

*Cyprus International Institute for Environmental and Public Health in Association with Harvard School of Public Health*

## **EHS-525 -Global Climate Change course**

Summer Semester 2013

Paper Title:

# **Climate Change and Indoor Environment**

Leading Instructor: Professor Tim Weiskel

Student's Name: Maria Sarri

Limassol 2013

## ***Introduction***

The topic of climate change for common people is not very clear and its origin and consequences are often misunderstood. Most people know that climate change has something to do with stationary and mobile pollution, greenhouse gases and that all of these result in changing weather and the warming of our planet. In simple words, climate change occurs when long-term weather patterns are altered either naturally or by human activity (which is the major cause). Natural causes of climate change are changes in volcanic activity, solar input and the Earth's orbit around the Sun [1]. Human activities contributing to climate change include the burning of fossil fuels, industrial activities and the conversion of land for forestry and agriculture [1]. Global warming is one measure of climate change, and is the increase of the average global temperature [2] because of the trapped greenhouse gases in the atmosphere.

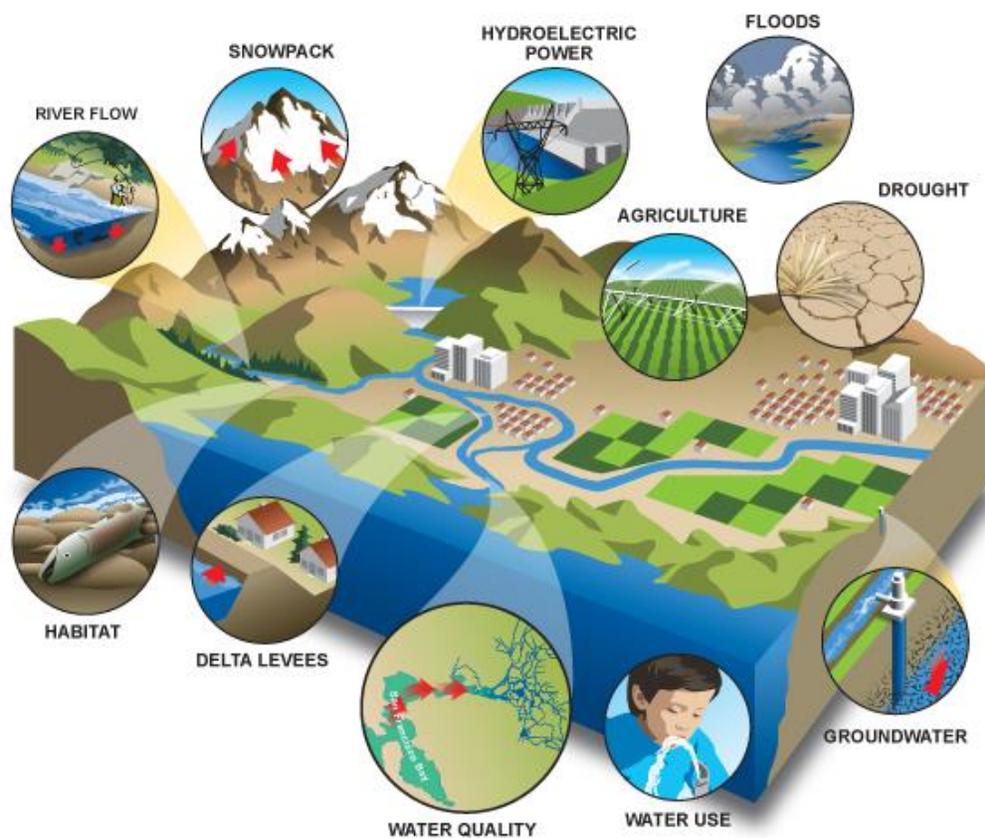
Climate change is a long-term shift in weather conditions identified by changes in temperature, precipitation, winds, and other indicators. Climate change can involve both changes in average conditions and changes in variability, including, for example, extreme events [1].

Our understanding of climate change is largely the result of the Intergovernmental Panel on Climate Change (IPCC), the world's most authoritative voice on the topic. Established by the United Nations, the IPCC assesses the scientific and socio-economic information relevant to climate change. The IPCC also looks at the potential impacts of climate change, and options for slowing it down or adapting to it [2].

The impacts of climate change are becoming more and more obvious to us as there are no actions taken to mitigate this threatening global issue. Climate change poses a threat on ecosystems (including animals, plants, water, air, forests, etc.), public health, economies and communities. With the yearly rise in average temperatures, some regions will experience more extreme heat while others may cool slightly. In the last 100 years, the world has warmed by approximately 0.75°C. Over the last 25 years, the rate of global warming has accelerated, at over 0.18°C per decade [3]. Flooding, drought and intense

summer heat could result from greenhouse gases capturing solar energy which is stored in the atmosphere. Violent storms and other extreme weather events could also result from the increased energy stored in our warming atmosphere.

One of the most serious impacts of climate change is how it will affect water resources around the world, as shown in figure 1 below. Water is intimately tied to other resource and social issues such as food supply, health, industry, transportation and ecosystem integrity.



**Figure 1:** This diagram shows the close interaction between the hydrology and water resources.  
Source: <https://www.e-education.psu.edu/geog438w/node/240>

All populations will be affected by climate change, but some are more vulnerable than others. People living in small island developing states and other coastal regions, megacities, and mountainous and polar regions are particularly vulnerable [4].

Climate change threatens the health, especially of the elderly and children through increased disease, freshwater shortages, worsened smog and more.

Children – in particular, children living in poor countries – are among the most vulnerable to the resulting health risks and will be exposed longer to the health consequences. The health effects are also expected to be more severe for elderly people and people with infirmities or pre-existing medical conditions [4].

Children and elderly mostly spend their times indoors. For this reason, the impact of climate change on the indoor environment is the major focus of this paper.

### ***Climate change and Indoor Environment***

The effects of climate change in the indoor environment and health constitutes an important issue. The indoor environment affects comfort, health and productivity. People in developed countries spend most of their times indoors, so most of the adverse exposures that they encounter regularly take place indoors. Many exposures that are potentially hazardous to health are exposures to substances emitted indoors from indoor sources [5]. Such emissions can occur from building materials; from products used or stored indoors; from processes that occur in indoor environments; from the microorganisms, insects, other animals, and plants that live indoors; and from the behavior of building occupants [5].

Climate change has the potential to affect the indoor environment. Like a global chain, the climate change affects the outdoor environment, the outdoor environment affects the indoor environments under different climate conditions and the indoor environments affect the occupant health. Ambient conditions in the outdoor environment serve as boundary conditions to the ambient conditions of the indoor environment. Outdoor air temperature, humidity, air quality, precipitation, and land surface wetness can all influence the indoor environment, depending on such factors as the integrity of the building's envelope; the state of its heating, ventilation, and the air-conditioning systems; the inhabitants of the outdoor ecosystem; and the characteristics of the building around it [5].

A change in the climatic conditions in a particular area, for example the climate becomes warmer or there are episodes of high heat or intense precipitation, the buildings that were designed according to the current conditions may not work efficiently for the new climatic changes. Moreover, in responding to climate changes, people and societies will seek to mitigate undesirable changes and adapt to changes but that cannot be mitigated [5].

The Institute of Medicine (IOM) of the National Academy of Science after the request of the Environmental Protection Agency (EPA), convene an expert Committee on the Effect of Climate Change on Indoor Air Quality and Public Health in order to summarize the current status of knowledge on the effects of climate change to indoor air and public health. The committee identified the major types of climate-induced indoor environmental problems which will be discussed further on, in combination with findings from other studies as well [6]. Figure 3 shows some of the possible pathways by which weather changes could influence the health of building occupants [5].

The first problem to be identified is *indoor air quality*. Indoor environments can be contaminated by chemical, organic components, pollen and other allergens, viruses and particulate pollutants that penetrate from outdoors. Once indoors, reactive pollutants like ozone can undergo further reactions and can damage housing materials and the human lung. Indoor contamination could also be the result from gas stove operation and other indoor emission sources, such as building materials, radon, and environmental tobacco smoke. Climate change can affect these factors in various ways. For example, changes in the outdoor concentrations of a pollutant due to alterations in atmospheric chemistry or atmospheric circulation will affect indoor concentrations [6]. Three classes of factors govern indoor pollutant levels in occupied spaces: (a) properties of pollutants; (b) building factors, such as the ventilation rate; and (c) occupant behavior [7]. Measures to reduce energy use in buildings, such as lowering ventilation rates may cause higher exposures to pollutants emitted from indoor sources. The expected increased use of air conditioning, if accompanied by reduced ventilation, could increase the concentrations of pollutants emitted from indoor sources. Additionally, power outages—caused by heat waves or other extreme weather events—could lead to the use of portable electricity generators that burn fossil fuels and emit poisonous carbon monoxide [6].

Dampness, moisture, and flooding was another major problem/category identified by the expert committee [5]. Extreme weather conditions associated with climate change may lead to more frequent breakdowns in building envelopes—the physical barrier between outdoor and indoor spaces—followed by infiltration of water into indoor spaces. Dampness and water intrusion create conditions that encourage the growth of fungi and bacteria and may cause building materials to decay or corrode, leading in turn to chemical emissions [6, 7]. Poorly designed or maintained heating, ventilation, and air-conditioning systems may introduce moisture and create condensation on indoor surfaces. Humid conditions can, however, be improved by well-designed and properly operating systems. Mold-growth prevention and remediation activities also may introduce fungicides and other agents into



**Figure 2:** Indoor health hazards caused by extreme weather events and climate change. [9]

the indoor environment [10].

Moreover, infectious agents and pests are considered to be another major problem concerning indoor environment and health. Weather fluctuations and climate variability influence the incidence of many infectious diseases [6]. Climate change may affect the evolution and emergence of infectious diseases, for example, by affecting the geographic range of disease vectors. The ecologic niches for pests will change in response to climate

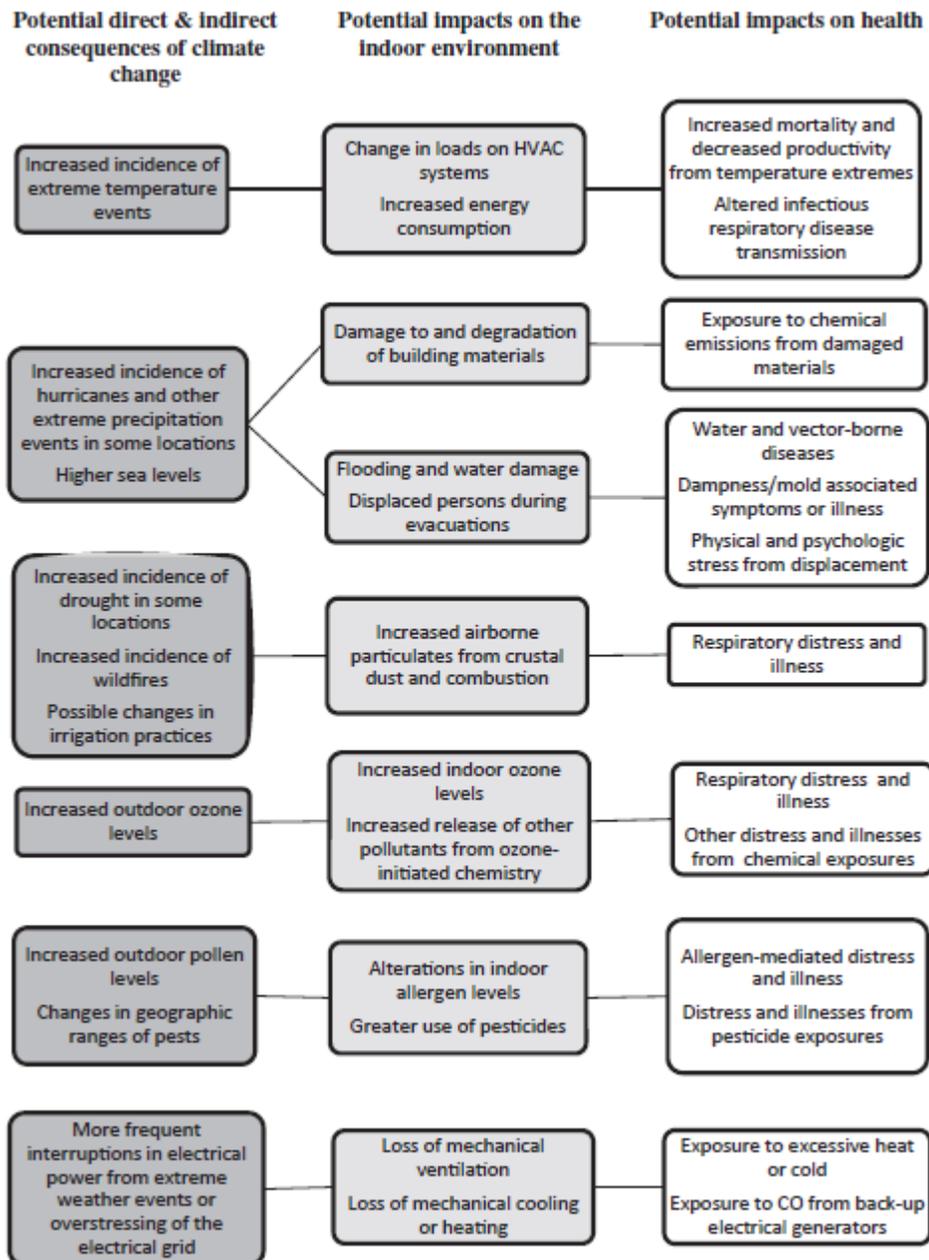
change, leading to changed patterns of exposure and, possibly, increased use of pesticides in some locations [6].

Extreme heat and thermal stress is another major problem. Long-term climate change may result in more heat-related illness and death as the average temperature of the globe increases, along with increased frequency, intensity and duration of heat waves in some locations [8]. Extreme heat and cold have several well-documented adverse health effects. High relative humidity exacerbates these effects in hot conditions. An increased frequency of extreme weather events may result in more frequent power outages that expose persons to potentially dangerous conditions indoors. The elderly, those in poor health, the poor, and those who live in cities are more vulnerable to both exposure to temperature extremes and the effects of exposure. Those populations experience excessive temperatures almost exclusively in indoor environments. More specifically, elderly people spend approximately 90% of their time indoors [11], especially older people who have been shown to be more vulnerable to heat [8].

Building ventilation, weatherization, and energy use are one of the major problems, identified by the committee [5]. Leaky buildings are common and cause energy loss, moisture problems, and migration of contaminants. Poor ventilation is associated with occupant health problems or lower productivity. The air-exchange rate of a building can substantially influence indoor air pollutant concentrations. For pollutants of outdoor origin, ventilation serves as the means by which the pollutants are introduced into an indoor environment. Also, whether pollutants are of outdoor or indoor origin, ventilation is an important removal mechanism that limits pollutant accumulation indoors [7]. Climate change may make ventilation problems more common or more severe by prompting the implementation of energy-efficiency (weatherization) measures that limit the exchange of indoor air with outdoor air. The introduction of new materials and weatherization techniques also may lead to unexpected exposures and health risks [6].

Home-specific characteristics that can influence indoor temperature and ventilation included exterior construction (brick/ asphalt, vinyl paneling or wood siding); date of construction and housing type (single family, high rise, two-family flat), number of floors,

air conditioning status, and prevailing surroundings (i.e. concrete, urban, residential or yard/park) [8].



**Figure 3:** Scenarios where climate changes impact buildings and could possibly affect occupant health, comfort, and productivity (Reproduced with permission from Climate Change, the Indoor Environmental and Health, IOM, 2011 by the National Academy of Sciences, Courtesy of the National Academies Press, Washington, D.C. Original figure adapted from Su, undated.)

Conclusively, some important messages that worth global attention, regarding climate change and indoor environment, are: that poor indoor environmental quality is creating health problems today and impairs the ability of occupants to work and learn. By one estimate, poor indoor conditions cost the nation's economy tens of billions of dollars a year in exacerbation of illnesses and allergenic symptoms and in lost productivity [5]. Climate change may worsen existing indoor environmental problems and introduce new problems. Last but not least is that there are opportunities to improve public health while mitigating or adapting to alterations in indoor environmental quality induced by climate change [5].

## References

1. Official Website of Canada's Action on climate change (Revised 2013-04-18)  
<http://www.climatechange.gc.ca/>
2. David Suzuki Foundation Website: [www.davidsuzuki.org/](http://www.davidsuzuki.org/)
3. Based on data from the United Kingdom Government Met Office. HadCRUT3 annual time series, Hadley Research Centre, 2008. Website:  
[www.metoffice.gov.uk/hadobs/hadcrut3/diagnostics/global/nh%2Bsh/index.html](http://www.metoffice.gov.uk/hadobs/hadcrut3/diagnostics/global/nh%2Bsh/index.html)
4. WHO website 2013, <http://www.who.int/mediacentre/factsheets/fs266/en/>.
5. Committee on the Effect of Climate Change on Indoor Air Quality and Public Health, Institute of Medicine. Climate Change, the Indoor Environment, and Health. Washington, DC: The National Academies Press (2011). Available:  
<http://tinyurl.com/4xn4rhj> [accessed 8 Aug 2011].
6. Spengler J. D., 2012. Climate change, indoor environments, and health Indoor Air, Volume 22, Issue 2, pages 89–95, April 2012.
7. William W Nazaroff. Exploring the consequences of climate change for indoor air quality, 2013, Environ. Res. Lett. 8 015022. doi:10.1088/1748-9326/8/1/015022
8. White-Newsome JL, et al. (2012) Climate change and health: indoor heat exposure in vulnerable populations. Environ Res 112, 20–7.
9. Potera C., 2011. Climate Change Impacts Indoor Environment. Environ Health Perspect 119:a382-a382. <http://dx.doi.org/10.1289/ehp.119-a382>
10. WHO (2009). WHO Guidelines for Indoor Air Quality: Dampness and Mould, Copenhagen, World Health Organization, Available at:  
[http://www.euro.who.int/\\_data/assets/pdf\\_file/0017/43325/E92645.pdf](http://www.euro.who.int/_data/assets/pdf_file/0017/43325/E92645.pdf) (accessed 1 February 2012).
11. EPA (Environmental Protection Agency), 2009. The Inside Story: A Guide to Indoor Air Quality Available at: <http://www.epa.gov/iaq/pubs/insidest.html>S (accessed 1 April 2009).