of global changes on vector-borne diseases. Results are expected in 2009.

Italian participation in research programmes continues to be active within the Framework Programmes of the European Union, in particular those linked to environmental issues. International projects include: PREDICATE, DEMETER, EARLINET, FUTURE-VOC, CARBOEUROFLUX, CONECOFOR, RECAB, PRISM, MEDACTION, MWISED, MEDRAP, PREDESODI, DESERTLINK, WEYBURN, CIRCE and ENSEMBLES, among others. It has to be mentioned, however, that there is no database summarizing the final results, allowing regions and countries to access outcomes. Activities in the field of impact studies are mainly concentrated on the study of the effects of sea level changes due to climate change in the Italian coastal areas. In recent years, Italy has made relevant progress in the analysis of ecosystems, and, in particular, an ecological model of the Adriatic Sea has been developed in order to estimate the impact of climate change. Italy is active in international projects aimed at understanding the evolution of desertification in the Mediterranean through the analysis of proxy data. Further activities are related to the study of response strategies to desertification and mitigation strategies for the management of water and agricultural resources under increased environmental, social and economic stress.

An Italy-United States bilateral agreement has also been set up as a framework for cooperation in the promotion of scientific research on climate variability, its uncertainties and ecological, technological and health implications.

At national level in the past few years the actions of the Italian Government have also included ad hoc funded initiatives. In 1999 Decree 381/1999 established a new research organization, the National Institute of Geophysics and Volcanology (INGV), with a special focus on the scientific aspects of climate change and carbon sequestration using a geo-engineering approach.

In 2000, CIPE approved the National Research Programme (Programma Nazionale per la Ricerca) which set up the criteria for the Strategic Programme for Sustainable Development and Climate Change (Programma Strategico Sviluppo Sostenibile e Cambiamenti Climatici) to meet research needs in fields such as:

- the study of the evolution of climate variability and its impacts on the urban, agricultural and forestry sectors;
- regional studies of climate variability and regional modelling and impacts on water ecosystems, fishery resources, biodiversity and soil degradation;
- regional studies on vulnerability of coastal zones and impact evaluations;
- monitoring, assessments, simulations and predictions of the evolution of agricultural systems in relation to climate change;
- carbon sinks;
- studies of the oceanic carbon cycle;
- sustainability of renewable resources.

This programme has been funded by the Integrated Special Fund for Research (Fondo Integrato Speciale per la Ricerca – FISR). Health impacts are not directly addressed within these research programmes.

Furthermore, this three-year programme, started in 2006, includes the creation of a new research infrastructure, the Euro-Mediterranean Centre for Climate Change, (Centro Euro-Mediterraneo per i Cambiamenti Climatici – CMCC), which is a network of public and private research centres focused on research into climate change and the impacts of climate change in the Mediterranean area. The main activities of this programme are to develop future climate change scenarios for the Mediterranean. Although health is mentioned, the actual programme permits only a very limited analysis.

This assessment has shown that a lot of information is available – but fragmented and scattered among many sectors and services. There are also many knowledge gaps concerning the interaction of climate change and human health. It would be interesting to create a single and comprehensive information system making the research results relevant to Italy available and visible. Furthermore, research activities should increasingly focus on relevant health aspects.

5.4.2.2 Monitoring

Monitoring is "the continuous or repeated observation, measurement and evaluation of health and/or environmental data for defined purposes, according to prearranged schedules in space and time, using comparable methods for sensing and data collection" (IUPAC glossary draft). Climate change/health monitoring should be able to detect early health impacts of climate change; to improve quantitative analysis of the relationships between climate and health; to improve analysis of vulnerability to climate change; to assist in the prediction of future health impacts of climate change and to validate predictions.

At a WHO meeting in 2001 on climate/health monitoring, several criteria for selection were discussed. The principal criterion for such selection should be evidence of climate sensitivity, demonstrated either through observed health effects of temporal or geographic climate variation, or through evidence of climate effects (e.g. temperature, rainfall, humidity) on components of the disease transmission process in the field or laboratory. For infectious diseases, detailed knowledge of transmission cycles is essential in selecting priority diseases. Climate change effects are likely to be most profound for diseases caused by organisms which replicate outside their human hosts (where they will be subject to ambient conditions), and will be less important and/or difficult to detect for those where human-to-human transmission is common. Monitoring should also be preferentially targeted towards significant threats to public health. These may be diseases with a high current prevalence and/or severity or those considered likely to become prevalent under conditions of climate change. Surveillance normally targets those infectious diseases where a preventive strategy, such as vaccination, is available.

However, it may also be useful to look at other diseases where high quality data are available, in order to test the methods used to detect early evidence of climate change; to establish the plausibility of the methods/task/question; and to provide any evidence on early effects of climate change on human health. Consideration should be given to whether a proposed system is likely to generate the data necessary to permit a clear analysis of climate sensitivity, given potential problems of data quantity, quality and reliability. The system needs to be sustainable on a long term basis. Networks are only sustainable where a common aim and purpose have been agreed and are constantly reinforced. Table 13 shows the exhaustive list of criteria for monitoring.

For many diseases transmitted through food, water or vectors, the usefulness of available monitoring data is limited by:

- temporal and geographic variation in diagnosis, case definition and completeness of case ascertainment, as well as reporting efficiency and completeness;
- lack of accurate recording and quantification of the effects of non-climatic causal factors and of adaptation strategies;
- insufficient temporal or geographic resolution in health data and their non-climatic risk and protective factors.

Table 13: Criteria for selecting potential diseases for climate change surveillance

Criterion	Reason for importance	Notes
Suitable for continuous surveillance	Need time series for comparison with climate factors	Low frequency infections suitable for detailed outbreak surveillance e.g. *Legionella*
Established etiology	Need to distinguish direct climate effects from other known factors	Etiology established for most prevalent infections
Environmental sources	Infections with strong environmental aetiology most likely to be affected by climate factors such as thermal/rainfall variation and extreme events e.g. floods and heat-waves	Particularly waterborne diseases and those sensitive to temperature changes
Low or no case-to-case transmission	Strengthens association with environmental exposure	E.g. malaria, *Campylobacter*, tick-borne encephalitis
Sustainable	Surveillance unlikely to be considered cost-effective for infections that are not routinely measured, or those with low clinical importance; sentinel surveillance methods may be considered	Need to agree surveillance priorities and to examine feasibility of using existing surveillance systems
European network already in existence	Increases feasibility	E.g. ENTERNET for *Salmonella*, *E. coli* and EWGLI for *Legionella*. Integration of existing EU networks considered by European Parliament; WHO Regional Office for Europe to associate
Disease occurs naturally in Europe	Increases feasibility	Travel-associated or infrequently occurring infections may be suitable e.g. cholera
Public health and preventive measures available	Justifies effort	E.g. vaccination or control measures such as improved sanitation and temperature control of foods

Source: WHO Regional Office for Europe, 1998

One of the important aims for future monitoring should be to address these limitations. In some cases this may be achieved through revision of existing health data sets and linkage to climate records. For many climate-sensitive diseases, however, the coverage or quality of available data precludes this approach. From the review available we concluded that in most cases, a strengthening of current monitoring systems would be a useful option to further monitor trends over time.

At the moment in Italy only the impacts of heat-waves on human health are monitored: Time series analysis of daily mortality data for just a few (4–10) years provides an estimate of the mortality attributable to low and high temperatures. Long series of daily meteorological data are easily available. Combined with models of temperature–mortality relationships, such data can be used to provide quantitative estimates of the impact of a change in the frequency of "hot" days on heat-attributable mortality.

The monitoring of climate parameters is much more advanced. APAT, in the framework of the national environmental information system, developed an ad hoc initiative to implement climate information named SCIA, in collaboration with the national weather service. The aim is to establish a common procedure for calculating, updating and representing climatological data useful to show the state of the climate and its trends. The main meteo-climatological variables taken into account are: temperature, projected temperature, equivalent potential temperature, precipitation, relative humidity, wind, water balance, bioclimatological index, insulation, potential evapotranspiration, daily maximum and minimum temperatures, fog and visibility, cloudiness, atmospheric pressure and global radiation. For each variable ten-day, monthly and annual indicators are calculated and are available on the web (http://www.scia.sinanet.apat.it). The second 2006 report is in progress.

Some existing monitoring activities will be expanded to climate change health risks. Current estimates of the future impact of climate change on air pollution concentrations, based on atmospheric modelling (large-scale) suggest that for Europe, summertime pollution episodes of tropospheric ozone and PM pollution may increase. It is suggested that ozone and PM concentrations should be monitored in summertime and also associated health effects in urban areas in Italy. An indicator for "ozone episodes" that combines a temperature component could be developed.

There is a need to monitor *Salmonella* and *Campylobacter*, *Cryptospiridia*, *Verotoxin-producing E. coli* (VTEC) and *Shigella*. There exist two systems in Italy for the surveillance of salmonellosis. Firstly, the National Laboratory-based Surveillance System (NLSS) which was created in 1967 for enteropathogenic bacteria and subsequently, in 1992, became part of the European computerized laboratory-based surveillance system of salmonellae isolates, the SALM-NET (network for human salmonella surveillance in Europe); and secondly the National Infectious Disease Reporting System (NIDRS) which was set up in the 1930s, revised in 1990 and has been used, since 1994, along with the Infectious Disease Informative System (IDIS) (Scuderi, 2000). Nowadays, the data is available from the Ministry of Health. In Italy no studies have been carried out so far to link changing climate with rates of infection of salmonella and other enteric infectious diseases.

A WHO study reveals that, in Italy, 100% of the urban population and 97% of the rural population have access to water. 20% of the bathing water does not satisfy bathing water standards. 70% of the population has access to sanitation. Surveillance of the endemic burden of water-related disease is important to set overall targets and monitor progress towards these targets.

One of the tools in place is the Protocol on Water and Health (see Box 4) of the Convention on the Protection and Use of Transboundary Watercourses and International Lakes. It has just come into force and its objectives are to protect human health through improving water management and preventing, controlling and reducing water-related diseases as outlined in Table 14. Italy has not yet ratified the protocol but is actively involved in all technical tasks supporting the protocol and its implementation including the development of the 2007–2009 workplan.

Box 4: Protocol on Water and Health

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 wholesome 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.

The responsibility for coordinating waterborne surveillance varies among the EU countries. In most of the countries waterborne disease surveillance is governed by national laws as part of the National Health Service. In a few countries coordination is carried out by national surveillance centres. It would be pertinent to include meteorological data and to establish some long-term studies. The questions to understand are whether there are changes in seasonal peaks, in onset and distribution of diseases and if new diseases appear.

Table 14: Priority waterborne diseases in the Protocol on Water and Health

Diseases	Protocol on Water and Health
Cholera	Diseases of primary importance
Bacillary dysentery (Shigellosis)	Diseases of primary importance
Enterohemorrhagic *Escherichia coli* (EHEC)	Diseases of primary importance
Typhoid fever	Diseases of primary importance
Viral hepatitis A	Diseases of primary importance
Campylobacteriosis	Disease and infections of secondary importance
Cryptosporidiosis	Disease and infections of secondary importance
Giardia intestinalis	Disease and infections of secondary importance
Calicivirus	Disease and infections of secondary importance
Acute gastrointestinal diseases	Symptoms of diseases of unknown aetiology
Severe and acute diarrhea	Symptoms of diseases of unknown aetiology
Vomiting	Symptoms of diseases of unknown aetiology
Continuous fever	Symptoms of diseases of unknown aetiology
Bradycardia	Symptoms of diseases of unknown aetiology
Jaundice	Symptoms of diseases of unknown aetiology

5.4.3 *Policy development*

Policy development is mainly carried out by empowering people, mobilizing partnerships and developing policies.

5.4.3.1 Inform

The key document to refer to for actions on education, training and public awareness with regard to climate change is the deliberation No. 218/99 of 21 December 1999 of the CIPE, which has the objective to define an action plan for environmental information in the field of climate change. This action plan includes in particular:

- the presentation and dissemination of the main documents under the IPCC and the UNFCCC, together with Italian national documents and programmes regarding the implementation of the commitments under the UNFCCC and the Kyoto Protocol;
- the dissemination of scientific information about the vulnerability of Italy related to scenarios of future climate change;
- the dissemination of technical information about energy efficiency of industrial processes, of products and the end-uses;
- the promotion of information programmes at the local level aimed at the dissemination of best practices and techniques for energy saving adopted by local administrations; the section also synthesizes activities undertaken by the central and many local governments, in particular in collaboration with organizations and municipality networks such as ICLEI ((International Council for Local Environmental Initiatives/Local Governments for Sustainability), the Climate Alliance and the Coordination of the Local Agenda 21 and the initiatives promoted by environmental NGOs.

As already mentioned above, the activities do not include systematic health information related to climate change.

NGOs such as WWF-Italy, Legambiente, Amici della Terra, together with other groups operating in Italy under the direct sponsorship of associations that deal with environmental matters, have assumed an important role in informing citizens and promoting their participation in decisions about initiatives to mitigate the effects of climate change. Reinforcement and financing, eventually through the supply of expertise, in support of campaigns designed to raise awareness, similar to those carried out by ICLEI, Climate Alliance and the Coordination of the Local Agenda 21, seem to be necessary. In addition, NGOs have a fundamental role in defining programmes aimed to promote energy saving, education, training and public awareness concerning the creation of sinks and changes in lifestyles. Synergy is needed between such programmes and the general objectives to be defined for the purpose of implementing the Kyoto Protocol.

ENEA has established the first Living Museum of Environmental Technology. Among its activities is the promotion of increased public awareness of climate change. The Living Museum of Environmental Technology is characterized by its innovative structure which leads the visitors through the different interactive sections of the museum entertaining them with multimedia games, scientific experiments and fascinating film shows. ENEA contributed with its technical scientific support to the realization of the section "climate and energy" aiming to facilitate the understanding of issues that are considered difficult and complicated. The aim is to explain to the public the meaning and the significance of "climate change" and "energy-related issues". In this way, it should be easier to raise awareness of unsustainable developments and of related individual and collective responsibilities. Health perspectives and arguments could be included in this activity.

From a public health point of view, the reduction of the burden of climate-sensitive diseases requires a major effort in mobilizing partnerships. An example is provided by the activities carried out within the national prevention programme for the definition of heat health effects set up by the National Centre for the Prevention and Control of Diseases (Centro nazionale per la prevenzione e il controllo delle mallatie – CCM) of the Italian Ministry of Health. These plans have to be designed and implemented by local authorities on the basis of pre-existing infrastructures, especially in terms of health and social services. The general aim of the national programme is to achieve this goal.

5.4.3.2 Environmental polices to implement national adaptation programmes

At EU level there will be a new Green Paper on adaptation to climate change in the summer of 2007, while EU Directive 2001/42/EC already acts as a European instrument for strategic environmental assessment which can be implemented by Member States for programme planning. Both initiatives provide opportunities to strengthen Community capacity in health policies, to assess the health impacts of policies in other sectors and to strengthen Community capacity for policy making in this area, by linking action to areas where regulation is possible.

In Italy, climate change has been declared a priority in the present government agenda. As part of this, the Italian Ministry of the Environment, Land and Sea at the end of 2006, launched the National Conference on Climate Change to be held in Rome in September 2007. This will focus on developing and programming a national adaptation strategy able to cope with sustainable development goals. This national event will bring together the results of six pre-conference technical workshops on specific environmental issues related to climate change where Italy is vulnerable, mainly:

- desertification (Alghero, 21–22 June 2007)

- marine coastal areas (Palermo, 27–28 June 2007)
- glaciers and mountains (Saint Vincent, 23–July 2007)
- landslides and flooding (Naples, 9–10 July 2007)
- Po river basin (Parma, 16 July 2007).

The workshops, organized with APAT support, are deliberately planned at the local level to raise fruitful discussion and contributions from among local authorities and environmental agencies. All workshops will focus on adaptation strategies and tracking options. For this purpose all cross-cutting socioeconomic issues, such as health, tourism and agriculture, will be the subject of workshop discussions. Results will be processed into a short technical report to be discussed at the national conference in September 2007.

It is essential to ensure that health aspects and the costs of inaction are highlighted within the selected activities.

It would be good to check and review the implementation level of some health policies considering the knowledge of meteorological risks: the directive on air pollution, the directive on sanitation, the directive on bathing waters, the law on food quality and others.

5.4.4 *Integrated information systems*

Integrated information systems need to be developed which include environmental and health issues related to climate, and, in particular:

- the vulnerability of human health needs to be recognized in rules and regulations regarding environmental information;
- as some research projects at European level include Italy, it would be useful to have a knowledge database of the results in order to facilitate understanding of the effects of climate change on health;
- information on the risks for public health and health systems other than those from heat-waves could be developed and extended.

5.4.5 *Health service assurance*

In future, especially in spring and summer, the planning of health services will need to consider the potential health risks of heat-waves, water-, food- and vector-borne diseases. An interesting approach has been proposed by the Centers for Disease Control and Prevention (United States) and the Health Protection Agency (United Kingdom) to activate an information network and health promotion activities in the early summer months. This includes (a) information for the public, (b) planning of human resources, (c) an update of health infrastructure (e.g. air-conditioned rooms) and (d) a revision of service quality during the summer.

Climate change can bring a whole range of potential threats. Therefore, it is essential not to wait until these events occur but to be prepared in order to avoid or limit damage.

6. Conclusions

– by Bettina Menne, Luciana Sinisi and Roberto Bertollini

This report is a preliminary screening report where the aims are to understand what the potential risks to human health are likely to in the face of climate change, climate variability and associated extreme events in Italy, and what adaptation and prevention measures are needed. As there has been, as yet, no systematic national climate change impact assessment, the findings of this literature review allow us to draw a picture of environmental and health risks and to provide some indication of impacts and possible action, with a particular focus on human health.

6.1 Observed changes and scenarios

Over recent years it has become evident that the global climate is changing. Italy too is already affected by climate change. It has already experienced an increase in temperature. The decrease in the number of rainy days throughout the whole national territory has occurred in parallel with an increase in precipitation intensity in central and southern Italy. Between 1981 and 2004 the number of tropical nights has increased; in the whole period, a net increase of about 14% of summer days has been estimated. Between 1961 and 2004, a variation of -0.25 frost days per year has been observed, corresponding to an average reduction of about 20% of the number of frost days over 43 years.

Italy is likely to experience greater warming in the decades to come. The analysis of scenarios shows a high probability for decreasing winter rainfall in the Mediterranean and southern Italy as well as a parallel increase of extreme precipitation events. Furthermore, an increase in frequency of the number of hot and tropical days is foreseen as is a decrease in frequency of the number of cold/frost days. Last but not least, sea temperatures are projected to rise further. The signature of the warming pattern is remarkably similar to the anomaly in the summer of 2003. It is possible to speculate that the average warming that is indicated by several models will probably take place through a change in the frequency and magnitude of seasonal anomalies like 2003.

Greenhouse gas emissions are rising. The IPCC concluded that global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750. Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations. Italy contributed 11.2% of the emission equivalent increase of greenhouse gases in Europe and 2.1% of global emissions. Between 1990 and 2005 the total greenhouse gas emissions in Italy increased by 12.1%. Italy is far from succeeding in its aim of reducing the national greenhouse gas emissions by 6.5% of the base level of 1990. Not only is it far from reaching these objectives, in fact emissions have increased constantly since 1997, even though the increase was reported to be only 0.3% between 2004 and 2005 (APAT, 2007a). Energy (32%) and transport (26%) are the main contributing sectors to CO_2 emissions.

The observed changes in the climate system have already had an impact on numerous physical and biological systems and some economic sectors. Some of these changes are likely to increase in future decades.

Water supply is becoming a social and economic emergency in Apulia, Basilicata, Sicily and Sardinia, primarily because of increasing water demand and lack of management practices. Further associated decreases in mean precipitation could aggravate this situation. Water stress might increase by 25% in this century.

Increased water temperatures cause thermo energetic changes in lakes, with an increased risk of growth of algae and cyanobacteria. Soil aridity has increased and this has increased the possibility of desertification, for example in Sicily, Sardinia, Puglia, Basilicata and Calabria.

In the past 20 years, fires have affected 1 100 000 ha of forest in Italy. During the hot year of 2003, 9697 fires were registered, with a territory of 91 000 ha being affected. The surface affected by fires just during the summer was more than 70 000 ha.

A lengthening of the growing period by about 10–15 days per each 1°C rise in yearly average temperature and a consequent shortening of cold winter periods are expected. Consequently, olive, citrus and vine cultivation would become possible in the north of Italy, whereas corn cultivation would suffer in the south. Overall, ecosystems are moving northwards and upwards (above sea level): about 100 km northward and 150 metres upwards per each 1°C rise in yearly average temperature. Such movements represent a potential danger to Italy due to its orographical features and to temporal incompatibility between the movements of the ecosystems and climate change.

The higher temperatures can favour the degradation of pesticides but the changes in rainfall patterns and increase in dry soils could increase the transport and persistency of pesticides.

The rise in sea level will increase flood risk for coastal regions. Rising sea water temperatures have allowed the migration and settlement of toxic algal species close to the Italian coasts. Climate change is likely to have impacts on tourism, especially regarding the choice of destination for seasonal activities. Traditional beach resorts may become too hot in summer, and insufficient snow precipitation on mountain sites may severely affect winter sport resorts. Important changes may also be occurring with regard to changes in air pollution concentrations, in particular an increase in ground level ozone in summertime.

In Italy the population will also be exposed to both a higher frequency and a higher intensity of extreme events as well as climate variability. The IPCC estimates an increase in frequency, intensity and duration of heat-waves in Europe, and an increase in the frequency of extreme precipitation.

The Ministry of the Environment estimates that the areas at risk of inland flooding are estimated to be 7774 km^2, corresponding to 2.6% of the national territory. In terms of flooding risk, the length of the Italian coastline and the high percentage of population living in coastal areas need to be taken into account. In Italy, some areas are affected by subsidence which further increases the risk.

In the European Mediterranean region the increase in extreme weather events at particular moments of the agricultural cycle, including intense rainfall and drought, will probably lead to a fall in agricultural productivity.

6.2 Health risks

Population health is and will be affected either directly or indirectly. Italian populations have been affected by heat-waves, with an average 3% increase in mortality per degree increase of temperature. Climate change may increase the frequency and duration of extreme ozone events, in particular during the warm season. The potential synergism between air pollution exposure and extreme weather events need to be examined in more detail, with particular emphasis on the effects of PM, ozone, and increases in temperature and humidity.

Floods have caused death, disability and disease – the extent of which is unknown. As for vector-borne diseases, there is a high potential risk of cases of West Nile fever, and an increased risk of leishmania moving northward. As for foodborne diseases, there is a risk of new types of micotoxin appearing. Climate change can greatly influence insect attack on plants and have an impact on food availability and quality. Waterborne disease outbreaks could occur due to extreme rainfall events (intense rainfall or drought) and changes in run-off that can influence the microbiological contamination of coastal, recreational or surface waters. There is also a direct relationship between salmonella and temperature increase. Algal bloom and possible toxic cyanobacteria have been observed, and are potentially associated with climatic changes; there is a potential for them to increase in future. Changes in seasonality of allergic disorders have been observed; this might change further in the future in connection with two trends: (a) earlier flowering and (b) invasion of new plant species.

Uncertainties about future developments are high. Future capacity to adapt to the effects of climate change depends on the future levels of economic and technological development, local environmental conditions and the quality and availability of health care and of public health infrastructure. Social, economic, political, environmental and technological factors strongly influence health. These determinants of health are so complex that future projections about stresses on population health, including but not limited to projections of the potential effects of climate variability and change, become increasingly uncertain with expanding timelines.

Public health should principally address the fundamental causes of disease and requirements for health, with the aim of preventing adverse health outcomes. Measures to ultimately reduce the health impacts of climate change are for both mitigation and adaptation. Several well-established principles point to the need for a vigorous, proactive public health approach to climate change in line with the precautionary principle (see section 5.1).

Some measures have been taken in Italy to reduce greenhouse gases (mitigation), but these are far from adequate. The European Union altogether aims at reducing emissions by 8% between 2008 and 2012 compared to the levels of 1990. For Italy the objective was set at achieving a 6.5% reduction in this period (Romano et al., 2005). In 1990 the emissions were 485.7 MtCO2eq. It has been estimated that between 2008 to 2012 Italy would reach 587.3 MtCO2eq. 4 MtCO2eq can be reduced through the Kyoto mechanisms: Joint Implementation (JI) and Clean Development Mechanism (CDM). The recent fourth assessment report clearly states that the costs of greenhouse gas mitigation can be offset by the benefits it will have for human health through the reduction of air pollution. Integrating air pollution abatement and climate change mitigation policies offers further potentially large cost reductions compared to treating those policies in isolation. Mitigation efforts will largely occur in other sectors than health, such as energy, transportation and construction, although the health sciences can contribute useful information. Today knowledge on how to reduce greenhouse gas emissions is available, but until now there has been very little implementation. Combined examples of greenhouse gas emission reduction and air pollution reduction measures are: reducing the use of resources through energy conservation, increasing efficiency, fuel switching, demand management and behavioural change.

Adaptation will be necessary to address impacts resulting from warming which is already unavoidable due to past emissions, as these are estimated to lead to an increase of about a further 0.6°C by the end of the century relative to 1980–1999, even if atmospheric greenhouse gas concentrations remain at 2000 levels. The array of potential adaptive responses available to human societies is very large, ranging from purely technological (e.g. sea defences), through behavioural (e.g. altered food and recreational choices) to managerial (e.g. altered farm practices) and policy (e.g. planning regulations). While most technologies and strategies are known and developed in some countries, the literature reviewed does not indicate how effective various options are at fully reducing risks, particularly at higher levels of warming with its related impacts, and for vulnerable groups. The development of a climate change adaptation plan for projected climate change, following the example of other European countries, could help to better understand what is needed.

Health is an essential element of adaptation strategies, environmental and overall policies. When looking at existing EU-level and national policies, it is clear that reduction of diseases linked to environmental determinants cuts across policy fields into public health and many nonhealth sector policies, including climate change, land-use, transport, trade, foreign relations, internal affairs, housing, energy, trade and suchlike. One important aspect is that many of them could potentially conflict; mainstreaming health also means understanding where the policies conflict and where they could be synergistic in protecting health, the environment and sustainable development.

6.3 Public health action

Overall five broad areas of public health services could be revised, strengthened or developed in response to climatic changes, namely, early detection and warning, assessment (research and monitoring), policy development (empowering people, mobilizing partnerships and developing policies) and service assurance.

- Health-targeted early warning systems: early warning has so far been developed for heat and associated with numerous actions implemented in 31 Italian cities. The efficiency of these interventions will be evaluated over time and modified accordingly. In this context the information strategies aim to reach specific groups such as physicians, managers of hospitals and care homes, social services and the most vulnerable population groups. Lessons learned in this regard could be expanded to early warning initiatives for other extreme events. Links to international systems like the WMO aerosol transboundary pollution remote sensing system could be set up and lessons learned in other countries could be explored.

- Climate, environment and health monitoring: the monitoring of health status and environmental conditions is important for assessing trends, anticipating future developments and evaluating the effectiveness and efficiency of mitigation and adaptation policies. At the moment, in Italy only the impacts of heat-waves on human health are monitored. There is a need to link the different existing networks and explore potentials for expansion to climate-related threats, for example associating the heat health watch warning systems with data concentration of ozone and particulate matter during summertime to observe the interaction between them and the negative health impacts. In addition, it is also necessary in Italy to study the relationship between salmonellosis, other enteric infectious diseases and temperature. This could improve knowledge of the cause–effect relationship and the estimated health impact and would support the introduction of adequate adaptation measures. The Italian ratification of the international Protocol on Water and Health could facilitate action to tackle hydrological risks. Furthermore, a systematic evaluation of the changes in distribution and frequency of vector-borne diseases is needed. The need for a research programme on risks and prevention policy could also be taken into consideration.

6.4 Information initiative

Information on the population's vulnerability in terms of health needs to be integrated into climate change scenarios. Many European research projects have also been carried out in Italy: the creation of a knowledge database could enhance the better understanding of climate change in general and health impacts in particular. Information programmes on several health risks from climate change could be set up for health professionals.

6.5 Health services assurance

Especially in spring and summer, but also at other times of the year, it is recommended that health services be planned in such a way as to allow an efficient response to risks related to heat-waves, and diseases related to bathing water, food intoxication and vector-borne diseases.

In order to implement some of the above suggestions, it is advisable:
- to develop and reinforce collaborative networks among health professionals, climate change scientists, environmental and health information system managers;
- to set up an environmental health working group with the specific role:
  - to estimate the future burden of disease caused by climate change in Italy in order to understand the effectiveness and sustainability of current measures to reduce it;
  - to create adaptation strategies and a priority list of actions to test examples of integrated policy implementation and the cost of inaction;
  - to develop case studies in specific areas to test examples of integrated policy;
  - to activate an information network for health and environmental staff.

Finally, the results of the Italian activities to prevent and reduce the health impacts of climate change could represent a useful contribution to the 5th Interministerial Conference on Health and Environment of the 53 Member States in the WHO European Region, which will take place in Rome 2009.

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Climate change is already having an effect in Italy, as elsewhere. The global effects of an increasing concentration of greenhouse gases in the atmosphere are reflected in the growing number of extreme weather events, such as heat-waves and intense rainfall. These have various consequences for the health of the population, both directly in terms of mortality, and indirectly through changes in the ecosystem.
As there has been, as yet, no systematic national climate change impact assessment in Italy, this report is a preliminary evaluation of the situation, using international and national literature and with the help of expert advice. The aim is to assess the potential risks of climate change to human health in Italy, to see what adaptive and preventive measures are available and to suggest what may be additionally needed.

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