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# **Climate Change and Health**

Lina Nerlander

Health specialist, Red Cross/Red Crescent Climate Centre

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Postal address: SE 103 39 Stockholm, Sweden

Visitors' address: Fredsgatan 6

E-mail: [info@ccdcommission.org](mailto:info@ccdcommission.org)

Website: [www.ccdcommission.org](http://www.ccdcommission.org)

# Climate change and health

## Introduction

Proactive health adaptation strategies are needed to protect the world's most vulnerable people from the effects of climate change on human health and well-being.

Public health planning and decision making need to shift from only focusing on relatively short term risks to the projected long term impacts of climate change<sup>1</sup>. It will be increasingly important to address the links between climate and health at different time-scales. Already today we need to be better at dealing with climate variability and its related health effects. Improving our capacity to prepare and respond, through using for example early warning systems and seasonal forecasts, will allow us to be better positioned to address the challenges that climate change will bring. Long-term climate projections will be increasingly important to ensure that we are prepared for risks changing over time when planning resource allocation, building infrastructure and ensuring that surveillance systems are able to detect changing patterns of disease.

Population health often depends on activities in other sectors. To ensure that the health effects of climate change are not overlooked, the health sector needs improved integration into strategic planning in sectors such as water, agriculture and disaster management. This includes safeguarding the integration of health concerns into for example National Adaptation Programmes of Action<sup>2</sup>.

Reducing vulnerabilities and increasing resilience in general will help populations cope with the health effects of climate change. This includes strengthening health systems and ensuring adequate water and sanitation facilities for all.

This paper will describe some of the major routes through which climate change impacts health and several approaches to adapting to these challenges will be outlined. Many of these measures are 'no-regret' options that may contribute to better health even without the threat of climate change. Still, health budgets are finite and there may be greater benefits to investing in prevention of other health risks<sup>3</sup>. Not all health risks due to climate change will manifest everywhere, and in the interests of prioritisation, it is important to conduct location-specific adaptation assessments<sup>4</sup>.

## Effects of climate change on temperature, precipitation and wind speed

Climate change is expected to increase global average temperatures, as well as the number and intensity of heat waves<sup>5</sup>. Climate change is also predicted to result in changes in precipitation patterns, with more pronounced extremes such as flooding or drought expected. Furthermore, *mean* annual precipitation is expected to change, with some areas seeing an increase, whereas other areas such as the Mediterranean region seeing a decrease. Precipitation may increase in one season and decrease in another. Flows in rivers may change in areas where rivers are fed by snowmelt or glaciers<sup>6</sup>.

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<sup>1</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

<sup>2</sup> Climate change and health. Report by the secretariat. World Health Organization: EB 124/11. 20 November 2008.

<sup>3</sup> Ebi, KL, Smith J, Burton I and Scheraga JS, 2006: Some lessons learned from public health on the process of adaptation. *Mitigation and Adaptation Strategies for Global Change*, 11, 607-620.

<sup>4</sup> Ebi, K and Burton I, 2008: Identifying practical adaptation options: an approach to address climate change-related health risks. *Environmental Science & Policy*, 11, 359-369

<sup>5</sup> IPCC, 2007: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tbridge, 996 pp.

<sup>6</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

Climate variability and climate change are however not the only drivers of water availability but is determined by other drivers such as population growth and industrialisation<sup>7</sup>. Tropical cyclones (typhoons and hurricanes) are predicted to become more intense with larger peak wind speed and more heavy precipitation<sup>8</sup>.

Changes in average climate, seasonal patterns and an increase in the number and intensity of extreme events can all influence human health. This paper will start with a section on extreme events in general, and then discuss several different other effects on health and well being of changes in climate and ways to adapt to these changes.

## **Effects on health and how to adapt**

### *Extreme events*

An increase in the frequency and intensity of extremes of temperature, precipitation and wind speed have clear implications for mortality and morbidity. Flooding and storms increase the risk of deaths and non-fatal injuries. Mental health effects such as depression and anxiety after extreme events have been reported and may result in prolonged impairment<sup>9</sup>. In addition to these effects, flooding has implications for other health effects such as diarrhoeal disease risk and the risk of outbreaks of vector borne diseases. These are discussed in more detail throughout this paper alongside the health implications of drought and extreme heat exposure and the health implications of non-extreme changes in climate.

To deal with the health effects of extreme events, the health sector must be engaged in disaster preparedness activities at all levels; international, regional, national, local and community. Some crosscutting aspects are discussed here, with more specific reference throughout the paper.

Better use should be made of existing early warning information on all time scales and new, easily accessible tools must be developed<sup>10</sup>. Early warning systems must be coupled with plans of action – incorporating both disaster management and health expertise. This is an area where national and local government, humanitarian organisations as well as national and regional meteorological institutes should all play a role, down to the community level. Short-term weather forecasts and seasonal forecasts should be used to plan for the coming weeks and season ahead. This will allow for early action in terms of procurement and pre-positioning of stocks and giving health prevention messages to communities.

Importantly, early warning tools need to be developed by meteorology services with different end-users in mind, including local humanitarian agencies. Such systems should ideally be developed *together* with users, with particular attention to developing and packaging the information in a way that truly helps the decision making process. Specific efforts need to be made to 'bridge' the knowledge gap between the weather scientists and the operational humanitarian sector.

It is also important to reduce underlying vulnerabilities, through measures such as improving water and sanitation infrastructure, health systems and building design, which are discussed in more detail below.

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<sup>7</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>8</sup> IPCC, 2007: *Climate Change 2007: The Physical Science Basis*. Ibid.

<sup>9</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>10</sup> Red Cross / Red Crescent Climate Guide. Available at [www.climatecentre.org](http://www.climatecentre.org)

### *Direct effects of heat exposure*

Climate change is expected to increase average temperatures as well as the number and intensity of heatwaves. Heatwaves are associated with increases in morbidity and mortality in the short term, especially in populations who are not adapted to extremely hot weather<sup>11</sup>. Specific risk groups include not only persons with respiratory and cardiovascular disorders and the elderly, but also physically and mentally handicapped and other groups that are not capable of caring for them-selves during an extreme event are at risk. The 2003 summer heatwave in Europe showed that even high-income countries are vulnerable to extreme weather events and although many deaths occurred among the elderly and ill, some of these deaths were associated with occupational exposure. The severity of the heatwave and the underlying health status of the population influences what proportion of the mortality that is due to short-term mortality displacement<sup>12</sup>. In south Asia, heatwaves have been associated with high mortality in rural populations as well as among the elderly and labourers who work outdoors<sup>13</sup>.

Hot working environments also have non-fatal implications. Heat exposure increases the risk of having accidents. Hot working environments may decrease the ability to carry out physical tasks as well as have implications for mental task ability. Prolonged heat exposure may lead to heat exhaustion or heatstroke. In addition to the implications for health and well-being, climate change may through exposure of workers to heat stress have important direct effects on productivity<sup>14</sup>.

Early warning systems for heatwaves are in operation in many countries, including some in Asia, and these must be coupled to concrete action plans with activities throughout many different sectors within a society. Individual people, the health sector, care homes as well as civil society organisations must be made aware of what actions need to be taken, so that the protection of the most vulnerable can be safeguarded. Strong networks of information distribution and outreach in communities will play a vital role in implementing such a strategy<sup>15</sup>.

With regards to longer-term planning, the risk of an increased frequency and intensity of heatwaves and higher average temperatures should be taken into account during the design of homes and work environments. Urban areas tend to have higher temperatures during hot weather, and this urban 'heat island' effect should be taken into account for future city planning<sup>16</sup>. The adverse effects of occupational exposure to heatwaves and high average temperatures may have implications for labour regulations. Interventions such as reducing direct sun exposure for workers can be made.

### *Diarrhoeal diseases*

High temperatures, water scarcity and water abundance resulting from flooding or heavy precipitation have been shown to be related to diarrhoeal diseases. After a flood-event, rates of diarrhoeal disease, including cholera, may increase, especially in areas where sanitation facilities are poor<sup>17</sup>. Heavy rainfall, even without flooding, may increase rates of diarrhoeal disease as latrines or sewage systems overflow. Increases in soil run-off may contaminate water sources. With heavy precipitation events expected to become

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<sup>11</sup> Kovats, RS and Ebi KL, 2006: Heatwaves and public health in Europe. *Eur. J. Public Health*, 16, 592-599. doi:10.1093/eurpub/ckl049.

<sup>12</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>13</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>14</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>15</sup> Kovats, RS and Ebi, 2006, Ibid.

<sup>16</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>17</sup> Ahern M, Kovats S, Wilkinson P, Few R, Matthies F, 2005: *Global Health Impacts of Floods: Epidemiological Evidence*. *Epidemiol Rev.*, 27: 36-46.

more common, rates of diarrhoeal diseases may increase<sup>18</sup> and it is likely that the most vulnerable populations will suffer the greatest burden.

Water scarcity on the other hand is also likely to have consequences for public health. A lack of availability of water for personal hygiene and washing of food may lead to an increase in diarrhoeal disease and other diseases associated with poor hygiene. Cholera outbreaks in the Amazon have been linked to low river flows in the dry season, which may be due to pathogen concentration in pools<sup>19</sup>. A high concentration of pathogens may also overload water treatment plants<sup>20</sup>.

Finally, high temperatures are an independent risk factor of increased rates of diarrhoeal diseases, including salmonella and cholera<sup>21</sup>. Cholera outbreaks in coastal areas of Bangladesh have furthermore been linked with sea surface temperature and abundance of plankton, which are thought to be an environmental reservoir for the cholera pathogen<sup>22</sup>.

*The better the sector is at dealing with climate current variability and extremes at present, the better prepared it will be for increased variability brought about by climate change.*

Ensuring a better baseline level of water and sanitation infrastructure and increasing awareness of the importance of hygiene are measures that are key to reducing a community's vulnerability to extreme weather events and more long-term changes in average water availability or average temperatures. The need to improve sanitation and access to safe water is represented in the Millennium Development Goals, and efforts to achieve this must take place at local, national and international levels. This is a clear example of 'no-regrets' measures, which will improve health even without the additional risks brought about by climate change.

Planning for gradual changes in average water availability requires many sectors to come together, ensuring that health concerns must be represented 'at the table' with water managers and city planners. Importantly, plans need to be developed to ensure water availability throughout the year in areas where precipitation is expected to increase in the rainy season and decrease in the dry season. Such collaboration between the health sector and other sectors must take place at local, national as well as regional levels. Long-term adaptive investments in infrastructure, in particular the capacity of water treatment plants and day water run-off structures in urban environments, are often needed in order to handle changes in seasonal precipitation patterns and extreme water-related events.

As regards extreme events, the use of early warning systems mentioned earlier in this paper could enable the health sectors to preposition stocks enabling water purification, and to provide hygiene education to communities at risk. This applies to extremes of rainfall in general as well as to flooding in particular.

### *Vector-borne diseases*

The geographical and temporal distributions as well as the incidence of many vector borne diseases such as malaria and dengue are sensitive to temperature and rainfall<sup>23</sup>. The vector itself, or the pathogen (virus, bacteria) replication rates can be sensitive to

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<sup>18</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>19</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>20</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>21</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>22</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>23</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

temperature. Changes in precipitation patterns can alter the number of breeding sites available or the way people store water – again creating breeding sites. Climate factors may however not be equally important determinants of disease rates in all regions. There is still considerable uncertainty with regards to how climate change may change the temporal and spatial patterns of many vector borne diseases<sup>24</sup>.

The distributions of these diseases are influenced by other factors too, such as urbanisation, land use, socio-economic development, population movement and levels of immunity within the population<sup>25</sup>.

In some areas, drought may reduce the transmission of some mosquito borne diseases, leading to reduction in the proportion of immune persons and therefore a larger amount of susceptible people once the drought breaks<sup>26</sup>. After a flood event, rates of vector borne diseases such as malaria can increase as mosquitoes breed in stagnant or slow-moving pools of water. However the relationship is complex, as flood events can also wash away breeding sites<sup>27</sup>. Outbreaks of various rodent-borne diseases, like leptospirosis, are commonly reported in the after-math of flooding<sup>28</sup>.

In general, it is likely that the better health systems and public health systems are at dealing with current levels of disease and current climate variability, the better prepared they would be for what climate change may bring. Adapting to climate change means getting better at vector control, detection and treatment as of today, paying particular attention to the most vulnerable populations. Particular efforts need to be made to improve surveillance systems, and better use can be made of the few existing early warning systems for disease.

There are few early warning systems for vector borne diseases in operational use. One example includes southern Africa where malaria is sensitive to rainfall and where there is an early warning system in place that puts together seasonal rainfall forecasts with data on population vulnerability and coverage of prevention activities<sup>29</sup>. An early warning system needs to be coupled with an action plan to be effective.

Even if no early warning system exists, the health sector still needs to be prepared for the distribution of vector borne diseases to change. These changes may occur in terms of intensity of transmission, geographical distribution or temporal distribution (i.e., the time of year that transmission takes place)<sup>30</sup>. In order for health authorities to be aware of these changes, it is crucial that good surveillance systems are in place. To ensure this, a good public health infrastructure with access to primary health care and adequate laboratory facilities and reporting systems are required<sup>31</sup>. Diagnosis and reporting should be standardized, to be able to use and compare data between different locations and over time. Existing surveillance systems should be reviewed in order to identify indicators that could be used for identifying and assessing climate-related health risks and the effectiveness of actions<sup>32</sup>. Vector surveillance should also be carried out<sup>33</sup>. Authorities and humanitarian organisations need to know when diseases re-emerge, emerge in new places, at higher rates or at different times of the year. Plans must be in place, outlining what to do if patterns are changing, such as alerting health services,

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<sup>24</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>25</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>26</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>27</sup> Ahern M et. al. 2005, Ibid.

<sup>28</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>29</sup> DaSilva J, Garanganga B, Teveredzi V, Marx M, Mason J, Connor J., 2004: *Improving epidemic malaria planning, preparedness and response in Southern Africa*. Malaria Journal, 3:37

<sup>30</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>31</sup> Ebi, K and Burton I, 2008: Identifying practical adaptation options: an approach to address climate change-related health risks. *Environmental Science & Policy* 11, 359–369.

<sup>32</sup> Climate change and health. Report by the secretariat. World Health Organization: EB 124/11. 20 November 2008.

<sup>33</sup> Ebi, K, 2009: Public Health Responses to the Risks of Climate Variability and Change in the United States. *J Occup Environ Med*. Jan;51(1):4-12.

engaging vector control measures, and providing education and awareness around how to prevent exposure to the vector and when to seek care. Many humanitarian and non-governmental organisations rely on government data to plan their activities, which means that good surveillance systems will have benefits beyond the state sector. Long-term climate projections should guide where surveillance systems as well as communities need to be particularly prepared for changing risks<sup>34</sup>. This may include for example putting particular attention to dengue surveillance in urban areas in Southeast Asia<sup>35</sup>. Potential changes in other climate-sensitive sectors that may influence disease transmission should also be monitored to guide prioritisation of the placement of surveillance systems<sup>36</sup>.

The above action needs to take place at national level, but integrated within regional systems, as exemplified by the European Centre for Disease Control, as well as international systems such as the World Health Organisation. These steps of integration will serve, among other things, to ensure that early warning is given to neighbouring countries of emerging diseases. Still, the building blocks of a functioning surveillance system, primary health care, laboratories and reporting systems, need to be at national level. With the implementation of the World Health Organisation International Health Regulations, the situation is expected to improve<sup>37</sup>.

Using the early warning systems for extreme events as earlier in this paper can also help prepare for any increased risk of vector borne diseases after flooding or heavy rainfall. Also here it is important that the health sector works closely with the disaster management sector in planning for and responding to disasters.

### *Health effects of air quality*

The formation of many air-pollutants is determined in part by climate factors such as temperature and humidity. In addition the transport and dispersion of air pollutants away from source regions are strongly affected by weather factors. Climate change may therefore influence pollutant concentrations, which in turn may affect health as air-pollution is related to cardio-respiratory health. Exposure to high levels of ground-level ozone, for example, which is formed from the exhaust of transport vehicles, increases the risk of exacerbations of respiratory diseases such as chronic obstructive airways disease and asthma, leading to hospital admissions or increased mortality<sup>38</sup>. The number of forest and bush fires may increase as certain regions face longer periods of extreme dry conditions and such fires can contribute to air-pollution. The direction and magnitude of the effects of climate change on air pollution levels are however highly uncertain and there will be regional variations<sup>39</sup>.

National energy policies and transport policies should take into account the health effects of air-pollution<sup>40</sup> and early warning systems for levels of air pollution can be implemented. Reducing emission from transport vehicles is a win-win solution contributing both improve health as well as reduce greenhouse gas emissions.

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<sup>34</sup> Ebi, KL, Smith J, Burton I and Scheraga JS, 2006: Some lessons learned from public health on the process of adaptation. *Mitigation and Adaptation Strategies for Global Change*, 11, 607-620.

<sup>35</sup> Cummings DA, 2004: Travelling waves in the occurrence of dengue haemorrhagic fever in Thailand. *Nature*, 427, 344.

<sup>36</sup> Ebi, KL, Smith J, Burton I and Scheraga JS, 2006: Some lessons learned from public health on the process of adaptation. *Mitigation and Adaptation Strategies for Global Change*, 11, 607-620.

<sup>37</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>38</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>39</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>40</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

## *Meningitis*

The spatial distribution, intensity of transmission and seasonality of meningococcal meningitis in the semi-arid areas of sub-Saharan Africa have been linked to climatic factors, particularly drought and hot, dry and dusty conditions, although the causal mechanism is not clear<sup>41,42</sup>. An early warning system is under development<sup>43</sup>.

## *Food security and malnutrition*

The relationships between climate change and food security are complex and climate is seldom the only factor at play. High temperatures, lack of rain or low river flows can put harvests at risk. Salinization of agricultural land due to sea levels rise can decrease yields and flood events or heavy rainfall can also destroy harvests. These effects of climate change together with other factors can have consequences for food security<sup>44</sup>. As rates of malnutrition increase, populations may also become more susceptible to other diseases<sup>45</sup>. Climate change is in this way affecting the underlying vulnerability of populations to other effects of climate change.

Climate stress may play a part in population movement, including rural to urban migration. Population displacement carries its own health risks, including malnutrition and increased risks of communicable diseases<sup>46</sup>. Vector borne diseases can spread as people from an affected area move into new areas. If non-immune populations enter an endemic area they are at higher risk of being infected and can contribute to the spread of disease<sup>47</sup>.

Addressing these complex effects of climate change goes well beyond what the health sector can deal with on its own and requires cross-sectoral collaboration. There can be real benefits to using existing early warning systems against drought and food insecurity.

## *Health systems*

Adequate health infrastructure with universal access to primary health is crucial to reducing a population's vulnerability to the impact of changing patterns of diseases due to climate change. A well functioning health system not only provides treatment, but, together with laboratory services and standardized diagnosis and reporting systems, is a crucial component of a national surveillance system. Health professionals must be better trained to understand the potential impacts of climate change on health<sup>48</sup>. One of the main challenges that health systems face in many developing countries today is that qualified health professionals leave developing countries to work abroad<sup>49,50</sup>. Improving health systems is another clear 'no-regrets' option for adaptation, and should include particular efforts to extend services to the most vulnerable populations. Climate change must also be taken into account when designing health systems, such as for example ensuring that health stations are built in areas that are accessible even during floods<sup>51</sup>.

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<sup>41</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>42</sup> Health and Climate Foundation – The MERIT project. <http://www.hc-foundation.org/merit.html>

<sup>43</sup> Health and Climate Foundation – The MERIT project. <http://merit.hc-foundation.org/>

<sup>44</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>45</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>46</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>47</sup> Martens P, Hall L., 2000: *Malaria on the move: human population movement and malaria transmission*. *Emerg Infect Dis.*, Mar-Apr;6(2):103-9.

<sup>48</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>49</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>50</sup> Haines A and Cassels A, 2004: *Can the Millennium Development Goals be attained?* *Brit. Med. J.*, 329, 394-397.

<sup>51</sup> Few R, Ahern M, Matthies F, Kovats S. 2004: Floods, health and climate change: a strategic review. *Tyndall Centre of Climate Change Research*. Working Paper 63.

## Health effects of adaptation and mitigation activities

### *Health effects of adaptation activities*

Activities carried out in order to adapt to climate change can in some cases lead to additional health risks. Examples include the construction of dams for water storage, which may provide breeding sites for disease-transmitting mosquitoes. Irrigation of land currently contributes to the spread of malaria and schistosomiasis<sup>52</sup>. The practice of using wastewater for agricultural irrigation may also become increasingly common in times of water scarcity<sup>53</sup>, leading to increased risks of diarrhoeal diseases and intestinal worms for populations living in close proximity to irrigated land<sup>54</sup>. These risks highlight the need for an integrated risk assessment during the development of new policies at national level or local level, taking into account the possible health effects and how to reduce these risks. However, it is likely that many such practices will take place informally in rural or peri-urban settlements so that national regulations may not be as effective.

### *Co-benefits of mitigation activities*

There are several potential co-benefits for health of some of the policies that seek to reduce greenhouse gas emissions. It is very likely that efforts to reduce emissions of greenhouse gases will have substantial co-benefits for health in terms of reducing pollutants that contribute to cardio-respiratory diseases<sup>55,56</sup>. Transport policies that promote cycling and walking have the potential to both reduce greenhouse gas emissions and also have health benefits through reductions in air pollution, accident risk, and increased levels of physical inactivity<sup>57,58</sup>. Better insulation of houses in cold climates is likely to reduce both energy consumption and cold-related morbidity and mortality<sup>59</sup>.

In low-income countries, many people rely on biomass fuels to a high degree, and as a proportion of these are harvested non-renewably this contributes to carbon emissions. In terms of health, the resulting indoor air pollution is a significant cause of morbidity and mortality in many developing countries and the disease burden is estimated to be in the order of 0.7 to 2.1 million premature deaths in low- income countries annually, two-thirds of which occur in children under five<sup>60</sup>.

There are therefore significant win-win options that can reduce greenhouse gas emissions as well as contribute to better health and such policies should be favoured when choosing strategies<sup>61</sup>.

## Summary

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<sup>52</sup> Sutherst RW, 2004: *Global change and human vulnerability to vector-borne diseases*. Clin. Microbiol. Rev., 17,136.

<sup>53</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>54</sup> WHO,UF. WHO guidelines for the safe use of wastewater, excreta and greywater. Wasterwater use in agriculture. II. 2006.

<sup>55</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>56</sup> Cifuentes L, Borja-Aburto VH, Gouveia N, Thurston G and Davis DL, 2001: *Climate change. Hidden health benefits of greenhouse gas mitigation*. Science, 293, 1257-1259.

<sup>57</sup> Wilkinson P, Smith KR, Joffe M, Haines A. 2007: *A global perspective on energy: health effects and injustices*. The Lancet, 370, 965 – 978.

<sup>58</sup> Dora C, 1999: *A different route to health: implications of transport policies*. BMJ, Jun 19;318(7199):1686-9.

<sup>59</sup> Campbell-Lendrum C and Corvalán C: 2007: Climate change and developing country cities: implications for environmental health and equity. *J Urban Health*. May;84(3 Suppl):i109-17.

<sup>60</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

<sup>61</sup> IPCC, 2007: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Ibid.

To summarize the recommendations made in this paper, the actions can be divided into those that mean doing more of the same: focussing on building resilience and strengthening public health systems at all levels while paying particular attention to the most vulnerable in society. However, some things need to be done differently, such as developing more user-friendly early warning systems, using information at multiple timescales, strengthen the health sectors involvement in planning in other sectors and look for win-win solutions that benefit health and reduce greenhouse gas emissions. Overall, there needs to be a better focus on how to better deal with short term climate variability, as well as planning for how to ensure that systems remain resilient and adaptable to changing risks in the longer term.

Climate change does not create new health hazards. Instead it may act as a multiplier of existing health problems or change the location of health concerns. Therefore, a cost-effective and prompt way of handling climate change adaptation is to add the climate dimension into existing international or community-based programs and actions. For more long-term adaptive strategies cross-sectoral approaches are needed.

Further research is needed on links between climate and health and projected effects, as well as the most effective adaptation measures, but a detailed discussion of research gaps and priorities is beyond the scope of this paper.

*Doing more of the same:*

- Strengthen health systems with a particular focus on human resources.
- Improve access to water and sanitation and improve knowledge about hygiene.
- Improve surveillance systems through strengthening access to primary care, improve laboratory facilities and standardise diagnosis and reporting. Increase international collaborations on surveillance.
- Make better use of the few existing early warning systems for particular diseases.

*Doing things differently:*

- The health sector should make better use of early warning information available nationally, regionally or through global providers such as academic institutions for climate variability extremes (flooding, drought, storms, heatwaves, seasonal rainfall patterns) to aid public health decision-making and preparedness for the state sector as well as the non-state sector, at all levels but especially down to the community level.
- Focus surveillance efforts at areas predicted to be at particularly high risk for changing patterns of disease.
- Where appropriate, invest in win-win solutions that reduce greenhouse gas emissions as well as improve public health.
- Take health risks into account when planning adaptation measures.
- Ensure the health sector is at the table when planning climate change adaptation in other sectors.
- When planning cities, take into account the urban heat island effect, ensure availability of shaded spaces and green areas, ensure that water and sanitation infrastructure is resilient to extremes of precipitation, and facilitate modes of transport that contribute to public health and reduce greenhouse gas emissions.
- Taking into account future sea level rise and flood-plains when planning infrastructure.
- Take into account changing temperatures during building design.

There is a need to document, assess and disseminate experiences of adaptation as countries and regions undertake and plan such strategies<sup>62</sup>.

*Climate change is likely to disproportionately affect the most vulnerable in both high and low income countries and special attention should be paid to these populations both when we think about doing more of the same as well as doing things differently.*

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<sup>62</sup> Climate change and health. Report by the secretariat. World Health Organization: EB 124/11. 20 November 2008.