Workshop

Impacts of Mediterranean Climate Change on Human Health

Energy, Environment and Water Research Center
The Cyprus Institute
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Scientific Report

by

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Summary

One of the major concerns of climate change is its impact on human health. To date, there is significant evidence that the Mediterranean Basin is already experiencing some of the impacts of climate change including those on public health. The international group of climate scientists and epidemiologists, joined by policy analysts and policy makers, as well as statisticians and modelers, has come together under the auspices of ESF-MedCLIVAR and The Cyprus Institute to join intellectual forces in identifying the challenges regarding the impact of Mediterranean climate change on human health. The workshop consisted of presentations organized under several broad themes and a discussion of priorities for future interdisciplinary collaborations, which were the main goal of the workshop. The main insights of the workshop based on the participants' presentations and discussions focused on the Mediterranean climate change, the impacts of heat stress and heat waves on public health, climate change and disease hazards, total ozone and UV changes, air pollution, vector-born diseases and drought. In addition, future pathways for research were discussed. These insights and ideas are described below.
We succeeded in creating an intellectual atmosphere to nurture the development of scientific collaborations and they, in fact, began to materialize and are continuing to develop. The workshop was a good start for further research and better understanding of the great challenges of the Mediterranean climate change impacts on human health.

SCIENTIFIC CONTENT DESCRIPTION

The world's climate system is an integral part of the complex of life supporting processes, one of several natural systems that are now coming under pressure from the increasing weight of human activity.

Climate change is global, long-term and accelerating. Mitigation and adaptation for its regional effects involves understanding of complex interactions between demographic, climatic, environmental, economic, health, political, institutional, social and technological processes. In particular, climate change will have a substantial impact on social, economic and environmental systems, and their interactions, and thereby on human security including water, food and health.

One of the major concerns of the global warming is the impact on human health. Climate change affects human health via pathways of varying complexity, scale and directness and with different timing. Similarly, impacts (both positive and negative) vary geographically as a function of the physical and environmental conditions and of the vulnerability of the local human population.

As global warming evolves, its initial effects will intensify and new ones will become apparent. Many prevalent human diseases are linked to climate fluctuations, from heat stress, cardiovascular mortality and respiratory illnesses due to heat waves, to altered transmission of infectious diseases and malnutrition connected to crop failures. Future impacts of climate change are likely to affect the health status of millions of people worldwide through:

- Increased morbidity and mortality as a result of exposure to extreme heat or cold, especially among the elderly and people with pre-existing illness
- Increased infectious diseases, especially those transmitted by organisms that are sensitive to temperature increase (such as mosquitoes and ticks)
- Increased malnutrition and related risk of infectious and respiratory diseases, with implications for child growth and development
- Increased deaths, diseases and injuries due to more frequent and intense extreme weather events (floods, windstorms, droughts)
- Increased diarrhoeal diseases and other food- and water-related diseases
- Increased frequency of cardio-respiratory diseases due to higher concentrations of ground level air pollution (ozone, NOx, CO, etc) related to heat directly through chemical reactions and indirectly via increased wildfire activity

- Changed geographical distribution of plants and disease-carrying vectors (e.g. rodents, mosquitoes, ticks, etc.) and associated diseases (e.g. malaria, encephalitis, dengue fever, etc.);

To date, there is significant evidence that the Mediterranean Basin is already experiencing some of the early impacts of climate change. The main phenomena are temperature increase (especially during the summer months), an enhance in the frequency and the intensity of heat waves, a reduction in the total precipitation amounts parallel with increasing rainfall intensity and enhanced drought.

In addition, the Mediterranean area has to deal with growing population pressure.

All of the above issues increase the population vulnerability to possible impacts of climate change on human security, such as sea level rise, reduced water availability, increased salinity and eutrophication of coastal waters, crop yields vulnerability as well as direct impacts on the human health – heat waves, wildfires, vector-borne diseases, air pollution, etc.

DISCUSSION AT THE WORKSHOP & ASSESSMENT OF THE RESULTS

The international group of climate scientists and epidemiologists, joined by policy analysts and policy makers, as well as statisticians and modelers, has come together under the auspices of ESF-MedCLIVAR and The Cyprus Institute to join intellectual forces in identifying the challenges that climate change poses to public health in the Mediterranean and similar climatic regions around the world. The goal of the workshop **Impacts of Mediterranean Climate Change on Human Health** was to forge collaborations to better understand these challenges and address potential solutions through collaborative research aimed at informing health risk mitigation through regional adaptation policies.

The workshop brought together active and creative researchers and analysts that for three days worked on the state of the climate system and the state of public health. The workshop consisted of presentations organized under several broad themes and a discussion of priorities for future interdisciplinary collaborations, which were the main goal of the workshop.

The workshop was divided to five main associated sessions:

- Mediterranean climate change: extremes and dynamics
- Impact modeling: analysis approaches
- Climate Change and Disease Hazards
- Extreme temperature impacts on human mortality
- Drought and pollution impacts (heat-compounded)

In addition, three invited talks enriched the workshop (please look at the full program below). At the end of each day, the day summary and discussion had been leaded by the committee members with an active contribution of the workshop participants. The last session of the workshop was dedicated to concluding remarks and future collaborations.

The main insights of the workshop based on the participants presentations and discussions, divided by sub-subjects are as follows:

Mediterranean Climate Change

In the 21st century the Mediterranean Basin (MB) is expected to be one of the most prominent and vulnerable climate change "hot spots". Several generations of climate change projections have consistently indicated much warmer and drier conditions in the MB. Mediterranean summers are expected to be much warmer and drier than today and the projected increased heat wave intensity and length might pose severe health problems while the higher temperatures could also increase the area of influence of vector-borne diseases such as malaria. During the last decades, there is a significant increase in air temperature, parallel with an increased frequency of heat waves, which are longer and more intensive. It is found that homogenization of daily temperature data is crucial for extremes analysis.

In a large part of the MB, there is a decrease in precipitation and the number of wet days parallel with more extreme rainfall events, related to cyclone intensity and the large scale atmospheric circulation. There is a connection between cyclone intensity and precipitation and

wind speed extremes in the cold season. The cyclone intensity is connected with the large-scale atmospheric circulation.

Heat Stress

The association between mortality and temperature is highly dependent on local factors such as: climate, air pollution, demographic structure, cultural patterns, housing equipment, public services, economy etc.

All these factors have a significant influence on the climatic impact on human mortality through changes in exposure, vulnerability, preparedness, adaptation and mitigation.

Sultry conditions prevail along the MB coasts in the summer. Additionally, global warming implies heat-stress aggravation. If accompanied by moisture increase further heat-stress aggravation is expected.

Global warming suggests stabilizing of the lower atmosphere in the summer over marine regions. An analytical consideration of the coastal summer conditions predicts increase in Relative Humidity (RH) as well as aggravation of air pollution. Indeed, the expected stabilization has been projected over whole MB while the increase in RH was found only in the eastern basin. It may be explained by lack of prominent inversion elsewhere.

Heat Waves

Global climate change has direct impacts on human health, including increased mortality related to heat waves. Mortality displays a seasonality with a general peak in winter, but there are peaks in the summer as well, corresponding to heat waves. Increase in heat-waves is one of the most certain consequences of climate change.

Observations in MB cities have shown that heat-waves can have very strong effects on mortality, while mortality increases between 1-4% for each degree of temperature raise.

Most at risk are: the elderly, persons with pre-existing chronic diseases, confined to bed, living alone and those being heavily exposed, i.e., living directly below the roof of a building.

There is evidence of a synergistic effect on mortality of strong air pollution events and the occurrence of a heat-wave.

Children are more vulnerable to heat waves because they do not have fully developed temperature regulation mechanisms and are unable to change their environments without help from adults. The very young are at higher risk of death while older children have more heat stress due to time spent in exercise – playing outdoors.

Here are few examples from heat-wave studies in Mediterranean climate areas:

Greece:

The number of deaths increased almost fivefold during a major heat-wave in 1987, especially in Athens compared to smaller cities and non-urban areas. A considerable number of heat-related deaths has been observed in Athens, both from moderate and extreme heat, during the 1992–2006 summer months. Even with an adaptation factor, both linear and exponential models show an increase in the heat related excess mortality and this fact should be taken into account by the governmental health services.

Iberia:

Summer mortality was detected. Most of the mortality occurs among the elderly, especially women over 75. This result allows for the ageing of the population being a promising measure of the vulnerability evolution.

In Iberia daily Tmax is the best indicator to analyze the mortality-climate association. Other variables, such as night temperature (i.e. Tmin) or humidity, have not been found to play as an important role. The impact is evident when daily Tmax exceeds a given threshold that is dependent on the location and is very close to the 95th percentile of the temperature distribution. The impact is detected even after a single day event and is not connected only with long hot spells.

California:

Great heat waves are primarily day or nighttime events caused by specific pressure, wind and moisture patterns. The observed tendency towards more humid heat waves and unprecedented nighttime temperatures has implications for energy demand, agriculture, public and animal health. Climate models suggest that the trends will continue and accelerate but not always in the observed sense.

Climate Change and Disease Hazards

There are disparities in climate change impact on public health for different populations and sub-groups. The relative impacts are a function of individual and population vulnerability while the vulnerability factors may differ at geographic locations and scales.

The impact of environmental factors on populations begins with impacts on individuals. The type and extent of public health risks associated with climate change varies across communities, and among individuals within communities. The variation in risk is a function of geographic distribution of vulnerability factors and the capacity of communities to adapt to public health challenges. Vulnerabilities and capacities change with time. Integrated assessments are needed as a solution to complex problems.

Total Ozone and UV Changes

Climate change can amplify several damaging effects of solar UV-B radiation on human health. For the same UV dose, each 1°C increase in temperature would result in estimated increases in the incidences of certain skin cancers of 3-6%. High temperatures and humidity may increase the deleterious effects of UV-B radiation on human health in the MB, including suppression of immunity to infectious diseases and skin cancers.

Air Pollution

The MB has a unique climate influenced by a particular atmospheric circulation strongly affected by the complex land topography that plays a crucial role in steering air flow. As a result, its air quality characteristics are associated with coexistence of natural and anthropogenic pollutants, regional climatic and weather patterns, long range transport of air pollutants, excessive solar activity for several months (=photochemistry) and gas to particle conversion and aerosol formation. Further, dust particles are often found to consist of bacteria and might be responsible for altering the particles properties, mainly through changes in their hygroscopicity in wet environments.

PM (particulate matter) affects the formation and the microphysical properties of clouds by influencing the amount of precipitation and in a long-term, the water budget in an area.

Studies indicate that air pollution episodes in the MB are characterized by light winds and pronounced stability, commonly associated with anticyclones that have both immediate and long-term health effects. It was found that downscaling the synoptic and meso-scale conditions into local NOx pollution potential is an efficient tool for alarming against pollution events. Forecasting the synoptic type is a powerful tool for predicting pollution events, however, the ambient atmospheric conditions induced and the dynamics implied by the upper-levels are of higher significance.

Studies applying modeling systems, measurements and satellite retrievals have identified the scales of transport of anthropogenic and natural pollutants (ozone, ozone precursors, aerosols, PM). It was found that interaction between gases and PM of natural and anthropogenic origin leads, in general, towards the reduction of O_3, SO_2, NO_2 and enhancement of aerosol formation. The long-range transport and transformation patterns (warm period of the year) showed that the amounts of the 3rd generation PM are considerable and must be taken into account in areas with limited amounts of precipitation. Dust particles acting as reactive surfaces in a wet environment might lead to the production of new generation of particles that are more drastic climate modifiers. Synergy between the modeling systems, observation networks and end-users (government, environmental agencies, research needs etc) should be supported towards the understanding/assessing of the environmental effects of air pollution.

Air pollution impact on children:

PM increases the risk of respiratory death in infants of less than one year of age, and affects the rate of lung function development. Air pollutants aggravate asthma and cause other respiratory symptoms such as cough and bronchitis. The children are vulnerable as a result of their greater exposures to pollutants because they spend more time outside. Additionally, they inhale more pollutants per kilogram of body weight than adults do. Since their airways are narrower, irritation can result in proportionately greater airway obstruction.

Vector-Born diseases

Global warming causes worldwide net increase in the geographical distribution of vector organisms. Temperature related changes in the life-cycle dynamics of both vector species and pathogenic organisms increase the potential transmission of vector-borne diseases.

Climate is changing infectious disease transmission by altering vectors' geographical distribution.

Examples relevant to the MB and Europe:

- Climate change challenge the progress made towards eliminating malaria
- Lyme disease is shifting to higher latitudes and altitudes, following movement of ticks
- Leishmaniasis, a skin disease transmitted by sand flies, is travelling north
- in Italy, the 2007 Chikungunya outbreak allowed sustained local transmission
- In Israel, extreme warm conditions were found to be a crucially important factor that instigated the launching of West Nile virus outbreaks. There is a potential influence of extreme heat in early spring, on the vector population increase and on the disease's appearance weeks later.
- In Israel, rising temperatures suggest to have facilitated the outbreak of *V. vulnificus* disease.

Drought

In the MB, water scarcity is a prevailing problem. With progressing changes in climatic conditions, it is expected that water demand will increase dramatically due to enhanced need for potable water, increased water demand for irrigation, additional need of cooling water for power plants. Water availability will decrease as a result of decreasing precipitation particularly in the winter/rainy season, extension of dry spells and increasing evaporation during extremely hot summer months.

The demand for energy/electricity will increase because of enhanced need for air-conditioning in private and public housing, the need to generate potable water through seawater desalination and enhanced treatment of waste water.

For Cyprus, an enhanced scarcity in available water is expected with significant repercussions in the health sector of the island.

IMPACT OF THE EVENT ON THE FUTURE DIRECTION OF THE FIELD

For the Mediterranean region and the 21st century, climate experts anticipate: increase in air temperature in the range of 2.2 C° to 5.1 C°, decrease in rainfall, ranging between -4 and -30%, increased frequency and length of drought periods, more frequent and violent extreme events, such as heat waves, droughts or floods and increase of the sea level. Therefore, a concerted effort is needed for a better scientific understanding of the future tendencies, as well as for an improved social adaptation.

During the workshop, and especially in the "Brainstorming" and "Concluding Remarks and Future Collaborations" sessions, several directions of future challenges, research and collaborations have been discussed, as follows:

Heat waves:

No universal definition of heat waves is available. There is a need to develop a better heat wave index that could be applied in larger areas without filtering out the particularities of the

locality. For example, in Iberia, for human mortality the impact depends on the tail of the local distribution. The exposure depends more on the size of the temperature tail than on the shift of the average.

There is a necessity to contribute to the *preparedness* to heat waves by improving the collaborative mechanisms between research institutions and lead bodies to coordinate emergency responses, the accurate and timely meteorological forecasts, the reduction of exposure to heat, particular care for vulnerable populations, the provision of health care, social services and infrastructure, risk communication mechanisms, urban planning, energy and transport policies, monitoring and evaluation.

Although the summer 2003 heat wave has been a landmark, the memory of catastrophes is limited. The predicted climate change will further intensify extreme events with a possible higher impact on public health. Therefore, there is a need to contribute to the improving of early warning systems and the index series that currently do not give an exhaustive picture.

Air Pollution:

Climate change and air pollution: better understanding of the combined effects and possible synergies is necessary.

PM can be considered responsible for causing warming of the middle troposphere and cooling near the ground, leading to possible changes in atmospheric stability (direct effect on climate). The estimation of the radiative forcing due to aerosols of natural and anthropogenic origin is a key-topic for future work for the Mediterranean Region.

Modeling:

Future pathways: developing a 1-D numerical model for quantifying results; extending the models to a 2-D version in order to better describe the conditions across coastal regions and the conditions during night hours; further research of extreme precipitation; developing model data analysis of extremes; expanding the models over the whole Mediterranean.

Other future pathways for research:

- Health effects of forest fires
- Quantification of the adaptation potential
- Defining the sensitive subgroups

In summary, we succeeded in creating an intellectual atmosphere to nurture the development of scientific collaborations and they, in fact, began to materialize in Cyprus and are continuing to develop. We believe that the workshop was a good start for further research and better understanding of the great challenges of the Mediterranean climate change impacts on human health.

We would like to thank to the ESF-MedClivar for the generous support.

Appendix

The Meeting Program

Monday, 19 October 2009

08:30 Registration
09:00 Welcome from the local organizer
Elena Xoplaki
09:10 Welcome and opening remarks to the workshop
Shlomit Paz and Alexander Gershunov
09:20 Introductory words on behalf of the Ministry of Health
Stella Canna Michaelidou
09:30 Introductory words from MedCLIVAR
Ricardo García-Herrera
09:40 Coffee break

Mediterranean climate change: extremes and dynamics

Chair: Shlomit Paz

10:10 **Christoph Raible** (University of Bern)
The Mediterranean - a key region of climate change: extremes and underlying dynamics
10:35 **Elena Xoplaki** (The Cyprus Institute & University of Bern)
Climate extremes in the Eastern Mediterranean
11:00 **Baruch Ziv** (The Open University of Israel)
Expectations for aggravation of heat-stress in the Mediterranean under global warming
11:25 **Alexander Gershunov** (University of California San Diego)
Heat waves - observations and projections
11:50 **Hervé Douville** (CNRM-GAME/GMGEC)
Uncertainties in projecting climate change over the Mediterranean: what did we learn from the CMIP3 simulations?
12:30 Lunch

Impact modeling: analysis approaches

Chair: Elena Xoplaki

13:30 **Andrew P. Morse** (University of Liverpool)
Integrating health impacts models in climate prediction systems along the path to being seamless
13:55 **Christos Giannakopoulos** (National Observatory of Athens)
An impact model for heat stress and mortality construction, validation and projections under future climate change: an application for the city of Athens
14:20 **Boris Portnov** (University of Haifa)
Using Geographic Information Systems (GIS) technology for disease analysis and mapping

14:45 **Anna K. Panorska** (University of Nevada Reno)
Stochastic models for weather extremes:
heat waves, cold spells, floods

15:10 Coffee break

Climate Change and Disease Hazards

Chair: Jan Semenza

15:40 **Panos Hadjinicolaou** (The Cyprus Institute)
Total ozone and UV changes: long-term trends,
climate change links and health implications

16:05 **Shlomit Paz (**University of Haifa)
Climate change impact on infectious diseases –
case studies from Israel

16:30 **Stella Canna Michaelidou**
(Cyprus National Committee on Environment and Children's Health)
The impact of climate change on children's health:
the challenge to protect them

16:55 **Helene G. Margolis (**University of California Davis)
Climate change and chronic disease morbidity:
a conceptual framework for assessment and solutions

Invited talk

17:30 **Anastasios A. Tsonis** (University of Wisconsin-Milwaukee)
The impact of ENSO on the social and cultural changes
in the eastern Mediterranean: A lesson from history

18:00 Free time

<u>Tuesday, 20 October 2009</u>

Invited talks

09:00 **Jan C. Semenza** (European Centre for Disease Prevention and Control)
The ECDC response to the climate change challenge

09:30 **James Creswick** (World Health Organization Regional Office for Europe)
WHO action on climate change and health in Europe:
research direction and technical developments

10:30 Coffee break

Extreme temperature impacts on human mortality

Chair: Marina Astitha

11:00 **Klea Katsouyianni** (University of Athens)
Effects of high & low temperature and heat-waves
on mortality in the Mediterranean region

11:25 **Ricardo García Herrera** (Complutense University of Madrid)
Impacts of extreme temperatures in Iberian mortality

11:50 **Chava Peretz** (Tel Aviv University)
Temperature and mortality in Tel Aviv, Israel:
a time series approach
12:15 **Day summary and discussion**
13:15 Lunch
14:30 Excursion
19:30 Dinner

Wednesday, 21 October 2009

Drought and pollution impacts (heat-compounded)

Chair: Alexander Gershunov

09:00 **Manfred A. Lange** (The Cyprus Institute)
The impacts of climate change on water availability
on Cyprus and the eastern Mediterranean
09:30 **Abdul-Latif M. Khalid** (Palestinian Hydrology Group)
Drought preparedness and mitigation program in Al-Fara'a area
09:55 **Marina Astitha** (The Cyprus Institute)
Air quality in the Mediterranean region
10:20 **Hadas Saaroni** (Tel Aviv University)
NOx pollution in the metropolitan area of Tel Aviv, Israel -
The role of the synoptic systems against mesoscale circulations
10:45 Coffee break
11:15 **Day summary and discussion**
11:45 Climate change impacts on human health – European research
Anna Maria Christophorou (Cyprus Research Promotion Foundation)
12:00 **Roundtable**
13:00 Lunch
14:30 **Brainstorming**
15:30 Coffee break
16:00 **Concluding remarks and future collaborations**

List of Speakers and Participants

Participant Name	Affiliation
Shlomit Paz *Committee member*	University of Haifa
Elena Xoplaki *Committee member*	The Cyprus Institute & University of Bern
Alexander Gershunov *Committee member*	University of California San Diego
Christoph Raible	University of Bern
Baruch Ziv	The Open University of Israel
Hervé Douville	CNRM-GAME/GMGEC
Andrew P. Morse	University of Liverpool
Christos Giannakopoulos	National Observatory of Athens
Boris Portnov	University of Haifa
Anna K. Panorska	University of Nevada Reno
Panos Hadjinicolaou	The Cyprus Institute
Stella Canna Michaelidou	Cyprus National Committee on Environment and Children's Health)
Helene G. Margolis	University of California Davis
Anastasios A. Tsonis	University of Wisconsin-Milwaukee
Jan C. Semenza	European Centre for Disease Prevention and Control
James Creswick	World Health Organization Regional Office for Europe
Klea Katsouyianni	University of Athens
Ricardo García Herrera	Complutense University of Madrid
Chava Peretz	Tel Aviv University
Manfred A. Lange	The Cyprus Institute
Abdul-Latif M. Khalid	Palestinian Hydrology Group
Marina Astitha	The Cyprus Institute
Hadas Saaroni	Tel Aviv University
Olga Kalakouta	Cyprus Ministry of Health
Maria Aletrari	Cyprus Ministry of Health