

# Protecting Human Health from Climate Change: Report of the Technical Discussions

*WHO/SEARO  
New Delhi, 18-21 August 2009*



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## Contents

	<b>Page</b>
Objectives.....	1
Recommendations .....	1
Introduction.....	6

### Annexes

1. Opening address by Dr Samlee Plianbangchang, WHO Regional Director for South-East Asia.....	38
2. Keynote Address: The special vulnerability of population health to climate change impacts in the SEA Region (SEAR )”, Dr Colin D. Butler, Associate Professor, National Centre for Epidemiology and Population Health, College of Medicine, Biology and Environment, Australian National University .....	43
3. Public Health Interventions to Protect the Vulnerable People in Mountain Regions from Climate Change Effects, Dr Fang Jing and Dr Mats Eriksson, International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal .....	57
4. “Strengthening climate resilience to protect health in island communities”, Dr Alistair Woodward, School of Population Health, University of Auckland, New Zealand.....	69
5. “Climate change effects on urban health”, Ms Sari Kovats, Centre on Global Change and Health, Department of Public Health and Policy, London School of Hygiene and Tropical Medicine.....	78

6.	“Increasing heat stress in occupational health due to climate change: Needs for research and prevention in South-East Asia”, Dr Tord Kjellstrom, National Centre for Epidemiology and Population Health, Australian National University, Canberra, Australia.....	89
7.	“Progress report on the status of implementation of the New Delhi Declaration 2008”, Alexander von Hildebrand, Regional Adviser, Environmental Health and Climate Change, World Health Organization, Regional Office for South-East Asia .....	120
8.	Agenda.....	125
9.	List of participants.....	126

## **Objectives**

### ***General***

To provide recommendations on “Protecting Human Health from Climate Change” for consideration by the Sixty-Second Session of the WHO Regional Committee for South-East Asia

### ***Specific***

To share evidence and experiences at regional and national levels on the health impact from climate change and mitigation and adaptation thereto;

To review the current scientific evidence on the impact of climate change on health;

To identify research gaps in protecting human health from climate change and develop an agenda for operational research in the Region; and

To provide recommendations on “Protecting human health from climate change” for consideration by the Sixty-Second Session of the WHO Regional Committee for South-East Asia.

## **Recommendations**

### ***Preamble***

We, Representatives of the Member States of the WHO South-East Asia Region as participants to the Technical Discussions on Protecting Human Health from Climate Change, held in SEARO, New Delhi, from 18 to 21 August 2009:

Aware of the findings of the 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) on the anthropogenic nature of global warming and the climate implications thereof, and alert to in particular the

projected direct and indirect harm that climate change has and will have on the health of the local communities in the countries of South-East Asia;

Recognizing that there is an urgent need for action by the national governments, and in particular the health sector, to reduce the impact on climate-sensitive health determinants such as heat and cold, floods and droughts, storms, food security and water scarcity, sea-level rise and forced migration, and the effects on heat stress and strokes, respiratory illnesses, vector-, water- and food-borne diseases, injuries and drowning, malnutrition and mental stress, which will primarily affect the health and livelihoods of the most vulnerable in the countries in the Region;

Recalling the 2008 New Delhi Declaration on the impacts of climate change on human health, the World Health Assembly resolution WHA 61.19 on climate change and health and the Regional Framework for Action to Protect Human Health;

Recognizing the various efforts undertaken by national authorities in Member States and by the health sector as well as by WHO in the South-East Asia Region, to prepare and implement national and regional climate action plans;

Considering that there is a critical need to increase the awareness on the climate change impact on health, to improve the capacity of the health sector to respond, to obtain evidence-based information on the relationship between climate change and health outcomes, and to translate research results into concrete action;

Recognizing the current challenges such as the poor research capacity, and limited data quality, low performance of epidemiological and environmental surveillance systems, the lack of gender- and age sensitive databases, the meager baseline data on climate-sensitive disease, the use of non-standardized assessment methods, the challenges in attributing disease burden to climate change, the uncertainty of research data due to projections on greenhouse gas emissions, climate-forcing factors, demographic trends, and the lack of forums for collaborative transboundary research;

Noting the urgent need of economic estimations of increased health costs linked to climate change, in particular for health conditions related to occupational heat stress and losses in labour-productivity;

Considering that climate change could lead to more pest pressure on crops and corresponding indiscriminate use of pesticides, which could increase both

resistance to insecticides and direct exposure of agriculture workers and the general population to toxic chemicals through air, food and water;

Aware that the impact of climate change will vary from country to country and location to location within the country and depend significantly on pre-existing vulnerability levels and disease burdens, and that therefore effective preventive and adaptive action will need to be developed and implemented with the active participation/leadership of local communities;

Further aware that responding to the challenges posed by climate change to health can only be overcome by fostering partnerships and effectively collaborating across the full range of the health sector including governmental, nongovernmental and especially community-based actors; and

Conscious of the fact that robust capacity to respond to climate change threats by the health sector can only be achieved by allocation of additional funding.

RECOMMEND Member States to:

- Accelerate the implementation of climate change-and health-related actions as committed to in the 2008 New Delhi Declaration;
- Appoint and allocate resources for the functioning of a specific climate change and health team in the ministries of health and strengthen strategies for interdepartmental coordination and coordination;
- Develop a communication strategy to increase the awareness of climate risks to policy-level officials within and outside the health sector, health professionals and health workers, nonprofit NGOs, community organizations, corporate and business sectors and the media;
- Increase awareness of the health consequences of climate change, the implications for the health system, the urgent need for action for developing appropriate policies within and outside the health sector;
- Build up the capacity of health professionals and health workers—but also of professionals in other related sectors—to comprehend the impact and challenges posed by climate change to health and the need to proactively collaborate and in a timely manner to identify and address the impacts and challenges posed by climate change to human health, and national health systems;

- Collaborate with national authorities to introduce climate change and health dimensions into education curricula at all levels, in particular medical and public health schools, to strengthen the capacity of professionals in all sectors to understand and contribute to the response to climate change;
- Develop and implement a prioritized national agenda for applied research and training on selected essential topics to assess the scale and nature of health vulnerability to climate change, making use of the best performing available assessment tools, with the aim to inform health planning and prepare actionplans to reduce the burden of disease and the economic impact of climate change;
- Map the available resources (including human resources), identifying ongoing programmes and national research institutions' networks and partnerships available and necessary to conduct priority studies, using a standardized research methodology and ensuring that research findings/results are disseminated in a timely, efficient and user-friendly manner;
- Strengthen the surveillance of climate-sensitive health determinants and health outcomes to improve the efficacy of early warning systems and increase the availability of reliable and active monitoring of climate change–related health risks for risk assessment purposes;
- Actively support the empowerment of local communities to become more climate change–resilient, fostering cross-disciplinary partnerships and collaboration with other key sectors, such as environment, agriculture and education, as well as with nongovernmental organizations, in particular with youth groups and consumer organizations;
- Recognize gender, fairness and equity when developing and implementing preventive and adaptive measures, which should also enhance health equity and the welfare of women;
- Promote and support community leadership and participation in mitigation measures that also improve health, and strengthen the health system and integrated adaptation actions that reduce the adverse health impacts of climate change at local, national and global levels;
- Ensure closer synergy and collaboration between health scientists and practioners and meteorologists, supporting efforts to strengthen regional

cooperation to share relevant climate information that can improve health decision-making;

- Collaborate with other sectors to assess the health co-benefits and potential negative consequences deriving from current and planned mitigation and adaptation measures undertaken outside the health sector; taking into consideration synergies with trends such as rapid urbanization, population growth, and industrialization.
- Provide resources so that health representatives can be fully engaged in development and implementation of national climate action plans, and contribute as well to international forums such as the relevant bodies of the United Nations Framework Convention on Climate Change (UNFCCC), in order to advocate that priority be given to addressing health issues in realms of both adaptation and mitigation;
- Prepare and implement a national plan to reduce the carbon footprint of the health sector; and
- Develop a strategy to fund health-related climate action plans.

RECOMMEND that WHO should:

- Identify and include all relevant climate change and health implications in the WHO 2010-2011 action plans;
- Ensure that health and climate change dimensions are included in the efforts to revitalize the primary health care (PHC) agenda and programmes aimed at health systems strengthening;
- Recommend to Member States of the Region to mainstream climate change-related health issues into the health sector reform agenda; and
- Direct the Regional Office-based Working Group on “Protecting Health from Climate Change” to set up a comprehensive regional mechanism involving all countries and WHO offices to:
- Create and update the inventory of the ongoing research programme’s, relevant expertise in the Region;
- Strengthen regional networking and cooperation to exchange and share evidence-based data and information on climate-sensitive diseases and health problems and on best coping practices through existing mechanisms such as the “Inter-Agency Standing Committee (IASC) Task Force on Climate Change”;

- Create a mechanism to discuss the findings and future plans to avoid duplication;
- Address health issues related to climate change by supporting the development and use of tools and methodologies to assess health and health systems' vulnerability;
- Strengthen local skills to find solutions to health threats posed by climate change through capacity development involving local communities and using robust monitoring and evaluation mechanisms;
- Attract potential partners and have them interested in networking with WHO's efforts in the domain of common interest; and
- Identify existing WHO collaborating centres in the Region that could undertake research in priority areas and shortlist institutions to become new WHO collaborating centres in the SEA Region in the area of human health and climate change.

## **Introduction**

The Twenty-fifth Meeting of Health Ministers of the South-East Asia (SEA) Region, held in Thimphu, Bhutan in 2007, addressed the issue of climate change impacts on health in the Region. The resulting Thimphu Declaration requested WHO to support countries in developing national plans and in formulation of a regional strategy to combat the adverse health impacts of climate change. The ministers also proposed that WHO should select "climate change and health" as the topic for World Health Day 2008. They also committed themselves to contribute to national plans and provide the needed funding for that purpose.

In October 2007, the Director-General of WHO selected "Protecting Health from Climate Change" to be the theme of World Health Day 2008.

In November and December 2007, WHO's Regional Office for South-East Asia (SEARO) supported national workshops on human health and climate change in Bangladesh, India, Indonesia and Nepal. The recommendations were to improve intersectoral communication and cooperation to assess vulnerabilities and identify interventions for mitigation and for adaptation; to increase awareness on impacts to health and gather more evidence-based data; to strengthen existing climate-sensitive health programmes, with the focus on early warning systems; and to empower local communities to become climate resilient.

In December 2007, the Regional Office sponsored a biregional workshop, in Bali, Indonesia, at which government representatives from 22 Asian countries endorsed the “Regional framework for action to protect health from the effects of climate change in Asia and the Pacific”. The framework aims to build capacity and strengthen national health systems in countries to protect human health from current and projected risks due to climate change, ensure that health concerns are addressed in the decisions to reduce risks from climate change made by other key sectors, and to reduce the carbon footprint of the health sector itself.

In May 2008, the World Health Assembly resolution WHA61.19 called for stronger action to address the health risks associated with climate change. The Health Assembly requested WHO “to continue close cooperation with appropriate United Nations organizations, other agencies and funding bodies, and Member States, to develop capacity to assess the risks from climate change for human health and to implement effective response measures, by promoting further research and pilot projects in this area, including work on:

- health vulnerability to climate change and the scale and nature thereof;
- health protection strategies and measures relating to climate change and their effectiveness, including cost-effectiveness;
- the health impacts of potential adaptation and mitigation measures in other sectors such as water resources, land use, and transport, in particular where these could have positive benefits for health protection;
- decision-support and other tools, such as surveillance and monitoring, for assessing vulnerability and health impacts and targeting measures appropriately; and
- assessment of the likely financial costs and other resources necessary for health protection from climate change.”

The Twenty-sixth Health Ministers’ Meeting, held in 2008 in New Delhi, India passed the “New Delhi Declaration on the impacts of climate change on human health”, and requested WHO to support its implementation and report the progress thereon.

The Sixtieth Session of the Regional Committee held in New Delhi, India in 2008 proposed the subject “Protecting Human Health from Climate Change” for the Technical Discussions to be held prior to the Sixty-first Session of the Regional Committee.

Technical Discussions on the subject were held in the Regional Office, New Delhi, India, from 18–21 August 2009. Representatives from 11 Member States of the Region were invited, representing ministries of health as well as ministries of environment, along with experts and centres of excellence from the Region and beyond. The 2008 New Delhi Declaration on the impacts of climate change on human health constituted the main working paper.

Participants included 24 representatives from nine Member States, five experts from the SEA Region countries and centres of excellence, four international experts, eleven participants from partner agencies, one participant from WHO-HQ, Geneva, one each from the India, Indonesia, Maldives, Nepal, Sri Lanka and Thailand country offices, and ten participants from the WHO Regional Office.

Dr R.S. Shukla, Joint Secretary, Ministry of Health and Family Welfare, India; Dr Babu Ram Marasini, Senior Health Administrator, Ministry of Health and Population, Nepal; Dr Twisuk Punpeng, Public Health Technical Officer, Department of Health, Ministry of Public Health, Thailand; and Mr Simad Saeed, Member Presidential Advisory Council on Climate Change, Maldives, were elected Chairpersons, while Mr Gyembo Dorji, Programme Officer, Ministry of Health, Bhutan; Dr Budi Haryanto, Faculty of Public Health, University of Indonesia, Indonesia; and Ms Nahida Ahmed, Public Health Programme Coordinator, Ministry of Health, Maldives were elected Rapporteurs.

Member States recognized the significant and varied efforts undertaken and results achieved by national authorities in countries and by the health sector, as well as by the WHO-SEARO-based Working Group “Protecting Health from Climate Change” to prepare and implement national and regional climate action plans.

Participants discussed the contents of nine technical papers in detail in groups and in the plenary. The Technical Discussions concluded with a corpus of recommendations towards accelerating the implementation of the New Delhi Declaration, comprising 17 action points for Member States and 11 for WHO. The participants to the Technical Discussions also proposed that the Regional Committee adopt a resolution.

### ***Key issues***

During the last 100 years, human activities, particularly related to the burning of fossil fuels, deforestation and agriculture, have led to a 30% increase in the carbon

dioxide (CO<sub>2</sub>) levels in the atmosphere, causing trapping of more heat. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC)<sup>1</sup>, states “Most of the observed increase in globally-averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations; 11 of the last 12 years (1995-2006) rank among the 12 warmest years in the instrumental record of global surface temperature; and the global average sea level rose at an average rate of 1.8 mm per year from 1961 to 2003.

The AR4 IPCC 2007 report also draws on projections of future changes in climate:

“The projected globally-averaged surface warming for the end of the 21st century (2090–2099) will vary between 1.1 and 6.4 degrees Celsius. The projected rate of warming is greater than anything humans have experienced in the last 10 000 years;

The global mean sea level is projected to rise by 9.88 cm by the year 2100;

It is very likely that hot extremes, heat waves and heavy precipitation events will continue to become more frequent; and

It is likely that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and heavier precipitation”.

At the 5663rd meeting of the United Nations Security Council held at New York, USA, on 17 April 2007, Mr Ban Ki-Moon, United Nations Secretary-General<sup>2</sup>, said that, according to the most recent assessments of the IPCC, the planet’s warming was unequivocal, its impact was clearly noticeable and it was beyond doubt that human activities had been contributing considerably to it.

WHO estimated that the warming and precipitation trends due to anthropogenic climate change of the past 30 years claimed over 160 000 lives every year. In 2000, at least 77 000 deaths attributable to climate change occurred in countries of the SEA Region.

A great deal of knowledge related to each of these topics exists already. The 2007 report of the Intergovernmental Panel on Climate Change summarized the

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<sup>1</sup> More at: <http://www.ipcc.ch/>

<sup>2</sup> See: <http://www.un.org/News/Press/docs/2007/sc9000.doc.htm>

state of existing science on the health implications of climate change. The current expert consultation aims to build on these, in order to provide a common understanding of priority research gaps relating to climate change and health.

In his opening address, Dr Samlee Plianbangchang, WHO Regional Director for South-East Asia Region warned that climate change was recognized as one of the defining challenges of the century. Protecting and promoting health in this context was assuming increasing priority for the public health community. Climate change would affect, in profoundly adverse ways, some of the most fundamental pillars of health: food, air and water. The warming of the planet would be gradual, but the frequency and severity of extreme weather events, such as intense storms, heat waves, droughts and floods could be abrupt and the consequences would be felt dramatically. The most severe threats were to developing countries, with direct negative implications for the achievement of the health-related Millennium Development Goals (MDGs), and for health equity.

Referring to the Region, Dr Samlee said that populations within the SEA Region remained highly vulnerable to a wide variety of health effects from climate change, but were also the fast-growing contributors to greenhouse gas (GHG) emissions. Health impacts would be disproportionately greater in vulnerable populations. In the SEA Region, people at greatest risk included the very young, the elderly, and the medically frail. Local communities with low incomes and living in areas where malnutrition was widespread, education was poor, and infrastructures were weak, would have the most difficulty adapting to climate change and its related health hazards. Vulnerability was also determined by geography, and was higher in areas with a high endemicity of climate-sensitive diseases, water stress, low food production and isolated populations. The populations considered to be at the greatest risk in the Region were those living on islands, mountainous regions, water-stressed areas, mega cities and coastal areas.

The Regional Director insisted on the fact that reducing current and projected health risks attributable to climate change was a risk management issue, with adaptation and mitigation the primary responses. Mitigation and adaptation are not mutually exclusive; co-benefits to human health can result concurrently with implementation of actions to reduce greenhouse gas emissions, and adaptation measures can reduce emissions. As the context for adaptation will change with changing climatic conditions, along with changes in demographics, technology, and socioeconomic development, an iterative risk management approach is likely to be the most effective. Because climate change is one of many public health issues that need to be addressed, policies and measures need to ensure that actions to reduce climate-related health risks support current programmes to address health issues

and explicitly consider key uncertainties. Finally, Dr Samlee pointed out that while the community had a very significant role to play in protecting the health of its members from climate-related threats, national health authorities and WHO had the responsibility, political leverage and staff with many of the necessary skills to help protect the health of local communities. (See Annex 1)

In his keynote address “The special vulnerability of population health to climate change impacts in the SEA Region”, Dr Colin D. Butler, Associate Professor, National Centre for Epidemiology and Population Health, College of Medicine, Biology and Environment, Australian National University, Australia, indicated that climate change was already having many adverse physical, ecological and social impacts. It was an amplifier of existing disadvantages, and a generator of many new problems, themselves likely to create and intensify vulnerability. The most likely and quantitatively important adverse effect to health in the SEA Region because of climate change was via worsened nutrition, especially due to localized agricultural impairment. Poor nutrition would in turn worsen many infectious diseases, from pneumonia to diarrhoea, and also some chronic diseases<sup>1</sup>. Worsened nutrition will also lower economic productivity and add to the burden of cognitive impairment and poverty among the severely undernourished<sup>2</sup>. The harmful effect of climate change on agriculture was likely to manifest in several ways, including increased heat, drought and reduced water for irrigation. Extreme weather events, such as heatwaves, droughts, very heavy rainfall, river floods, and coastal storms were also likely to become more intense, and each would bring immediate and long-term agricultural and health sequelae. As climate change increases, adverse direct effects of chronic heat stress were likely to become increasingly frequent among unprotected workers and other high-risk groups, such as outdoor labourers and those in factories and offices with inadequate air conditioning, the elderly, and those with chronic illnesses. (See Annex 2)

**Business session 1:** Share evidence and experiences at regional and national levels on the health impact from climate change and mitigation and adaptation thereto.

All Member States recognized the findings of the 2007 Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) on the anthropogenic nature of global warming due to the historical accumulation of greenhouse gases in the atmosphere and the climate implications thereof, and in particular the projected direct and indirect harm that climate change has on the health of communities in countries of the SEA Region.

Member States, through individual country presentations, shared evidence and experiences at regional and national levels on the health impact from climate change and mitigation and adaptation thereto.

Consensus was reached on the urgent need for action by national governments, and in particular the health sector, to reduce the climate change impact of climate sensitive-health determinants such as heat and cold, floods and droughts, food security and water availability, and the effects of these on health conditions such as heat stress and strokes, respiratory illnesses, vector-, water- and food-borne diseases, malnutrition, and mental well-being, which will primarily affect the health and livelihoods of the most vulnerable populations.

Delegates from Indonesia presented a country overview. They pointed out that Indonesia was located at the equator in between the Asia and Australia continents, and Pacific and Indian oceans, putting most of the 230 million population of Indonesian islands on the risk of climate change's vulnerability. Increasing temperature, rainfall and humidity are estimated to be associated with increasing cases of vector-borne, waterborne, foodborne and airborne diseases; malnutrition, cardiocerebral vascular diseases; hypertension; mental disorders; and injuries since 1985.

Indonesia's strategy for health adaptation from climate change includes: Putting "health adaptation" as a priority in development plans at national and local levels; Scheme of Health Adaptation based on the integrated programme of diseases control and environmental health; Involving other sectors, NGOs, academicians and communities; and intensifying integrated role of the National Committee on Climate Change. Several actions have been conducted in Indonesia, such as: a pilot study in three cities (Padang, Palembang, Surabaya); a road show on "Climate Change and Human Health" among related decision makers in the same cities; Brain-storming on "Climate Change and Human Health" among stakeholders led by Ministry of Health (MoH); Development of National Environmental Health Action Plan (NEHAP) including issues of climate change and health; Developing a strategy and Actionplan on climate change and health jointly with other sectors; and conducting several seminars and workshops nationally as well as internationally, involving academicians and public health professionals.

However, there are challenges: Disparities in the health status; poor performance and quality of health services delivery; poor environmental health conditions; insufficient number of trained health officers; and a biased budget that is more focused on curative programmes.

Dr Bandana K. Pradhan, Dr Babu Ram Marasani, Dr Kedar Narshingh and Dr Mohamed Daut made a joint presentation on “Emerging Health Risk due to Climate Change in Nepal”. They informed that in Nepal, climate varies greatly with polar in the northern Himalayas to tropical in the south within 200 km span owing to extreme altitudinal variation. The annual mean temperature is around 15°C. The average rainfall for the country is 1500mm, which varies spatially across the country — decreasing from east to west. Nepal has witnessed an estimated annual increase in temperature of 0.06°C. Higher altitudes have faster increase in temperatures than lower altitudes. The per capita CO<sub>2</sub> equivalent emission of Nepal is 1.9 tonnes per year, which is very low as compared to the global average value of 3.9 tonnes per capita. Global warming has affected the Himalayas and over 20 glacial lakes have been identified to be at risk of bursting (GLOF) (Mool et al. 2001).

The major estimated health impacts of climate change at national and subnational levels are as follows: (i) Temperature-related illness and death: since the last few years, cold waves and heatwaves have occurred in the Tarai (southern plain area), increasing morbidity and mortality; (ii) Extreme weather-related health effects: the historical evidence in Nepal indicates that prolonged droughts and flashfloods have triggered disasters, famines and diseases outbreaks; (iii) Air pollution-related health effects: respiratory diseases like acute respiratory infection (ARI), bronchitis and asthma, etc. are showing an increasing trend; (iv) Water and foodborne diseases: diseases like diarrhoea, dysentery, typhoid, cryptosporidiosis, giardiasis, amoebiasis, gastritis, jaundice and infectious hepatitis are also showing temporal and spatial increment. Diarrhoeal disease and typhoid cases are also increasing and occurring more frequently in the mountains than in the hills and the Terai region. Water scarcity leads to increased exploitation of existing water courses, increasing the water- fetching distance and thereby resulting in different types of water-related diseases; (v) Vectorborne and rodent-borne diseases: encephalitis, leishmaniasis, malaria and kala-azar (Visceral leishmaniasis) are crucial public health concerns in Nepal. Of these, malaria and kala-azar have reappeared in Nepal’s warmer districts. Kala-azar (visceral leishmaniasis) is an endemic disease reported in 12 districts of eastern Terai region of Nepal. Japanese encephalitis is found in all 20 Terai and 4 adjoining hill districts. Lymphatic filariasis is endemic in 60 districts. Dengue appeared in Nepal only in 2001.

The most vulnerable communities in Nepal are the poor who are living on the banks of rivers in slums and squatter settlements, and in remote areas. However, despite the health system, the government has not directly addressed climate change as one of the issues in morbidity and mortality patterns. The adaptation measures undertaken by the government are not yet adequate to address the climate change impact on health.

Dr Fang Jing and Dr Mats Eriksson, International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal, presented Working Paper Number 1 on “Public health interventions to protect the vulnerable people in mountain regions from climate change effects”. They reported on the fact that warming at high elevations in mountain regions was greater than the global average in the last 100 years (IPCC, 2007; Nogues-Bravo et al., 2007). For instance, temperature in the Tibetan plateau in the last 40 years (1961-2000) increased at a speed of 0.26 centigrade per decade, which was much faster than temperature increases in other parts of the world (Du, 2001). So far, changes in the total amount of precipitation in the Himalayan region has been difficult to detect. However, preliminary studies indicate that the variability is increasing, with more dry spells separated by intense rainfall events. There are also signs of changes in the monsoon pattern leading to changes in the seasonal distribution of precipitation.

The changing temperature and rainfall pattern can expose mountain people to increased health risks. For example, malaria-carrying mosquitoes may move to higher altitudes. Both Bhutan and Nepal have reported malaria cases at altitudes over 4000m (WHO, 2006), previously free from such disease although it is not very clear whether the infection was contracted locally or imported. The warming weather and changing precipitation may also make the control of malaria in endemic places more difficult. Sensitivity to climate change is determined by exposure-effect and population characteristics (Kovats et al., 2004).

Mountain regions are the frontiers of climate change. Mountain people have more exposure, higher sensitivity and lower adaptive capacity to climate change. While acknowledging the uncertainties of climate change impact on human health and the challenge to isolate the effects of climate change from the effects of other health determinants, public health interventions need to be taken urgently to actively protect people’s health from climate change. (Annex 3)

In presenting Working Paper Number 2, “Strengthening climate resilience to protect health in island communities”, Dr Alistair Woodward, School of Population Health, University of Auckland, New Zealand, described the ways in which climate change threatened the health of populations living on small island states and reviewed what is known about factors that promoted resilience of island communities. He drew on the experience of a range of island states, particularly from two countries, Maldives and Samoa.

Dr Woodward pointed out that climate change would affect island states in many ways. In brief, sea-levels will rise as a result of warming of the oceans, possibly exacerbated by the melting of land-based ice sheets such as the Greenland

ice shelf, and this will be a particular issue for densely populated low-lying islands. Increased intensity of rainfall will be associated in many places with flash flooding, and longer dry spells in many parts of the world are also projected. Average temperatures will rise, but more importantly, there will be a disproportionate increase in the frequency of extremes of heat. There is less certainty about the future pattern of storms – however it is possible that both the frequency and intensity of storms and cyclones will increase. Ocean warming, with increased acidity due to rising levels of CO<sub>2</sub>, will stress coral reefs, and cause re-distribution of fish stocks. The health impacts that will follow as a result of these changes include direct effects such as the disease and injury associated with flooding and storms, infectious diseases spread by water and food that multiply more quickly in warmer conditions, and heat stress. Other effects that have more indirect links with climate change include nutritional problems resulting from failures of crops and fisheries under climate change, and changing patterns of vector-borne diseases, as mosquitoes and other disease carrying agents are affected by alterations in temperature and precipitation.

Lastly, he said that pollution arising from human activity has overwhelmed the planetary system – the complex geophysical and biological network that impinges on climate. Wherever CO<sub>2</sub> is generated, it acts to increase temperatures at every point on the world's surface. This means that the response to climate change must be global. Countries can take local actions, to reduce emissions and to adapt to change. But these will be fruitless unless they are matched by international actions that ensure everyone carries a share of the load. The Alliance of Small Island States (AOSIS) has been a force in international climate change negotiations. The 37 members of AOSIS have argued effectively for emissions reductions, monitoring, consideration of impacts on the most vulnerable populations, and support from high-income countries for adaptation in developing countries. Such activities constitute an important part of building resilience to protect health. (Annex 4)

Ms Sari Kovats, Centre on Global Change and Health Department of Public Health and Policy, London School of Hygiene and Tropical Medicine, London, United Kingdom, presented Working Paper Number 3 "Climate change effects on urban health". Climate change will affect the health of urban populations. It represents a range of environmental hazards and will affect populations where the current burden of climate-sensitive disease is high – such as the urban poor in low- and middle-income countries. Understanding the current impact of weather and climate variability on the health of urban populations is the first step towards assessing future impacts. She reviewed the effects of temperature, rainfall and extreme events on human health, in particular the impacts of heatwaves and floods. The methods for assessing the risks of climate change are undergoing

development, and there is a need to shift the focus from global and regional to local studies.

Sectoral approaches to climate change impact assessments often ignore the effects on health, thus there is a need to better describe the risks to health from extreme weather events as well as improve the effectiveness of public health interventions. Improving the resilience of cities to climate change also requires improvements in the urban infrastructure, but such improvements may not be achieved quickly enough to avoid an increased burden of disease due to global climate change.

**Business Session 2:** Review the current scientific evidence on the impact of climate change on health, and identify research gaps in protecting human health from climate change and develop an agenda for operational research in the Region.

Member States reviewed the scientific evidence on the impact of climate change on health and recognized the current challenges in terms of poor research capacity, limited data quality, lack of robust research protocols to assess the full dimensions of the burden of disease linked to climate change, the uncertainty linked to vague projections on greenhouse gas emissions, and the need for estimates of the increased health costs linked to climate change.

Member States identified research gaps in protecting human health from climate change and developed a draft agenda for operational research in the Region.

Given that climate change impact will vary from location to location, the most effective preventive and adaptive action will need to be developed and implemented with the active participation of local communities.

Consensus was reached that these challenges can only be overcome by fostering partnerships and collaborating with governmental, nongovernmental and especially community-based actors, and on the fact that a robust capacity to respond to climate change threats by the health sector can only be achieved by allocation of additional funding.

Dr H. Saiyed, formerly Director, National Institute of Occupational Health (NIOH), Indian Council of Medical Research, Ahmedabad, India, presented the Working Paper Number 7 "Ongoing research on climate change impacts on health in South-East-Asia". He indicated that over 50 research projects on health impact from climate change in the SEA Region had been undertaken and that 36 research

centres in the Region had or were carrying out research on health impact from climate change (India: 22; Thailand: 8; Bangladesh: 3; DPR Korea, Indonesia and Myanmar: 1 each (Table 1).

**Table 1:** Overview of key research findings relating to climate change and health impact, carried out in countries of the SEA Region

Research topic / findings	Reference
<b>Diarrheal diseases</b>	
A study conducted in Pune, India, correlating hospital cases of diarrhoea and meteorological data using Auto Regressive Integrated Average model. Rotavirus diarrhoea cases coincided with annual change of climate. It was inversely proportional to temperature and also linked with days of trade winds.	1
A strong evidence for an increase in rotavirus diarrhoea at high temperatures, by 40·2% for each 1°C increase above a threshold (29° C) was reported from Matlab, Bangladesh.	2
In Bangladesh, several studies describe a regular seasonal cycle for cholera outbreaks, including specific studies on different strains of <i>V. cholera</i> .	3, 4, 5, 6, 7
This seasonal pattern of cholera in Bangladesh is correlated with sea-surface temperatures in the Bay of Bengal and with seasonal plankton abundance (blue green algae/copepods — the possible environmental reservoirs of the cholera pathogen, <i>V. cholerae</i> ).	8, 9, 10, 11, 12, 13, 14
Flood and cyclone-related increases in diarrhoeal disease reported in India and Bangladesh.	15, 16, 17, 18
The Energy and Resources Institute, New Delhi, and The National Institute of Cholera & Enteric Diseases, Kolkata, India, have undertaken a research project to examine the potential relationship between climate change and diarrhoeal diseases, assess the vulnerability and adaptability and evaluate the economic impact.	19

Research topic / findings	Reference
<b>Malnutrition and food safety</b>	
A study in Bangladesh found that drought and lack of food were associated with an increased risk of mortality from a diarrhoeal illness.	20
In Gujarat, India, during a drought in 2000, diets were found to be deficient in energy and several vitamins. In this population, serious effects of drought on anthropometric indices may have been prevented by public health measures. Malnutrition increases health vulnerability.	21
Studies following severe drought in 2003 in Western Rajasthan, India, showed high prevalence of protein-energy malnutrition and micronutrient deficiencies among children under 5.	22, 23, 24
A study in rural children in Bangladesh, aged less than 2 years, during pre- and post-1987 monsoon flooding revealed an adverse effect of flood on nutrition — the effect was dependent on sex of the child and intake of vitamin A.	25
<p>The following projections have been made for India for crop production in view of climate change:</p> <p>Two to 5% decrease in yield potential of wheat and maize for a temperature rise of 0.5 to 1.5°C;</p> <p>For every 75 part per million (ppm) increase in CO<sub>2</sub> concentration, rice yields will increase by 0.5 t ha<sup>-1</sup>, but yield will decrease by 0.6 t ha<sup>-1</sup> for every 1 °C increase in temperature;</p> <p>In Rajasthan, a 2°C rise in temperature was estimated to reduce production of pearl millet by 10-15 %;</p> <p>If the maximum and minimum temperature rises by 3°C and 3.5°C respectively, then soya bean yields in Madhya Pradesh will decline by 5% compared to 1998;</p> <p>Agricultural production will be worst affected in the coastal regions where fertile areas are vulnerable to inundation and salinization.</p>	26

Research topic / findings	Reference
<p>In view of projected reduction in wheat and rice productions, increases in levels of malnutrition are likely to be experienced in some states in India.</p> <p>A model of vulnerability of different states of India to climate change (taking into consideration various factors) was developed. The Vulnerability-Resilience Indicator Prototype or VRIP model has been applied to the 26 Indian states on the basis of following indicators such as: economic capacity; human and civic resources; environmental capacity; settlement/infrastructure sensitivity; food security; ecosystem sensitivity; human health sensitivity and water resource sensitivity. The model found that only three states were more vulnerable than India as a whole, 23 states were less vulnerable, and nine states showed resilience.</p>	27, 28
<b>Vector-borne diseases</b>	
<p>The study undertaken under the aegis of NATCOM, India, on the impact of climate change on malaria in India revealed that most states particularly in the north, showed fluctuations in malaria cases over the months and were vulnerable to climate change. The states of Uttar Pradesh, Uttarakhand, Rajasthan, Madhya Pradesh, parts of Karnataka, Gujarat, Maharashtra and Andhra Pradesh and Brahmaputra valley were found to be vulnerable to malaria epidemics that usually occur due to change in meteorological conditions. Transmission windows of malaria (in view of the projected rise in temperature at coarse level) were determined.</p>	29
<p>India: Projection of malaria using IS92a emission scenario driven by HadRM2 projections (at 50 x 50 km resolution) of daily temperature and relative humidity for 2050.</p>	30
<p>Models based on distribution and vectorial capacity of malaria vectors have projected 2-5 times changes in the epidemic potential for <i>P. falciparum</i> malaria with 2°-40° C increase in temperature; highest changes are projected for high altitudes.</p>	31

<b>Research topic / findings</b>	<b>Reference</b>
Potential dengue transmission with a 40° C rise in temperature may be 2-5 times more in northern subHimalayan region and in the southern most areas of India. With a 20°C rise in temperature there is a possibility of one-week increase in transmission in New Delhi, India, while with a 40°C increase, the transmission may be reduced to 34 weeks. In Kolkata, currently the dengue transmission takes place for 44 weeks. With 2°-40°C increase in temperature, the malaria transmission may continue for 53 weeks.	32
A case study undertaken in India indicates that sustainable development variables may sometimes reduce the adverse impacts on the system due to climate change alone, while it may sometimes also aggravate these impacts if the development variables are not managed well. Well-crafted and well-managed developmental policies could result in enhanced resilience of communities and systems, and lower health impacts due to climate change.	33
<b>Respiratory diseases</b>	
The report on a retrospective analysis undertaken of urban air pollution data with the focus on particulate air pollution from 1993 to 2002 in Delhi, Kolkata, Mumbai, Hyderabad and Chennai, India, highlights the progress and challenges in urban air quality management in India.	34

Research topic / findings	Reference
<b>Occupational health</b>	
<p>Studies done in small glassbangle, ceramics and brassware industries in India showed radiant heat exposure exceeding 50°C. Further-more, there was a significant rise in oral temperature and the measurement of psychological responses of those affected showed impairment of their immediate memory, significant effect on their visuo-motor coordination and vigilance, and downward trend in visual perception, thereby indicating their increased proneness to accidents. An analysis of accident data in textile industry showed that the hottest part of the year (May - September) had the greatest number of accidents per employee. A study on beedi smoking (hand- rolled cigarettes) revealed a 9% loss of production per degree of external temperature increase.</p>	<p>35, 36, 37, 38, 39, 40</p>
<p>Experimental studies on healthy volunteers in climate control chambers with varying workloads comparable to the industrial conditions described above, were carried out at the National Institute of Occupational Health, Ahmadabad, India. These studies showed (i) rise in the core body temperature of up to 2°C and a simultaneous rise in skin temperature and sweat rate 3-7 times above the threshold limit, indicating imminent danger; and (ii) the dangers from heatload could be reduced by reducing the workload and increasing the intervening rest periods.</p>	<p>41, 42, 43</p>
<p>Studies in Bangladesh and Asia have reported heatstrokes among metal workers and cycle rickshaw drivers, suggesting that the long- term continuous exposure to heat does not necessarily produce acclimatization.</p>	<p>44, 45</p>
<p>Mortality data due to heatwaves in India have been compiled by De and Mukhopadhyay (1998) for the period 1979 to 2004. Recently, Akhtar (2007) reviewed the mortality due to heatwaves in India and found that heatwaves occurred in the months from March to June. Maximum deaths (1658) occurred in the year 1998. Andhra Pradesh, Orissa, Punjab, Uttar Pradesh, Rajasthan, Bihar and Madhya Pradesh suffered the most. The National Physical laboratory, Delhi is working on an assessment of heatstress linked to climate change.</p>	<p>46, 47</p>

He pointed out the need to address capacity building of research workers in Member s of the Region — key staff from the Regional Office and from country offices, besides members of academic and other institutions that actively participate in the network, and national control programmes. Existing WHO collaborating centres (CCs) in the Region that could undertake research in selected priority areas should be identified and medical colleges and public health institutions that could become new WHO CCs on climate change and health should be shortlisted. Table 2 lists institutes working on climate-related health disorders.

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**Table 2:** Research institutions in SEAR countries undertaking research related to climate change impact on health (as on 1 August 2009)

Area of research / Institute	Research activities
<b>Diarrhoeal Diseases (water and food-borne)</b>	
International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR) Dhaka, Bangladesh <a href="http://www.icddrb.org">www.icddrb.org</a>	Collaborative research in areas of: diarrhoeal diseases of diverse etiologies; and impact of a community-based integrated management of childhood illnesses and nutrition.
National Institute of Cholera and Enteric Diseases (NICED), Kolkata, India <a href="http://www.niced.org/">http://www.niced.org/</a>	In-depth epidemiological and operational research in diarrhoeal diseases of diverse etiologies.  Retrospective and prospective studies to assess the impact of climate change on cholera.
Asian Institute of Technology (AIT), Bangkok, Thailand <a href="http://www.ait.ac.th/">http://www.ait.ac.th/</a>	Basic and applied research on health and quality impacts of community water supply, waste disposal, and air quality-related interventions and actions.
<b>Nutrition and Food Safety</b>	
National Institute of Nutrition (NIN) Hyderabad, India <a href="http://www.ninindia.org">http://www.ninindia.org</a>	Determining the social, cultural and environmental factors leading towards healthy dietary practices.

Area of research / Institute	Research activities
National Nutrition Monitoring Bureau of NIN, Hyderabad, India <a href="http://www.nnmbindia.org">http://www.nnmbindia.org</a>	Promotion of nutrition and intervention research to combat different forms of malnutrition.
Department of Foods and Nutrition, Faculty of Home Science in Maharaja Sayajirao University, Baroda, India <a href="http://www.msubaroda.ac.in/">http://www.msubaroda.ac.in/</a>	Generating dynamic state-wise database on diet and nutritional status of communities.
Indian Agriculture Research Institute, New Delhi, India <a href="http://www.iari.res.in">www.iari.res.in</a>	Estimation of crop production in view of climate change in India.
Centre for Research and Development in Food and Nutrition, Jakarta, Indonesia <a href="http://www.seameo-rccn.org">www.seameo-rccn.org</a>	Assessing micronutrient malnutrition in the Indonesian population and generating evidence for developing innovative strategies for combating micronutrient malnutrition.
Institute of Nutrition, Mahidol University, Bangkok, Thailand <a href="http://www.inmu.mahidol.ac.th/eng/">http://www.inmu.mahidol.ac.th/eng/</a>	Community nutrition and food safety — generating database on nutrition values of Thai foods; evaluation of nutrition status, micronutrient assessment, metabolism and interventions; development of nutrient-rich rice strains and research studies on practical ways of solving food safety problems in products developed by small and medium producers.
<b>Vector-Borne Diseases</b>	
National Institute of Malaria Research (NIMR), New Delhi, India <a href="http://www.mrcindia.org">http://www.mrcindia.org</a>	Impact of climate change on malaria and dengue; develop framework for adaptation measures for malaria control under climate change scenario; development of tool for early warning of malaria through international collaboration; burden of vector-borne diseases following tsunami.
Vector Control Research Centre (VCRC), Pondicherry, India <a href="http://www.vcrc.res.in">http://www.vcrc.res.in</a>	
Centre for Research In Medical Entomology (CRME), Madurai, India <a href="http://www.icmr.nic.in">www.icmr.nic.in</a>	

Area of research / Institute	Research activities
National Institute of Virology (NIV), Pune, India, <a href="http://www.niv.co.in">www.niv.co.in</a>	Basic and applied research in the field of arbovirus (arthropod-borne or arthropod-transmitted viral diseases) including dengue fever; development of models for prediction of viral epidemics.
Department of Medical Research, Yangon, Myanmar <a href="http://www.moh.gov.mm/">http://www.moh.gov.mm/</a>	Basic and applied malaria research activities that support diagnosis, treatment, prevention and control of malaria; studies on effective and sustainable vector control measures.
Malaria Research Division, Institute of Health Research, Chulalongkorn University, Bangkok, Thailand <a href="http://www.ihr.chula.ac.th/e4.html">http://www.ihr.chula.ac.th/e4.html</a>	Biological characterization of malaria.
Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand <a href="http://www.tm.mahidol.ac.th/eng/">http://www.tm.mahidol.ac.th/eng/</a>	Molecular and field studies related to malaria and dengue fever.
<b>Health System Development/adaptation strategies</b>	
National Institute of Preventive and Social Medicine (NIPSOM), Dhaka, Bangladesh <a href="http://www.nipsom.org">http://www.nipsom.org</a>	Creation and collection of evidence base for services, education and policy in the area of public health.
Institute of Public Health Administration, Ministry of Health, Democratic Republic of Korea <a href="http://www.dprk.searo.who.int/EN/Section17_21.htm">http://www.dprk.searo.who.int/EN/Section17_21.htm</a>	Development of a model of PHC-based district health system.
Indian Institute of Health Management and Research, Jaipur, India <a href="http://www.iihmr.org/">http://www.iihmr.org/</a>	Organization and management of health systems based on primary health care with particular emphasis on district health systems in urban and rural districts, and quality assurance in health care.
Tata Institute of Social Sciences, Mumbai, India, <a href="http://www.tiss.edu">http://www.tiss.edu</a>	Understand dynamics of utilization of research in health policy formulation, and implementation and utilization.

Area of research / Institute	Research activities
Indian Institute of Management (IIM), Ahmedabad, India, <a href="http://www.imahd.ernet">www.imahd.ernet</a>	Sociological research and adaptation measures in view of climate change threats.
The Energy Research Institute (TERI), New Delhi, India, <a href="http://www.teri.res.in">www.teri.res.in</a>	
M.S. Swaminathan Research Foundation, Chennai, India <a href="http://www.mssrf.org">www.mssrf.org</a>	Vulnerability assessment and adaptation strategies.
Health Economics Research Unit, Chulalongkorn University, Bangkok, Thailand, <a href="http://www.md.chula.ac">http://www.md.chula.ac</a> .	Quantitative and qualitative research towards a global standard in health excellence.
<b>Epidemiological studies</b>	
National Institute of Communicable Diseases (NICD), New Delhi, India <a href="http://nicd.org/">http://nicd.org/</a>	Operational research on the application of new epidemiological tools and development of cost-effective disease surveillance and control strategies.
National Institute of Epidemiology, (NIE) Chennai, India <a href="http://icmr.nic.in/pinstitute/nie.htm">http://icmr.nic.in/pinstitute/nie.htm</a>	Intervention studies, disease modelling, health system research, evaluation of health schemes and issues of statistical methodology, epidemiological investigations and clinical trials on traditional medicine.
Bureau of Epidemiology, Ministry of Public Health, Bangkok, Thailand, <a href="http://203.157.15.4/">http://203.157.15.4/</a>	Outbreak investigations and responding to emerging and reemerging diseases; studies on surveillance systems with emphasis on topics relevant to public health needs and emerging and reemerging diseases.
<b>Occupational/environmental health</b>	
National Institute of Occupational Health (NIOH), Ahmedabad, India, <a href="http://icmr.nic.in/pinstitute/nioh.htm">http://icmr.nic.in/pinstitute/nioh.htm</a>	Health impacts of indoor and ambient air pollution on human health; basic and applied research in the field of heat stress.
Bangladesh Centre for Advanced Studies (BCAS), Dhaka, Bangladesh, <a href="http://www.bcas.net/">http://www.bcas.net/</a>	Sustainable development at local, regional, national and global levels.

Area of research / Institute	Research activities
Bureau of Occupational and Environmental Diseases, Ministry of Public Health, Bangkok, Thailand <a href="http://occ.ddc.moph.go.th">http://occ.ddc.moph.go.th</a>	Assessing the health impact of occupational and environmental pollutants.  Molecular mechanisms of toxic pollutants, including air pollution.
Chulabhorn Research Institute (CRI) Bangkok, Thailand <a href="http://www.cri.or.th/en/">http://www.cri.or.th/en/</a>	
National Physical Laboratory, New Delhi, India, <a href="http://www.nplindia.org">www.nplindia.org</a>	Developing models to compute the health impact of indoor and ambient air pollution on human health.
The LRS Institute of Tuberculosis and Respiratory Diseases, New Delhi, India, <a href="http://www.lrsitbrd.nic.in">www.lrsitbrd.nic.in</a>	
Ramachandra Medical College and Research Institute, Chennai, India <a href="http://www.srmc-ehe.org.in/">http://www.srmc-ehe.org.in/</a>	
National Environmental Engineering Research institute, Nagpur, India <a href="http://www.neeri.res.in">www.neeri.res.in</a>	

He proposed that SEARO should create Task Force to monitor periodically the progress being made to promote research on climate sensitive diseases in the Region. The membership of the task force may constitute of two categories: (1) core members, belonging to SEARO's technical units and departments which is already created and (2) invitees from within SEARO or outside. The first step is to create and update an inventory of the ongoing research programmes, and relevant expertise in the Region, and to detail the specific domains of the research programmes and expertise. Create a mechanism to discuss the findings and the future plans to avoid duplication. The second step will be to attract potential partners and interest them in networking a with SEARO's efforts in the domain of common interest. He insisted on the need to Identify through the present meeting a topic of immediate interest for SEARO and Member countries and organize a South-East Asia conference.

For Member States he proposed the following initiatives to be undertaken:

- Designate focal point on climate change in the ministry of health.
- Map the available resources (including human resources and institutes) and ongoing programmes
- Establish network of the national institutions.
- Match programme needs with evidence produced by the research.
- Promote operational research in priority areas identified at the Regional forum
- Improve research designs and stimulate follow-up action based on the research results.
- Implement WHA recommendations related to research.
- Situation analysis of health system to identify need for strengthening.
- Development of generic protocols for undertaking impact assessments.
- Assessment of impact of climate change on climate sensitive diseases with emphasis on heat stress, eye diseases, cholera, respiratory diseases and vector borne diseases like Malaria, dengue, chikungunya and Leptospirosis etc.
- Identification of researchable issues on the climate-disease relationship or host – pathogen-climate interdependence and attribution of health outcomes due to climate change.
- Assessment of vulnerability and adaptive capacity of population keeping in view the socioeconomics and development should be studied in different climatically vulnerable areas.
- Evaluation of economic loss due to climate change on health.
- Integration of comprehensive climate risk management into development, planning, programmes (Annex 7)

Dr Ramesh C Dhiman, NIMR (ICMR), India made a presentation on the “Current knowledge of health impacts from climate change and related research initiatives in India” which focused on global and Indian projections of temperature and precipitation, potential impacts of climate change on human health, review of work undertaken climate change impacts on various aspects of health mainly on

occupational health, mortality due to Heat wave, injuries and mental health, vector borne disease, diarrheal disease and malnutrition. Published work on cholera and vector borne diseases provided evidence that climate change is likely to exacerbate the spatial and temporal rise in transmission intensity of malaria and dengue and link of climate parameters with cholera. Mortality due to heat waves and reduction in crop yield leading to malnutrition are also expected.

A case study on development and malaria highlighted that sustainable development sometimes aggravate the impacts if the development variables are not managed well. However, well crafted and well managed developmental policies could result in enhanced resilience of communities and systems, and lower health impacts due to climate change.

Research Initiatives undertaken by the Government of India including development of National Action Plan on climate change (NAPCC), identifying action points for health sector, setting up of Institutes for disaster Management and Centre for climate Change Research etc. Constitution of task Force in Ministry of Health & family Welfare for implementing the actions identified by NAPCC and Setting up of Global Environmental Change & Health task Force in Indian Council of Medical Research for supporting research projects addressing the issues of eye, respiratory and Vector borne diseases.

The presentation also highlighted the occurrence of malaria cases in highland area of Uttarakhand in northern India. The working paper contributed jointly with Dr Saiyed incorporated a review of all published literature and ongoing studies in the area of climate change and Health in India. (Annex 6)

Dr Tord Kjellstrom, National Centre for Epidemiology and Population Health, Australian National University, Canberra, Australia presented Working Paper Number 8 and Working Paper Number 9 “Increasing heat stress in occupational health due to climate change: Needs for research and prevention in South-East Asia”.

Dr Tord Kjellstrom pointed out that global climate change may become a major threat to public health in the future, undermining improvements achieved due to decades of socio-economic development and concerted health sector policies and actions. The baseline climate of the South-East Asia region is already very hot in most places and the additional heat exposure that climate change will bring at local level will create major new challenges for public health. He drew the attention to one area that has received little attention so far: occupational health. Heat exposure and heat stress is already a common feature for many working

people during the hot season of the year, particularly during the hottest part of the day, the afternoons.. However, the majority of affected working people are likely to recover at the worksite after preventive actions (stopping work and cooling down), and the health sector statistics would not show the full picture. Moreover, the cases of heat related disorders may pass unnoticed due to poor reporting, lack of awareness and lack of access to health services for poor people.

Based on estimated future climate developments and occupational health protection standards for heat exposure his team has calculated the likely increased occupational heat stress in major South-East Asian locations. The estimated increase of the risks of heat exhaustion, heat stroke and daily productivity losses for affected workers based on well-established physiological knowledge are substantial. Additional research is needed to measure in field studies the current actual heat exposure and the health and productivity impacts. Improved physiological and heat exposure models that apply to workers in this region are needed, taking into account age, sex, and ethnic group variations, in order to establish suitable occupational health standards. Inter-disciplinary research on climate and human exposure modelling, as well as the linkages between climate change mitigation and adaptation programs and the potential economic impacts is also of great importance in South-East Asian countries. This would involve estimation of economic and social costs of the heat effects and their importance in relation to other climate change impacts in the region. It is also important to review existing adaptation measures and their effectiveness in reducing climate impacts. Finally he said that there is also need for pilot studies of adaptation methods to climate change and to develop and test methods for monitoring if preventive adaptation measures are successful.

## Results of working groups of Business Session 2

**Table 3:** List of essential topics for priority studies on relationships between climate change and human health

General health risk assessments and vulnerability mapping.
Baseline data for current dynamics of health outcomes vis-a-vis climate events such as heatwaves, droughts, floods, sea-level rise, biodiversity loss and land use change and evaluation of future projections taking into account the IPCC scenario-based predictive models.
Specific health vulnerability of children and pregnant women, elderly people and of the poor living in densely populated urban settings.

Effects of the Atmospheric Brown Cloud (ABC) on food production, water availability and rainwater quality.
Climate change impact on the health of mountain communities in the Hindu-Kush Himalayan Region who depend heavily on highly climate-sensitive ecosystem services for their livelihoods.
Special vulnerabilities and limited adaptation options of small island and coastal populations entirely dependent on delivery of ecosystem services.
Biodiversity availability and sensitivity of medicinal plants to climate change.
Evaluation of the potential and limitations of community-based research and of indigenous knowledge-based coping mechanisms to protect health from climate change.
Vulnerability mapping of health infrastructure and emergency management systems to extreme weather events.
Evaluation of health system capacities to identify, prepare, respond and manage changing burdens and distributions of climate-sensitive diseases and conditions, including extreme weather events, and potential long-term changes in water and food availability.
Economic estimation of increased health costs due to climate change impact.
Food security, food safety, malnutrition and climate change.
Linkages between nutritional status, including micronutrient availability, climate and climate change.
Biodiversity availability and sensitivity of coral reefs.
Sustainability and availability of marine food products, particularly tuna.
Impact on food safety due to microbial and mycoses growth from increased temperatures, and variable humidity conditions; and localized exposure risks from activities such as aquaculture.
Identify operational strategies to reduce occupational hazards and exposures of high- risk groups (including children).
Better understanding of seasonal nutritional status variation, and improved monitoring of nutritional trends of vulnerable populations.
Study of MRL fluctuation of pesticides or harmful chemicals in food crops and associated health risks, due to alterations in pesticides use/performances/by-products, in the context of climate change and increasing temperatures.

Study of increasing health risks of mycotixins in staple foods in the context of climate change and variability in humid-temperate locations.
Occupational health and climate change.
Morbidity and mortality records during heatwaves and evaluation of future projections taking into account the IPCC scenario-based predictive models.
Health impact from increased exposure and use of agricultural, industrial and public health pesticides.
Identification of high-risk groups to occupational hazard of rising temperatures (indoor and ambient).
Understanding risk and toxicity of chemicals in relation to increased exposure and vulnerability at higher ambient temperatures.
Air quality and climate change.
Impact from forest fires, pollens and chemical air pollutants on respiratory health conditions.
Impacts and management options of heat island effects on cardiopulmonary health and heat stress in urban areas.
Physical injuries and climate change.
Vulnerability to increase in physical injuries linked to climate-related extreme events.
Tracking and monitoring of flood-related drowning.
Mental well-being and climate change.
Acute and long-term mental health consequences from climate change.
Prevention of mental stress in children related to the threats of climate change.
Vector-borne diseases and climate change.
Bionomics of disease vectors in relation to climate and climate change and its effects on disease patterns.
Eco-epidemiological stratifications of temporal and spatial, particularly altitudinal distribution of primary and secondary vectors, and related disease incidence levels.
Establish or enhance regular insecticide resistance monitoring to measure the potential impact of the increased use of insecticides in agricultural and public health sectors attributable to climate change.

Operational research to evaluate promising vector control approaches, tools and urban-based environmental vector control initiatives.
Evaluation of community-based integrated vector and pest management systems as coping strategies to reduce the potential increase of disease vector and pest pressures.
Impact of changes in temperature/precipitation on the incubation of infectious agents in vectors and climatic effects on natural predators.
Water and sanitation and climate change.
Water quality monitoring assessment with special reference to macro and microbiological change in relation to ambient temperature change, and in reference to impact of floods and evaluation of future projections taking into account the IPCC scenario-based predictive models.
Better understanding and of the linkages between water availability and water access in the Region, identifying future scarcity and shortage hotspots.
Risk-mapping and better understanding of the magnitude of risks to water quality linked to accelerated urbanization, industrialization, and agriculture intensification.
Monitoring and research on risks to water quality linked to increased aquaculture.
Study of integrated water resources management methods as adaptation mechanisms to climate change effects; including identification of increased negative health risks from some water management strategies.
Dynamics of thermal-stratification of stagnant water bodies, and impact of water safety with increasing temperatures.
Study of major challenges and necessary alterations on water and wastewater treatments for large supplies using microbial and chemical processes in the context of climate change and increasing temperatures.
Study of the increasing potential of rainwater harvesting and use, to supplement urban supplies and groundwater recharge, because of diminishing surface and groundwater sources for large-scale supplies in the context of climate change and variability.
Study on holistic or unified approach to water and wastewater management in communities to promote such approach for water use, reuse, and pollution control in the context of increasing water scarcity or abundant rainfall/surface run-offs due to climate change and global warming.

Study of BOD due to increasing water-washed category of diseases in human communities (e.g. skin diseases and eye infections) due to the threat of water scarcity; and evidence-based promotion of alternative water use and hygiene in the context of global warming and climate change.

Study of prolonged droughts and their effects on fluctuating arsenic concentration in groundwater abstractions posing serious health threats to water-users living in flood plains.

Study of the increasing use and viability of ecological sanitation (ECOSAN) or urine diversion toilets (UDTs), linking them to groundwater-table fluctuations in the context of increasing extreme weather events and climate change.

**Business Session 3:** Provide recommendations on “Protecting human health from climate change” for consideration by the Sixty-Second Session of the WHO Regional Committee.

Alexander von Hildebrand, Regional Adviser, Environmental Health and Climate Change, World Health Organization, Regional Office for South-East Asia, presented the Working Paper Number 8: “Progress report on the implementation of the New Delhi Declaration 2008”. He informed about the Working Group (WG) on Protecting Health from Climate Change established in the Regional Office to effectively support countries in the SEA Region in mitigating and adapting to the adverse health impacts from climate change in support of the implementation of the New Delhi Declaration 2008. The WGs also takes into account the main aspects of the Sixty-first World Health Assembly Resolution WHA61.19 (2008) and of the 2007 Regional Framework for Action to Protect Human Health from Effects of Climate Change in the South-East Asia and Pacific Regions. The thrust areas include: Strengthen health systems capacity to address the challenges posed by climate change; Increase awareness of health consequences of climate change within the health sector and with other key sectors; Promote applied research and pilot projects to assess health vulnerability to climate change; Support the empowerment of local communities to become more climate-change resilient; Collaborate with other key sectors to assess health impacts of adaptation and mitigation measures and ensure that health concerns are integrated in an appropriate manner.

Among the results obtained by the group, Dr Alex highlighted the development and field- testing of various school-based educational materials, and of regional training materials such as the course on Climate Change and Human Health for Health Professionals , a regional training course on Environment and Health Impact Assessment (EHIA) with the WHO Collaborating Centre for

Integrated Management of Disease Vectors (IMDV), Mahidol University, Bangkok, Thailand , a regional training course on Integrated Vector Management (IVM) with the WHO Collaborating Centre, Vector Control Research Centre (VCRC), Pondicherry, India.

The WG also coordinated the ongoing revision of the training course on how to protect health from climate change for urban planners and managers, with the WHO Collaborating Centre, Kobe, Japan. Dr Alex also presented a list of educational videos on how to protect health from climate change. Finally, he informed about the Report of the Regional Office Carbon Footprint Assessment and the plan to monitor the indicators such as “Greening SEARO”.

The Technical Discussions concluded with a set of recommendations to be submitted for consideration to the Sixty-Second Session of the Regional Committee.

## **Annex 1**

### **Opening address by Dr Samlee Plianbangchang, WHO Regional Director for South-East Asia**

Distinguished participants,

Ladies and gentlemen,

Climate change is now recognized as one of the defining challenges of the century. Protecting and promoting health in this context is assuming increasing priority for the public health community.

Climate change is expected to cause intensified periods of drought, increasing water stress and desertification. Increased water scarcity and climatic variations in turn, could seriously affect agricultural productivity. Indeed, climate change may well usher in widespread, chronic hunger and malnutrition across areas that are already struggling to meet basic water requirements.

Changes in temperature and precipitation will alter the incidence and geographic range of some climate-sensitive health determinants and outcomes. Traditional morbidity patterns of diseases such as malaria and dengue fever are likely to change and spread to reflect changing environmental conditions.

Health risks will be much greater in low-income countries because the current burden of climate-sensitive health outcomes is high and because public health systems that could substantially reduce health risks tend to be relatively weak.

According to the United Nations Emergency Relief Coordinator, 9 out of 10 disasters are now climate related, and the number of natural disasters related to climate events has doubled in the past two decades. Millions of people are already internally displaced due to disasters and conflict. Displacement within and across international borders is expected to grow as a consequence of climate change, as people seek improved livelihood opportunities.

Rising sea-levels could force the relocation of tens of millions of people in countries of our Region. Glacier melt in the Himalayas could drive out hundreds of

millions by changing the nature of the main life-giving rivers like the Indus, Ganges and Brahmaputra.

Climate change could precipitate resource conflicts — above all, for energy, arable land and fresh water — leading to millions of climate change refugees.

In conflict and disaster situations, refugees and internally displaced persons face a heightened risk of gender-based violence. Gender-based violence pervades many conflict and disaster situations, resulting in serious health and human rights challenges. While women and girls are the most likely to experience sexual violence, we know that men and boys are, by no means, immune. Sexual violence can cause not only immediate physical trauma and death, but also long-term psychological scars and reproductive and sexual health problems.

In many small island states, an increase in the sea-level is making people's homes vulnerable to increasingly high tides and storm surges, while water supplies and soil fertility are threatened by the intrusion of salt water. By 2025, the number of people living within 60 miles of a coastline is expected to increase by 35% over 1995 levels, exposing millions to the effects of rising sea-levels and other coastal threats posed by climate change.

Distinguished participants,

Ladies and gentlemen,

Climate change presents real risks to human health. The scientific evidence of the effects of man-made release of greenhouse gases in the atmosphere, and of the health impacts resulting thereof, has led to calls for significant and immediate action to protect human health from the risks of climate change. The Sixty-first World Health Assembly requested the WHO Director-General to develop appropriate methods and tools to assist Member States in assessing their health risks from climate change and in identifying and implementing effective health protection strategies. Solutions to the health impacts of climate change should be seen as a joint responsibility of all States and developed countries should assist developing countries in this regard.

National governments are now committing themselves to undertake evidence-based actions to protect health from climate change. In May 2008 and in May 2009, the World Health Assembly adopted two resolutions calling for a stronger commitment by Member States and WHO to protect health from climate change. In particular, the resolutions called on WHO to work with other agencies to identify

research requirements and pilot projects that should be supported by the international community on a series of practical themes, with the aim of designing concrete and effective actions.

The Member States of the SEA Region, represented by the Health Ministers committed to take decisive action to reduce the health risks linked to climate change by signing the New Delhi Declaration in 2008. The Declaration highlights the need for creating more awareness and increasing capacity to respond to climate threats. The Declaration further asks for collecting more evidence through applied research and to launch pilot projects for the empowerment of local communities to become more climate resilient.

These Technical Discussions have been organized to support these aspects with three specific objectives: to share evidence and experiences at regional and national levels on the health impacts from climate change and mitigation and adaptation thereto; to review the current scientific evidence on the impacts of climate change on health; and to identify research gaps in protecting human health from climate change and develop an agenda for operational research in the Region.

Concurrently with the Technical Discussions, we have also convened a meeting of a group of scientists who are public health researchers to look at this issue. The results of their deliberations will be shared with us later today for further discussion.

Research on climate change and health must be placed more firmly within the overall context of improving global health, and health equity, rather than being considered as a stand-alone issue.

For example, research on the health effects of mitigation and adaptation decisions taken by other sectors can help to avoid harm, and identify important opportunities for health promotion. Applied research on surveillance and other decision-support tools is necessary to enhance operational effectiveness and early warning mechanisms.. Improved economic assessments of the costs associated with the health impacts of climate change can help support investment in health adaptation programmes, and support mitigation policies that enhance health.

The necessary research effort will not occur spontaneously: it requires a sustained process to update and adapt priorities, mobilize resources and build interdisciplinary research capacity and to recognize that strengthening applied interdisciplinary research to protect health is an essential investment in responding to the challenge of climate change.

Distinguished participants,

Ladies and gentlemen,

It is important in the context of climate change to stress that we are not helpless. We can adapt to climate change, as well as try to stop and, eventually, reverse it.

Risk reduction and risk management are our first line of defense against the impact of climate change. We need to intensify our efforts to reduce vulnerability and build community resilience.

For over 60 years, Member States in our Region, in collaboration with the WHO Regional Office for South-East Asia have worked extensively in implementing programmes that are addressing climate-sensitive health determinants and health outcomes. From disease surveillance and response to control of vector-borne diseases to health action in crises. Our Member States and network of WHO collaborating centres have well-skilled health professionals dealing with climate-sensitive diseases, many of them world renowned experts. We can mobilize our resources to combat climate change.

Interventions deployed to address the health risks will need to take into account changing socioeconomic and environmental conditions, while, at the same time reducing the current burden of climate-sensitive health outcomes. Therefore, the focus of a vulnerability assessment is to identify modifications to current and planned programmes designed to reduce the burden of climate-sensitive health outcomes to ensure that they also meet future challenges.

Reducing the current and projected health risks attributable to climate change is a risk management issue, with adaptation and mitigation the primary responses. Mitigation and adaptation are not mutually exclusive; co-benefits to human health can result concurrently with implementation of actions to reduce greenhouse gas emissions, and adaptation measures can reduce emissions. As the context for adaptation will change with changing climatic conditions, along with changes in demographics, technology, and socioeconomic development, an iterative risk management approach is likely to be most effective. Because climate change is one of the many public health issues that need to be addressed, policies and measures need to ensure that actions to reduce climate-related health risks support current programmes to address health issues and explicitly consider key uncertainties.

While the community has a very significant role to play in protecting its health from climate-related threats, the national health authorities and WHO have the responsibility, political leverage and staff with many of the necessary skills to help protect the health of local communities.

I feel that the Technical Discussions on “Protecting Human Health from Climate Change” is an important step, in that direction. These discussions are being held prior to the Sixty-second session of the Regional Committee to be held in September 2009 in Kathmandu. The recommendations arising from your deliberations and discussions will be considered by the Regional Committee.

It is expected that the Technical Discussions suggest recommendations that will assist Member States on how best to respond to the urgent need to empower local communities in protecting their health from climate change. I wish you fruitful discussions and strong results, and a pleasant stay in New Delhi. Thank you

## Annex 2

# **Keynote Address: The special vulnerability of population health to climate change impacts in the SEA Region (SEAR )”, Dr Colin D. Butler, Associate Professor, National Centre for Epidemiology and Population Health, College of Medicine, Biology and Environment, Australian National University**

## **Introduction**

Climate change is already having many adverse physical, ecological and social impacts. Climate change is an amplifier of existing disadvantages, and a generator of many new problems, themselves likely to create and intensify vulnerability. The most likely and quantitatively important adverse effect to health in the SEA Region because of climate change is via worsened nutrition, especially due to localized agricultural impairment. Poor nutrition will in turn worsen many infectious diseases, from pneumonia to diarrhoea, and also some chronic diseases<sup>1</sup>. Worsened nutrition will also lower economic productivity and add to the burden of cognitive impairment and poverty among the severely undernourished<sup>2</sup>. The harmful effect of climate change upon agriculture is likely to manifest in several ways, including increased heat, drought and reduced water for irrigation. Extreme weather events, such as heatwaves, droughts, very heavy rainfall, river floods, and coastal storms are also likely to become more intense, and each will bring immediate and long-term agricultural and health sequelae. As climate change increases, adverse direct effects of chronic heat stress are likely to become increasingly frequent among unprotected workers and other high-risk groups, such as outdoor labourers and those in factories and offices with inadequate air conditioning, the elderly and those with chronic illnesses.

In the second half of this century, substantial sea-level rise, of at least 1 metre<sup>3</sup>, is predicted and will tax the provision of protective infrastructure (eg. sea walls) in even the richest countries. The synthesis report of the recent Copenhagen conference on climate change estimated the global mean sea-level rise as about double the Intergovernmental Panel on Climate Change (IPCC) projections from

2007<sup>3</sup>. In the SEA Region, sea-level rise at even lower levels appears likely to drive largescale human migration, and generate millions of eco-social refugees, of which climate change will be an increasingly important contributor.

In the worst case, as the multiple manifestations of climate change unfold, growing conflict, failing governance, and impaired general health through numerous pathways are plausible outcomes. Mechanisms of such wider impairment include not only from heat stress, renal impairment and undernutrition, but even, perhaps, a resurgence of vaccine-preventable disease, or a worsening in health due to reduced provision of basic surgical or obstetric services.

The paper finds that the persisting rate of poverty in the SEA Region is the most fundamental determinant of vulnerability to climate change, and that without excellent governance this vulnerability will be worsened by climate change. It finds that the time before the impacts of climate change become severe is a risk and an opportunity. It is a risk because the non-catastrophic and even scarcely noticed nature of climate change in many settings is and will continue to be used as reasons to obstruct the steps that can be taken to reduce the extent of climate change and to prepare for it. However, this time is also an opportunity, if used wisely. If society waits for catastrophe to be evident, preparation will then be ineffective. All that will be possible are rescue and triage.

The paper thus pleads for recognition of the immense risks to health and society from unmodified climate change, and hence for the allocation of substantial governmental and human resources to be applied to this problem. It is true that the SEA Region is not primarily responsible for climate change. However it cannot wait for and should not expect responsible leadership from high-income countries concerning this issue. Further, the reduction of poverty – which, if done well is the primary means to prepare for climate change – will have many “co-benefits”, and is a highly desirable goal in itself.

## **Poverty, health and climate change**

Of the many determinants of population vulnerability to climate change the most important is poverty. In turn, poverty has numerous causes, which interact and reinforce each other. While there is no space in this paper to discuss these causes in detail the following observations are made. Fundamentally, inequality, exploitation, and poverty appear to be part of the human condition, at least in complex non-hunter gatherer societies<sup>4,5</sup>. Nonetheless, modern resources, technology and knowledge are at such a high global level that modest poverty-

relieving targets, such as those of the Millennium Development Goals should be feasible, and for a short time appeared achievable.

What has been less well recognized, however, is that approximately parallel to the growth in human capacity there has been a commensurate growth in the complexity of human problems. The late economist, Julian Simon, described additional people as the “Ultimate Resource”, claiming that every additional person on Earth could contribute to the creation of a well-ordered, harmonious and prosperous society<sup>6</sup>. Less acknowledged is the possibility that every additional person born on Earth can also add to the sum of problems, especially if that additional person fails to receive the resources needed for a “good life” such as enough food, nurturing, education and opportunity for employment<sup>7,8</sup>. Good public health and governance are vital to tilt the scales in favour of the Simonian claim, i.e. that additional people contribute to the solution.

Human well-being and health improved in many parts of the SEA Region in the decades following World War II, although progress was uneven. At the moment, though data are inconclusive, it is plausible that some of these indicators and determinants of human health in the SEA Region are no longer improving, and perhaps even in decline. For example, several populous states in northern India have rates of stunting in children under the age of 5 that exceed 60%<sup>1</sup>.

Poverty has many dimensions. Material poverty is often accompanied by a scarcity of access, information, redress and insurance, whether formal or informal. Poverty places the poor at risk from any additional stress. Climate change is likely to be such a stress. There is a continual race between the alleviation of poverty and the emergence of new threats and risks. While the alleviation of poverty is a long-term investment, whose importance is endlessly proclaimed by governments of all kinds, actions to relieve it remain comparatively scarce, and often disposable when competed for by a new problem, such as the global financial crisis.

## **Uncertainty concerning climate change in the SEA Region**

While there is scientific consensus that anthropogenic climate change is occurring and will continue to increase throughout this century<sup>3</sup>, substantial uncertainty remains, which concerns its likely rate, severity and consequences, at both global and regional scales. Global projections for climate change range from catastrophic<sup>9-11</sup> to tolerable. It is true that a few scientists, publishing almost exclusively beyond the peer-reviewed literature, claim that climate change is neither important nor anthropogenic, or that it is being reversed by natural means. Because their

arguments coincide with the interests of many lobby groups (especially the oil and coal industry), this group retains disproportionate influence, not only in the media but among many governments.

At the global level this uncertainty is further complicated by whether changes in global temperature will be apparent in the next decade or so. Easterling and Wehner write: “periods of no trend or even cooling of the globally averaged surface air temperature are found in the last 34 years of the observed record, and in climate model simulations of the 20th and 21st century forced with increasing greenhouse gases<sup>12</sup>”.

This uncertainty is an opportunity and risk. The opportunity is that a delay in global warming might provide a little more time before dangerous climate change unfolds. The risk is that any apparent decline in the rate of warming might be seized upon by climate change skeptics to slow the scale of political support and the speed of technological evolution required to forestall dangerous climate change<sup>11</sup>; that is, that the opportunity might be lost. On the other hand, an obvious acceleration in the rate of climate change in the next decade may sharpen the urgency of the response to climate change, but at the same time reveal how little time we have.

There is also considerable spatial variation in the degree of warming due to climate change, with consensus that the high latitudes are warming at a far greater rate than the tropics, in which most of the countries of the SEA Region are located. Even within this Region there is variation, particularly affecting South Asia. There is consensus that hilly and mountainous regions have warmed more than tropical lowlands, with the IPCC noting this in India, Nepal and Sri Lanka. In India, the IPCC concluded that temperatures had risen by about 0.7°C, that is about the average global increase. However, some other experts argue that there has been recent cooling in much of India, despite an increase in the average global temperature. They attribute this cooling to a mix of anthropogenic atmospheric and landuse changes. These are, principally, cooling aerosols — which contribute to the atmospheric brown cloud (ABC) over South Asia and the Indian Ocean<sup>13</sup> — and expanded irrigation in North West India<sup>14,15</sup>.

While the effect of aerosols on temperature in the lower troposphere remains uncertain there is growing understanding that aerosols containing black carbon, or "soot", produced by low-temperature household burning of biofuels and coal are important in their own right<sup>16</sup>. For example, black carbon deposits on white snow reduces the albedo (whiteness), thus encouraging glacial melting.

## **The size, heterogeneity and complexity of the Region and of climate change**

Countries of the SEA Region vary enormously by geography, religion, language, wealth and forms and effectiveness of governance. The dimension they have most in common, apart from Thailand, is widespread poverty. Climate change also has numerous manifestations, including changes to temperature, sea-level, rainfall intensity, climatic variability, and to storms, glacial sizes and river flows. It may also affect the severity and timing of drought and alter the strength and timing of the Indian monsoon<sup>13,17</sup>. The accumulation of the main greenhouse gas, carbon dioxide, is also increasing the acidity of the ocean<sup>18</sup>. This, together with other climate change influences, is likely to change and reduce the productivity of fisheries. The widespread construction of seawalls will also reduce fishery productivity.

While poverty creates a general vulnerability, the additional stress represented by climate change varies considerably by location. For example, Bangladesh, India, Maldives and parts of Myanmar are especially vulnerable to flooding from sea-level rise and storms. The quality of governance, is also likely to influence vulnerability, separate to poverty, and has been briefly discussed above.

### **Low-lying coastal areas, including islands**

Bangladesh and Maldives exemplify entire nations that are vulnerable to even a moderate sea-level rise. The government of Maldives is already discussing the relocation of its entire population. In the near term, Maldives may be able to construct sea walls, but if sea-level rise continues, a point will be reached where such defences become perceived as hopeless. Well before that point, many people in Maldives are likely to be anxious and depressed by these events. A sea-level rise of only 40cm higher than today has been projected to increase the annual number of people flooded in coastal populations in Asia from 13 million to 94 million, with almost 60% of this increase occurring along coasts from Pakistan, through India, Sri Lanka and Bangladesh to Myanmar. People in Thailand and Indonesia will also be affected<sup>19</sup>. Seas rising beyond this level now appear inevitable towards the end of this century, and will displace far more people. If, as also seems likely, many inland parts of the SEA Region will become less hospitable due to climate change, then many of these coastal refugees will have no obvious refuge. Although unpalatable to consider, many are likely to be forced to live in increasingly large refugee camps, facing an uncertain, anxious, and unhappy future. Population health in these camps

will almost inevitably be poor<sup>20</sup>, though well-organized relief services may be able to meet basic health needs, such as vaccination coverage and a monotonous diet. If climate change continues to worsen while people are held in such camps, then morale will suffer, as the possibility of relocation or return will likely fall with time.

## **Agriculture, food insecurity, climate change and health**

Climate change is likely to harm crop yields, through numerous mechanisms, especially in tropical regions, although this might be partly offset by the “carbon fertilization effect” – the theory that increased levels of carbon dioxide, essential for photosynthesis, encourage plant growth<sup>21,22</sup>. Inadequate crop yields, if localized, can of course be compensated for by trade, borrowing and governance. But the reality for the poor is that these means are rarely available on the scale required. This situation could worsen if the agricultural impact of climate change is widespread. In turn, nutritional status is determined not just by food intake but also by co-existing diseases, particularly infections such as diarrhoea and tuberculosis.

Already, with little evidence of a substantial adverse climate change impact upon crop production in South Asia, around 40% of adult women in Bangladesh and India have a low body-mass index<sup>1</sup>. Inadequate food intake (whether in terms of quantity or quality) is an important cause of poor health. Globally, deaths attributed to undernutrition exceed that from frank starvation by a factor of at least twenty, with most deaths due to acute respiratory illness, diarrhoea, malaria and measles<sup>23</sup>. Several important chronic diseases are also influenced by poor childhood nutrition.

A growing number of studies and an increasingly coherent and disturbing body of evidence point to a likely deterioration of agricultural capacity, especially in hot, tropical conditions. According to the UN World Food Programme, the number of food emergencies every year increased from an average of 15 during the 1980s to more than 30, by 2004<sup>24</sup>. While there are multiple causes for this, climate change is already likely to be a factor<sup>25</sup>.

All plants have an optimal temperature for growth. In cold regions, higher temperatures (provided there is adequate water, soil, essential elements and so on) will improve yields<sup>26</sup>. However, beyond the narrow window of optimal temperature, which varies for different crops (for example, millet tolerates heat better than maize). In the SEA Region the agricultural land area likely to benefit from warmer temperatures is limited in area, confined largely to mountainous

regions, which have many other disadvantages for large-scale cultivation, such as for transport and other infrastructure.

Rice, the staple food in the SEA Region, is also sensitive to additional heat, especially nocturnal. In 2004, workers at the International Rice Research Institute (IRRI) reported that rice grain yield declined by 10% for each 1°C increase in growing-season minimum temperature in the dry season<sup>27</sup>. Heat increases, of course, are far from the only means likely to harm agricultural productivity. In 2008 Cyclone Nargis and the accompanying tidal surge swamped an estimated 783 000 hectares, destroying a third of the rice crop in the Ayeyarwady delta, the country's rice bowl. The cyclone ruined much of the delta's rice seeds, which had been stored in bamboo containers that were easily waterlogged. It also drowned over 120 000 water buffalos and robbed survivors of farm implements and fishing boats and gear. As an adviser to the United Kingdom's Department for International Development commented, "Nargis made a bad food-security situation worse"<sup>28</sup>.

While not all storms as severe as Nargis can be attributed to climate change, there is growing consensus that climate change is leading to an increase in the strongest categories of storms<sup>4,5</sup>. A research group recently concluded that the most notable increases in storms are in the North Atlantic and northern Indian Oceans; the latter region of course is relevant to the SEA Region. A commentator, not involved in the study, noted that "It'll be pretty hard now for anyone to claim that cyclone activity has not increased"<sup>29</sup>.

In addition to stronger and perhaps more frequent storms, other forms of extreme events are also predicted, and there is some evidence that these are already occurring, such as more intense droughts and heavier rainfall<sup>19</sup>. There is also increasing recognition that wheat and rice yields, especially of cultivars grown in Asia, are harmed by ozone concentrations, by as much as 3%-48%<sup>30</sup>.

Aquaculture is one of the most promising strategies to enhance food security, especially if it focuses on the growth of algae, shrimp and herbiferous fish such as freshwater carp and tilapia<sup>31</sup>. China now produces more aquacultural products than the rest of the world combined; much of this is comparatively high in protein and also contains beneficial fatty acids. Sea-level rise and flooding of coastal lands, including shrimp farms, will lead to salination or contamination of fresh water and agricultural lands, and loss of nursery areas for fishing. Drought and changing patterns of plant and livestock diseases and pest infestations, reduction of income from animal production, decreased crop yields, decreased forest productivity and changes in aquatic populations will also affect food production and security.

Although comprehensive data are lacking there are growing concerns that the vast majority of glaciers in the Himalayas and Tibetan Plateau are in retreat<sup>32,33</sup>. These glaciers accumulate water mainly as snow during winter from a “water tower”. During spring and summer the melt of these glaciers is a reliable source of water, and the great rivers which spring from this region flow reliably even during the dry season. This is of critical importance to hundreds of millions of people in the SEA Region who are dependent on these rivers, particularly from two great rivers of Asia, the Ganges and the Brahmaputra.

Although analysis of the hydrological cycle of the Himalaya region is complicated by the Asian monsoon, Barnett et al. write that “there is little doubt that melting glaciers provide as much as 70% of the summer flow in the Ganges and 50–60% of the flow in other major rivers, including several that water the Indian Punjab. This flow is also very important in the absence of significant water storage, which is common in the rivers that flow into South Asia.

## **Extreme weather events – floods, droughts, heatwaves, coldwaves and storms**

Climate change is increasingly recognized as likely to increase the frequency of several kinds of extreme weather events. Most of these changes are likely to be harmful to human health, however a reduction in cold weather, especially in rural areas, is likely to partially offset these harms<sup>34</sup>. Climate change is also likely to bring more variability, meaning that severe coldwaves could still occur even if the average temperature is warmer.

The recent notable extreme weather events in the SEA Region include the record flood in Mumbai, India in July 2005, when almost 1 metre of rain fell in 24 hours, leading to the loss of over 1000 lives<sup>19,35</sup>. Though not in the SEA Region, up to 3 metres of rain, falling in just a few days, flooded much of Taiwan in August 2009. The severity of droughts in parts of the SEA Region is also considered to be increasing, largely due to atmospheric aerosol pollution<sup>36</sup>. Droughts are also of special concern in India. The vulnerability of the poor to drought, especially in rural regions, is an important cause of seasonal and distress migration, indebtedness and farmer suicides<sup>37,38</sup>. India is also the country with by far the largest number of people with chronic undernourishment<sup>1</sup>. Any increase in drought is likely to adversely affect nutrition and thus health.

The effect of black carbon and other forms of warming upon glaciers has been raised above. Predicted consequences are reduced winter snow and faster spring

melts in these glacial regions. In turn, this may increase flooding at a time which is less crucial for agriculture. Recently-formed lakes, formed by the melting of glaciers, have been observed in Nepal. Many threaten to flood, harming homes and livelihoods. The devastating Kosi River flood in Bihar, India, in 2008 was exacerbated by glacial melting<sup>39</sup>. This flood affected 4.4 million people, damaged 290 000 hectares of land (40% of the area estimated to have been affected by Cyclone Nargis) and cost an estimated US\$ 6.5 billion<sup>39</sup>. Its adverse health effects are likely to have included physical and mental trauma, diarrhoea, displacement and further impoverishment. However few quantitative data are available.

Increased heatwaves, especially in urban areas, compounded by the heat island effect, and deterioration in air quality are also likely. On the other hand, warming is likely to reduce mortality related with cold weather, especially in rural areas<sup>34</sup>. Both acute and chronic health effects, due to increased urban heatwaves are probable, but high quality data are limited, while distributing causality between global climate change, local air quality and the urban heat island effect is difficult; all three factors are likely contributors<sup>40</sup>. However, a 2002 heatwave in the Indian state of Andhra Pradesh was reported to have killed 622 people, with labourers such as rickshaw pullers found to be at special risk<sup>35</sup>.

## **Vector-borne diseases: malaria, dengue fever and chikungunya**

In the past, considerable attention has been paid to the possibility of an increased distribution of vector-borne and arthropod-dependent diseases because of climate change. Attention has focused upon malaria in Africa<sup>41</sup> and schistosomiasis in China<sup>42</sup>, with comparatively little work investigating the possible increase of malaria to higher altitudes in Asia. However, especially in regions marked by poverty, such as Nepal,<sup>43</sup> or marked drug resistance (such as near the Thai-Cambodian border)<sup>44</sup>, the uphill spread of the potentially lethal malarial infection due to *plasmodium falciparum* is highly plausible.

Climate and hence climate change also influences the distribution of several other vector-borne diseases that are already common in parts of the SEA Region, such as dengue fever<sup>45</sup> and chikungunya. Although it is possible that the epidemiology of these diseases may be favourably altered in some parts of the Region, such as by increased dryness, overall they are likely to become more common. Some studies have found that climate change is likely to increase dengue transmission in India<sup>45</sup>. It is also plausible that, as with malaria, dengue fever will in future be found and transmitted in areas beyond its historical range. The distribution of the vaccine-preventable arbovirus Japanese encephalitis may also be

altered by climate change effects, especially if governance falters in ways that reduce vaccine coverage. The distribution of soil-transmitted helminths may also be altered by climate change, especially by heavier rainfall.

## **Social cohesion and the likely problems of forced migration**

Many parts of the SEA Region have an ancient history of receptivity and tolerance. India, in particular, has famously provided a tolerant refuge for minority populations fleeing persecution, such as the Parsees, Tibetans and many people from Bangladesh. People of different faiths in India have also long co-existed. On balance, while the SEA Region is likely to have a comparatively high capacity to tolerate, care for and absorb refugees fleeing the environmental and social disruption secondary to climate change, this capacity is likely to be exceeded unless the effects of climate change and other environmental challenges<sup>46</sup> are far more benign than currently predicted.

## **Responding to the likely impact upon human health imposed by climate change**

The human consequences, including to health from climate change, were at first under-recognized by both the social science and the health community. Many people in these disciplines thought that either technology would solve human problems<sup>47</sup> or perhaps that the main adverse effects would be to ecosystems and the environment itself, rather than to humans. While this is starting to change, many health workers still focus on adverse health effects of the more obvious tangible effects such as from heatwaves and altered vector-borne disease epidemiology. Indeed, the health chapter in the Fourth IPCC Report<sup>48</sup> pays little attention to these more complex and potentially far more severe “tertiary”<sup>49</sup> impacts upon health – that is, those likely to occur later this century through the interaction of large-scale undernutrition, coastal flooding, population dislocation and, perhaps, conflict.

A policy of “wait and see” to detect the worst impacts of climate change is to wait too long, as pointed out by Charney et al. 30 years ago<sup>50</sup>.

This review closes with one observation and one appeal.

The observation is that while reduction of poverty is seen as the most essential element with which to reduce the adverse impact of climate change, this should

not be pursued in the SEA Region only by an intensification of carbon-intensive electrification. Instead, ways should be found, where possible, to accelerate energy transition<sup>51</sup>, and other components of the broader sustainability transition, preferably by grants, subsidies and low-interest loans, including from high-income countries. The price of comparatively clean energy is declining. Combined with greater energy efficiency, the cost of electricity to consumers may not be much higher than that provided by centralized coal-fired power stations – and would already be cheaper if the full price of externalities was considered.

My appeal is for the governments of Member States of the SEA Region to try harder to reach the Millennium Development Goals, especially those that relate to female education. Better education will have multiple social benefits, and will also lower fertility, which remains an essential element for population health and development<sup>52,53</sup>. Greater public goods will, in time, benefit those who are better off as well as the poor. “Business as usual” will be a fatal error.

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## **Annex 3**

# **Public Health Interventions to Protect the Vulnerable People in Mountain Regions from Climate Change Effects, Dr Fang Jing and Dr Mats Eriksson, International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal**

## **Introduction**

Human health is the outcome of complicated interaction of many health determinants. The impact of climate change and variability on human health has increasingly been recognized in the last few decades. It is now widely acknowledged that climate change is profoundly affecting every aspect of our planet and human life, including human health. The effects of climate change on human health can be direct and indirect as well as positive and negative. It is also commonly agreed that the adverse impact of climate change on human health will outweigh the positive ones (McMichael and Githeko, 2001). The excessive morbidity and mortality associated with extreme weather events such as heatwaves, flashfloods and droughts are visible evidence of direct adverse impact, as did the European heatwave in August 2003 that claimed over 35,000 excess deaths (Kovats et al., 2004). India also had several heatwaves during the 1990s that caused thousands of deaths. The impact of climate change on human health is mediated through many other factors such as access to safe water, agricultural production, natural disasters, environmental pollution, biodiversity, and disease vectors. Thus this type of impact is indirect and much less visible compared with the direct one. The climate change effects are often alleviated or exacerbated by “effect-modifying factors” such as geographic location, socioeconomic development levels and institutional capacity. Climate change is only one of the environmental factors that affect human health, interacting with many other variables to jointly shape human well-being. Therefore, it is a big challenge to measure and quantify the impact and to separate the effects of climate change on health from the effects caused by other health determinants. Despite this challenge, we still can do a lot to mitigate the effects of climate change and to help people better adapt and reduce its negative impact on human health.

The effects of climate change on human health are unevenly distributed among different groups and geographic locations. The poor, the young children, the elderly and people with poor health conditions such as cardiovascular diseases and respiratory problems are the most vulnerable groups to the adverse impact of climate change. Regarding geographic location, in addition to small islands and coastal delta areas, mountain regions are among the frontiers of climate change due to a number of physical and social factors that make mountain people have more exposure, high sensitivity and less adaptive capacity to climate change, and thus more vulnerable to the effects of climate change (Eriksson et al., 2008). Nevertheless, mountain perspectives have often been left out, so far, in many debates on climate change.

With a focus on Himalayan mountain regions, this paper analyses the health vulnerability of mountain regions to climate change and suggests public health interventions that can be taken to protect people's health.

## **Health vulnerability of mountain people to climate change**

Although there are many different understandings about vulnerabilities, the convergent view defines vulnerability to climate change from the dimensions of exposure, sensitivity and adaptive capacity (Kovats et al., 2004). Seen from each of the three dimensions, mountain people are more vulnerable to the adverse health effects of climate change.

### **2.1 Rising temperatures and changed precipitation patterns may lead to increased exposure to health risks**

Warming at high elevations in mountain regions was greater than the global average in the last 100 years (IPCC, 2007; Nogues-Bravo et al., 2007). For instance, temperature in the Tibetan plateau in the last 40 years (1961-2000) increased at a speed of 0.26 centigrade per decade, which is much faster than temperature increases in other parts of the world (Du, 2001). So far, changes in the total amount of precipitation in the Himalayan region have been difficult to detect. However, preliminary studies indicate that the variability is increasing, with more dry spells separated by intense rainfall events. There also are signs of changes in the monsoonal pattern leading to changes in the seasonal distribution of precipitation.

The changing temperature and rainfall pattern can expose mountain people to increased health risks. For example, malaria-carrying mosquitoes may move to

higher altitudes. Both Bhutan and Nepal have reported of malaria cases at altitudes over 4000m (WHO, 2006), previously free from such disease although it is not very clear whether the infection was contracted locally or imported. The warming weather and changing precipitation may also make the control of malaria in endemic places more difficult. In past decades the prevalence of malaria in Yunnan Province and Tibet Autonomous Region, China, Nepal and Bhutan shows a declining trend, which may be attributed to various control programmes and the advances made in the diagnosis and treatment. The Yunnan Province of China used to have serious malaria epidemics. In 1953 the incidence of malaria was 249.38 cases per ten thousand people (249.38/10,000) and in 2003 it had decreased to 3.82/10,000 (Yunnan (China) Institute of Parasitic Disease, 2006). However, since 2001 the malaria incidence in China has shown an increasing trend (Li, 2007). During 2001- 2003 the malaria cases in Yunnan Province, China increased from 9267 (21deaths) to 15 431 (43 deaths). The malaria cases in Yunnan, China in 2003 accounted for 39.2% of the total malaria cases in China, with malaria cases in 2003 increasing 26.3% compared with 2002 (National Institute for Parasitic Disease, Chinese CDC, 2005). The cases in border areas where the poverty level is higher account for 67% of the total cases (Li, Yang and Jiang, 2005).

## **2.2 High sensitivity to climate change**

Sensitivity to climate change is determined by exposure-effect and population characteristics (Kovats et al., 2004). Many factors make mountain regions and people highly sensitive to climate change. Most mountain people are subsistence farmers who rely on agriculture and forest for their livelihoods that are highly sensitive to climate variability and change, for much of the agriculture in mountain regions is rain-fed cultivation. Under ordinary weather conditions crop yields in mountain regions are lower than in plains due to the sloping farming land and erosion-prone and infertile soil. While the average rice yield per hectare in Nepal is 2,770 kg (Basnet, 2008), in hilly and high mountain regions where indigenous groups are the main residents the crop yield would be lower. A recent survey conducted in Chepang communities (one of the most marginalized ethnic groups in Nepal) showed that the grain produced is only sufficient for about five months per year and wild food still accounted for 35% of daily consumed food of local people (Fang et al., 2009). More than 50 000 children die in Nepal each year with malnutrition as the underlying cause for more than 60% of these deaths; half the children in Nepal are underweight and three fourths of pregnant women are anaemic<sup>3</sup>, and 17% of the total population in Nepal are undernourished World Food Programme (WFP), 2009). In 2008 the World Food Programme conducted a sampling survey of 1100 household in 34 districts of Nepal and the result showed

that more than 50% of sampled households reported having experienced a food shortage and almost 50% asserted that the food shortage was more severe than previous years (WFP, 2008).

Food insecurity is a chronic problem in many mountain regions and contributes to malnutrition. Increased climate variability, even minor changes, particularly affecting precipitation, can hamper food production and thus exacerbate food insufficiency. A projection showed that by 2050 China's grain output could fall by as much as 10% unless crop varieties adapt to new temperatures and water regimes (Khoday, 2007). Similarly it has been estimated that the crop yield of India will decrease in spite of the impact of CO<sub>2</sub> fertilization effect.

Climate-induced natural disasters such as snow avalanches, landslides, debris flows, and flashfloods as well as glacial lake outburst floods (GLOFs) can have a dramatic impact due to the geographic and geological characteristics of mountain settings. Local communities suffer from worrying about the possible disasters, causing an increased burden of psychological stress. This is one of the health effects of climate change but is often ignored by health and other sectors. Such disasters can destroy crops, farming land, infrastructure and even people's livelihoods completely and cause displacement, which will have a huge impact on every aspect of people's life, including mental and physical well-being. In Bhutan out of the existing 2 674 glacial lakes, 25 have been identified as potentially dangerous and at risk of causing GLOFs (UNDP, 2008). A GLOF can sweep away houses, farming land, roads, but also destroy hydropower stations and related infrastructure located downstream. Outbreaks of diarrhoea and other waterborne and foodborne diseases that often follow floods can claim more lives, particularly among children and the elderly if proper and timely rescue and public health interventions are absent.

Due to lack of access to safe drinking water and basic sanitation, waterborne and food-borne diseases such as diarrhoea are still highly prevalent in the SEA Region even without the effects of climate change. These diseases are the major killers of children under five years of age. For example, in 2006 the coverage of tap water and hygienic toilets in Yunnan Province, China were only 61% and 51% respectively (Yunnan Statistical Bureau, 2007) and in 2004 only 29% of the total population in Tibet Autonomous Region, China had access to safe drinking water. In Nepal the census data in 2001 showed that only 66.1% urban population and 51.1% rural population had access to piped water (WHO/UNICEF, 2008), and only 27% population used adequate sanitation facilities (UNDP, 2001). In these parts, many water sources are contaminated by human and animal faeces that cause high prevalence and frequent outbreaks of diarrhoea and other waterborne diseases.

The data of infectious disease reporting system of the Centre for Disease Prevention and Control (CDC) in Yuanmou County, Yunnan Province, China showed that from 1974-2007 dysentery had remained the number one or two reported infectious disease despite the rapid economic growth of the previous three decades in the county. In Tibet, China, diarrhoea is the second- highest cause of infant mortality and the first cause of death among children under the age of five (National Working Committee on Children and Women under the State Council, 2003). Warm climate may increase the likelihood of bacteria and other pathogens present in water and thus cause more waterborne and foodborne diseases.

In general, people in Himalayan mountains have a relatively poor health status. This is clearly indicated by some commonly used health indicators such as maternal mortality rate (MMR), infant mortality rate (IMR), under-5 children mortality and life expectancy. These indicators not only indicate the health status of the concerned population but also reflect the general socioeconomic conditions of the population. In 2001 for the whole of China, the MMR was 48.44/100, 000 and IMR was 16.95/1000 livebirths, while MMR in Yunnan, China and Tibet, China were 78.15 and 327.27/100, 000 livebirths respectively (Ministry of Health, China, 2001). Life expectancy at birth in 2000 in both Tibet, China (64.37 years old) and Yunnan, China (65.49 years old) was shorter than the over-70 years national average life expectancy (Chinese Health Statistical Digest, Ministry of Health, 2007). Bhutan, Nepal and the states in north-eastern India also have higher MMR, IMR and shorter life expectancies. Poor health status makes people highly sensitive to the adverse impact of climate change.

The Himalayan region spans 3 of the 34 global hotspots of biodiversity, and this rich biodiversity is under the threat of climate change (Xu et al., 2009). Some plant species including medical plants, which many people, particularly poor mountain people, depend on for health care may be disappearing or even getting extinct due to climate change. For example, even today traditional herbal preparations account for 30-50% of the total medicinal consumption in China (IUCN, 2009). This will cause a huge loss to the existing and potential tools that human beings can use to cure and control diseases.

### **2.3 Low adaptive capacity**

Adaptive capacity of a region or population is determined by many factors that include resources, awareness and perception of people, institutional arrangements and governance etc. Mountain regions in general have a low adaptive capacity to climate change.

First, the geographic features of mountain regions make it hard for rapid delivery and transportation of goods, services and information. Mountain perspectives have often been left out or marginalized in many international, regional and national development forums. Accordingly, resources available for mountain regions are more limited compared, for instance, with plains. This contributes to the low adaptive capacity of mountain regions to climate and other environmental changes.

Second, infrastructure such as roads, transportation, electricity, water supply and communication facilities are often underdeveloped in mountain regions, which constrain governmental, institutional, household and individual response and adaptation to changes, including climate change. Conflicts and social unrest are also common in the Himalayan region, which further aggravate the situation.

Third, the poverty level is usually higher in mountain regions; particularly for the Himalayan region. For example, in Bhutan extreme poverty is relatively rare and few suffer from hunger or homelessness but there were still 32% of the population living under the national poverty line in 2003 (United Nations, Bhutan, 2006). In 2005, the economic status of both the Tibet Autonomous Region (TAR) and Yunnan Province, China were ranked at the bottom among 31 provinces/municipalities in China: for gross domestic products (GDP), TAR was ranked 31st and Yunnan (China) 24th, and for per capita income TAR was ranked 27th and Yunnan (China) 31st (Xinhua News Agency, 2007). In Nepal, 38% of the population live under the poverty line (Nepal Poverty Report, 2005). Nepal was ranked 13th from the bottom of a list of 90 developing countries, and 38% of the population fall below the one-dollar-a-day poverty line (UNDP, 2001). Both Bhutan are among the 2009 list of 50 least developed countries (LDCs) in the world<sup>3</sup>. Poverty make people have few assets that they can draw on to adapt to changes. Poverty also makes people more vulnerable to diseases and health problems such as malnutrition, malaria and disasters.

Fourth, weak health system and service facilities particularly contribute to low adaptive capacity to deal with climate-sensitive diseases and health problems. Health systems in poor mountain countries are often dysfunctional due to lack of suppliers and low motivation of health workers who are usually poorly paid. The coverage of some basic health services such as children immunization and women's maternal health care is lower in mountains; this makes people susceptible to many common infectious diseases and avoidable health problems. For example, one

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<sup>3</sup> See: <http://www.un.org/special-rep/ohrls/ldc/list.htm>

survey on Chepang communities revealed that 60% women reported that they had had a uterus prolapse. Long distances, steep terrain and insufficient health facilities in mountain regions make it harder for people to access health care. In many mountain villages in Nepal, due to the long distance to a governmental health post, women usually take their sick children to expensive private practitioners. In addition, public health workers and facilities in mountain areas are generally overwhelmed by the needs to deal with health problems such as pneumonia, diarrhoea and other waterborne diseases, TB, and HIV/AIDS, leaving them with little opportunity to prepare to cope with new challenges such as those related to climate change. It can be concluded that climate change will put an additional strain on the poorly functional health systems and thus make the region much less adaptive to any change.

### ***Public health interventions to protect human health in the context of climate change***

Health is a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity (WHO, 1992). Thus, public health interventions include a broader range of policies, strategies, technologies, methods and measures that governments, communities, households and individuals can take to protect health. Although there are still a lot of uncertainties in terms of the effects of climate change on human health, many interventions can be taken to protect human health from the existing and potential adverse impact of climate change. These interventions include both interventions that can be taken by the health sector and interventions that can be taken by non-health sectors. This paper will focus on interventions that the health sector can take a lead on.

### ***Awareness-raising among health workers on the effects of climate change on human health***

Climate change has gradually become a hot topic at various international conferences organized and participated in by organizations and individuals working on environment, meteorology, water and conservation, etc. However, the health sector does not seem to be involved in those events as much as other sectors, particularly the health sectors in mountain regions. Health workers, particular those working at the grassroots level have little awareness of climate change and its health effects. Therefore, awareness-raising activities are needed to make health workers alert to the health consequences of climate change, so that they can actively participate in adaptive activities related to climate change.

### ***Capacity-building of health professionals on climate-sensitive health problems such as heatwave-associated illness***

Climate change is likely to open mountain regions to infectious diseases that did not exist in such areas before, for example, malaria and dengue. Health workers in mountain regions have little experience in diagnosing and treating these infectious diseases; they also have much less experience in dealing with heatwave-associated illnesses. Capacity-building is a crucial public health intervention that can equip health workers with needed knowledge and skills in dealing with those diseases so they can effectively respond to the new health risks brought about by climate change. The curriculum of medical schools should be updated to include or strengthen the components of climate-sensitive diseases and health problems.

### ***Conducting carefully designed and planned epidemiology studies***

Although we know that climate change has been affecting people's health, there is little empirical evidence to date that shows to what extent this is happening (Michael and Woodruff, 2002). Indeed, the scientific evidence is still patchy and we particularly lack epidemiology evidences in mountain regions. The IPCC report (2001) suggests that carefully planned epidemiology studies, should be conducted as they would be very relevant for mountain regions. Carefully designed and planned epidemiology studies can not only provide powerful scientific evidence on the impact of climate change, but can also help identify vulnerable areas and population groups so as to contribute to setting of priorities and allocation of resources.

## **3.4 Strengthening the surveillance of climate-sensitive diseases and risk assessment**

Both Bhutan and Nepal reported malaria cases in altitudes above 4000 metres, however, the source of infection was not clear due to the absence of reliable disease surveillance systems in the two countries. A reliable climate-sensitive disease surveillance and reporting system is urgently needed in those mountain countries in order to assess the health impact of climate change, and to timely identify the risks and formulate adaptive policies and strategies. Countries like Bhutan and Nepal may have difficulty in independently setting up their disease surveillance systems; regional and international aid and cooperation are thus needed. China has greatly strengthened its disease surveillance system since the severe acute respiratory syndrome (SARS) epidemic in 2003. This disease

surveillance system can be used to monitor climate change-sensitive diseases and health problems.

### ***Early warning systems on climate change-related health problems***

On the basis of climate-sensitive disease surveillance systems and risk assessment, early warning systems should be set up to timely disseminate information to stakeholders and thereby facilitate their preparedness. Mountain regions usually have poor transportation and communication facilities; however local people have their traditional ways of communication, also modern technologies such as radios and in some cases mobile phones are available. New technologies and traditional channels of communication should be used to deliver health-related early warning messages to people who live in remote mountain villages.

### ***Reviving and refining the primary health care (PHC) agenda***

The health vulnerability of mountain people to the impact of climate change is very much linked to the lack or insufficiency of health infrastructure that includes safe drinking water and basic sanitation, nutrition and access to health-care services. Those, in fact, are on the agenda of primary health care (PHC) programme promoted by WHO in 1978. The PHC agenda is still valid in the context of climate change. This unfulfilled agenda needs to be revived and refined in order to combat the negative health impact of climate change.

### ***Mainstreaming the consideration of climate change related health issues into the health sector reform agenda***

Since the 1980s many countries in the world have reformed their health sectors despite different underlying causes. At present, health sector reform is under way in many countries in this region. For example, China just issued its new health sector reform policy and strategy, and India also launched its National Rural Health Mission in the recent past, which intends to strengthen the basic health-care system over the period 2005-2012. This provides some window of opportunity to mainstream the considerations of climate change-associated health issues into the health sector reform agenda. It is crucial to put climate change issues into the agenda of health sector reform, for it will not only raise the needed awareness but can also draw the needed resources to respond to health effects of climate change.

### ***Strengthening collaboration with other sectors***

One important public health intervention in dealing with climate change is to strengthen collaboration and cooperation of the health sector with other sectors such as meteorology, water, agriculture, veterinary and the sectors responsible for social safety. The implementation of this intervention is often full of challenges given that in most countries administrative sectors are vertically organized with little interaction and exchange crossing sector boundaries. However, it is imperative for the health sector to have close collaboration and cooperation with other sectors in order to effectively protect people's health from the effects of climate change.

### ***Strengthening regional cooperation to exchange and share information on climate-sensitive diseases and health problems***

The proper territory and space for studying the impact of climate change is often inconsistent with the administrative areas of a country, thus regional cooperation and exchange are essential in terms of research, early warning and control of infectious diseases. Regional databases and platforms are also needed to allow sharing and exchange of information. Here regional organizations can play a key role.

## **4. Conclusion**

Mountain regions are in the frontiers of climate change. Although we still lack of sufficient scientific evidence to show the effects of climate change on human health, the vulnerability to climate change exists. Mountain people have more exposure, higher sensitivity and lower adaptive capacity to climate change. While acknowledging the uncertainties of climate change impact on human health and the challenge to isolate the effects of climate change from the effects of other health determinants, public health interventions can still be taken to actively protect people's health from the adverse effects of environmental changes including climate change.

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## Annex 4

# **“Strengthening climate resilience to protect health in island communities”, Dr Alistair Woodward, School of Population Health, University of Auckland, New Zealand**

In this paper we describe the ways in which climate change threatens the health of populations living on small island states and review what is known about factors that promote resilience of island communities. We draw on the experience of a range of island states, but our examples come particularly from two countries, Maldives and Samoa.

### **Effects of climate change on health**

Climate change will affect island states in many ways. In brief, sea-levels will rise as a result of warming of the oceans, possibly exacerbated by the melting of land-based ice sheets such as the Greenland ice shelf, and this will be a particular issue for densely populated low-lying islands. Increased intensity of rainfall will be associated in many places with flash flooding; also projected are longer dry spells in many parts of the world. Average temperatures will rise, but more importantly, there will be a disproportionate increase in the frequency of extremes of heat. There is less certainty about the future pattern of storms – however it is possible that both the frequency and intensity of storms and cyclones will increase. Ocean warming, with increased acidity due to rising levels of CO<sub>2</sub>, will stress coral reefs, and cause re-distribution of fish stocks.

These and other impacts on small island states are described in detail in Chapter 16 of the Report of the Second Working Group of the Fourth IPCC Assessment (<http://www.ipcc.ch/ipccreports/ar4-wg2.htm>). Many island states are at particular risk for physical reasons – small land area, low altitude and location in tropical storm zones are all markers of vulnerability. Economic development is also key, although there is a severe disjunction between responsibility and impact. It is estimated that between 1950 and 2000, the wealthiest 10% of people in the developed world emitted 155 times more CO<sub>2</sub> than the poorest 10% of the world's population<sup>1</sup>. Together, the Pacific island countries are responsible for less than

0.5% of total greenhouse emissions. But it is the poorest countries, and many small island states among them, that will carry the heaviest burden of climate-related damage and disease since they lack the resources to buffer themselves against change.

The research that is summarized in the IPCC reports runs up to about 2005 – more recent work on emissions, climate trends, and emerging impacts indicates that the IPCC projections have been relatively conservative. For example, loss of Arctic sea ice is occurring even more rapidly than the worst case scenarios in the Fourth Assessment Report<sup>2</sup>.

The health impacts that will follow as a result of these changes include direct effects such as the disease and injury associated with flooding and storms, infectious diseases spread by water and food that multiply more quickly in warmer conditions, and heat stress. Other effects that have more indirect links with climate change include nutritional problems resulting from failures of crops and fisheries under climate change, and changing patterns of vector-borne diseases, as mosquitoes and other disease-carrying agents are affected by alterations in temperature and precipitation. (For further information on the links in general between climate change and health, please see (3) and (4) under “references”).

### **Case study 1: Samoa**

Samoa is located in the south-western Pacific, and has a population of about 170 000, most of whom are settled on two major volcanic islands within 50 km of one another. In the last two decades the country has benefited from stable political environment and strong economic growth. Life expectancy has risen from 64 years in 1991 to 72.8 in 2001.

Adult literacy rates for both genders (96%) and gross enrolment rates in primary (94%) and secondary (70%) levels are high by the Pacific developing-country standards. Infant mortality (22 per 1000 births), under-5 mortality (35 per 1000 births), and maternal mortality (4 per 100 000 births) rate among the lowest in the Pacific region. Ninety per cent of the population (90%) have access to potable water.

Samoa was part of the Pacific Islands Climate Change Assistance Programme PICCAP, funded by UNDP and the Global Environmental Facility, from 1997 – 2001. Samoa has since prepared a National Adaptation Plan of Action, based on island-wide consultations, and this was updated in the second National

Communication to the United Nations Framework Convention on Climate Change (UNFCCC) in 2009. The Global Environmental Facility funded in 2009 a substantial project to extend adaptation in Samoa, with a focus on two sectors – agriculture and health.

## **Factors that promote resilience**

This discussion is organized under four generic headings.

### **1. Information**

A fundamental aspect of coping with climate change is being informed about the risks. This includes an awareness of global trends (such as indications that sea-level will rise by considerably more than what the IPCC projected in 2007, perhaps as much as 1 metre by 2100)<sup>5</sup>. Of course, it is necessary for countries to have knowledge also about what global trends mean locally, including flooding risks, drought likelihood, fire risk, water flows, and frequency of heatwaves.

Population change will also be an important contributor to vulnerability, and not just the absolute numbers of people, but also the age structure. In the Pacific, only 8% of the population was aged over 60 years in 2000, so there is a perception that relatively youthful populations in this region will not be as vulnerable as in other parts of the world. But by 2050, the proportion over 60 is projected to rise to 23%. Life expectancy is also expected to rise in this region, so a single age cut-off such as 60 years may overestimate the effects of ageing. Another metric that has been proposed is the proportion with a life expectancy of 15 years or less: in the Pacific it is estimated that this fraction will increase from 6% at the beginning of the century to 14% in 2050<sup>6</sup>. Whichever measure is applied, it is apparent that climate-related issues that are important for older people will become more significant for island states in the Pacific as the century proceeds. In general, it is important that states that are planning to cope with long-term climate changes anticipate, as far as possible, the changing age pattern of their populations.

Where the population is located is also important. Urban drift is common in many countries, including Samoa. In Samoa the density of settlement has increased (8% rise in people per square kilometre in the last 15 years)<sup>7</sup> but the pattern is very uneven. Villages in rural areas have often been depleted by migration, undermining economic activities, in some instances threatening the viability of local services (such as schools) and weakening informal community networks. In Samoa, it is the

urban areas in which the pressure of increasing population is most keenly experienced. Often the new settlers face significant obstacles (such as lack of quality housing at affordable rates, restrictions on land sales, and public services that are not equipped to handle the influx of families).

## **2. *Effective services***

Since climate change acts as a multiplier of disadvantage and risk, adaptation entails strengthening the health sector to cope better with the present demands. However, it is important to do this with a view to the pressures that climate change will cause in the future. Some insights may be obtained from assessment of coping strategies for present day climate-related risks — the limitations here point to what needs to be developed for climate resilience in the future.

In Samoa, for instance, some of the weak points that have been identified in the current services include inaccurate disease surveillance systems with slow response, the lack of monitoring of many community-based interventions, subgroups in the population who are not well-served by the present system, and disease control activities that are dependent on donor aid and therefore of questionable viability in the long term<sup>7</sup>.

A lack of public awareness and understanding of climate change and its effects on health is also reported commonly as an obstacle to adaptation – engaging communities effectively, raising understanding, and presenting adaptation in terms that are meaningful are significant tasks in Samoa, and in most countries.

Problems with service reach typically involve groups that are mobile (including migrants to urban areas), and also those who for a variety of reasons are excluded from traditional support structures. For example, in Samoa those without access to a reticulated water supply are more likely to include people of low status in village life, those who have been ostracized, and those on low incomes. Remote areas and parts of Samoa that are already water-stressed are more likely to have substandard supplies, and therefore are at particular risk in the future as dry spells lengthen.

The new urban settlements are frequently in low-lying areas, at risk of flooding, and the poor quality of the housing presents a number of risks to health. These include climate-sensitive conditions such as foodborne infections, due to the difficulties of maintaining hygiene in cramped and poorly designed spaces, diseases

caused by contaminated water supplies, the physical risks of flooding, and vector-borne diseases.

Flooding is already an issue in the capital of Samoa, Apia, as a result of overloaded drainage systems, uncontrolled land fill, rubbish that obstructs drains, and overflow from septic tanks. The health risks are demonstrated by the recent history of typhoid in Samoa: the first large-scale outbreaks of this disease occurred after the major cyclones of Ofa (1990) and Val (1991).

On the positive side, developments in the urban settlements also point to resilience-building activities that may be applied more broadly. These focus on challenges such as restrictions of leasehold occupation, unemployment, children not going to school, and locally-based interventions that build the capacities, skills and potential of communities. For instance, in Apia the Red Cross has been training peri-urban dwellers in gardening.

As part of service development to increase resilience, special attention should be paid to health problems that are likely to be amplified by climate change, and are not at present well controlled. In Samoa, typhoid has been a persistent problem since it reemerged in the early 1990s. As part of increasing adaptive capacity, it will be important to understand the environmental factors associated with recurring outbreaks of typhoid; and also the difficulties in providing effective clinical services (antibiotic resistance for example is threatening to become a major issue).

## **Case study 2: Maldives**

Written by Mohamed Ali (Environment Research Centre, Ministry of Home Affairs and Environment, Maldives)

Report of a WHO workshop 2003<sup>8</sup>

The most important feature of Maldives' physical environment is the coral reefs that surround the islands. The reefs play a role in the physical preservation of islands and in fisheries, tourism, and local traditions and culture. In 2000, tourism provided 33% of Maldives' gross domestic product (GDP), and the fishing industry provided 6%. The reefs are the main attraction for tourism and provide fish for consumption and export as well as bait for the tuna fishery.

Stress on the reefs originates from dredging, coral and sand mining, harbour construction, reclamation, construction of seawalls and jetties, and island-based

pollution. Global sources of stress include global warming, climate change, El Niño conditions, ozone depletion, and sea-level rise. Stress on the reefs threatens fresh water and other natural resources, and island communities become more vulnerable to natural disasters.

Economic threats include trade blocks, regional associations, phytosanitary restrictions, and ecolabelling requirements that limit commerce in the few products potentially available for export. Like other small-island developing states, Maldives is losing market preferences, export benefits, preferential borrowing rights, and access to special funds. The result is a situation of compounding vulnerabilities, with environmental vulnerability hastening economic vulnerability and both contributing to increased social vulnerability.

### **3. *Economic development***

Low incomes are an important cause of vulnerability to environmental change. Coping strategies that take account of the changes accompanying global warming may include introduction of new forms of tourism and variations in agricultural practices. There may be some benefits, at least in the short term: with warmer temperatures mangoes are now fruiting twice a year in Samoa, for example, and breadfruit is available the year round. In communities in which fishing is an important economic activity, it will be important to build in flexibility, anticipating the movement of critical fish stocks as sea surface temperatures rise.

There may be a conflict between the present modes of economic development and resilience to climate change. Deforestation is a significant issue in many countries, since logging activities provide valuable economic returns, but increase the risks of flooding and polluted water supplies, as well as contributing to rise in greenhouse gases. In Samoa and Maldives, there is extensive sand mining in coastal areas. This provides raw material for construction of infrastructure projects such as schools, roads and churches, and generates considerable income for local landowners. However the removal of sand makes the coast far more vulnerable to erosion, a problem that is already evident, but will become more serious with rising seas and more severe storms. (By 2025, in Samoa, a 1.8 metre storm surge above the mean sea-level is projected to be a one-in-four-year event.)

In general, it is important to ensure that long term infrastructure plans are “climate proofed”. For example, in planning water supplies for Samoa, the government will need to allow for a possible doubling in the maximum duration of the dry period (from three months to six months).

#### 4. Governance

The considerable uncertainties that accompany climate change and its impacts make it difficult for governments to plan for particular risks and outcomes in a particular time period. This makes it important to focus on generic adaptive capacity, which necessarily, has a strong governance component<sup>9</sup>. It also includes support for existing institutions and services, nurturing human resources and developing administrative arrangements that are responsive, flexible, and well-informed.

In Samoa reforms of the health sector in the early 2000s created an agency responsible for clinical services (the National Health Service), separate from the Ministry of Health that undertook regulation, monitoring and administration of the remainder of the health system. If this division leads to increased efficiency of all aspects of the health service, then the country will be better prepared for climate challenges. However with reforms of this kind, there is always the potential for lack of clarity over roles and miscommunications that would have the opposite effect, increasing vulnerability.

Policy responses may be better accepted where they take account of potential “co-benefits”. This means investments that achieve short-term development outcomes as well as climate resilience in the long term. There are many examples in sectors such as transport, energy, food and housing<sup>10-14</sup>. On the other hand, uncoordinated activities may increase vulnerability (eg. *ad hoc* coastal protection that may increase the destructive force of currents and waves and exacerbate the risks of climate change).

The risks of climate change could have positive consequences if they stimulate society to engage with underlying issues such as environmental justice and sustainability. In some respects, mobilization in response to climate change has strengthened NGOs, stimulated sectors to develop new ways of working together, and increased the profile of environmental ethics, and these are all positive outcomes (analogous to some of the more constructive sequelae of the HIV/AIDS epidemic.)

Lastly, it must be noted that climate change is unique among modern environmental problems in that it is essentially global. Pollution arising from human activity has overwhelmed the planetary system – the complex geophysical and biological networks that impinge on the climate. Wherever CO<sub>2</sub> is generated, it acts to increase temperatures at every point on the world’s surface. This means that the response to climate change must be global. Countries can take local actions, to

reduce emissions and to adapt to change. But these will be fruitless unless they are matched by international actions that ensure everyone carries a share of the load.

The Alliance of Small Island States (AOSIS) has been a force in international climate change negotiations. The 37 members of AOSIS have argued effectively for emission reductions, monitoring, consideration of impacts on the most vulnerable populations, and support from high-income countries for adaptation in developing countries. Such activities constitute an important part of building resilience to protect health.

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## **Annex 5**

# **“Climate change effects on urban health”, Ms Sari Kovats, Centre on Global Change and Health, Department of Public Health and Policy, London School of Hygiene and Tropical Medicine**

### **Introduction**

Climate change will affect the health of urban populations. Current attempts to reduce carbon emissions are insufficient to avoid further climate warming, and so the policy and research agendas are moving from mitigation (controlling greenhouse gas emissions) to adaptation (responding to climate change), and from global to local studies of impacts and responses.

Irrespective of global climate change, cities alter their local climate, particularly by reducing rainfall and increasing nighttime temperatures (Oke, 1995; Oke, 1997). The “urban heat island” effect is caused by daytime heat being retained by the fabric of buildings and by a reduction in cooling vegetation. In temperate latitudes, this has the effect of raising night-time temperatures by 1–5°C. In tropical cities, the mean monthly urban heat island intensities can reach 10°C by the end of the night, especially during the dry season. Urban heat islands are measured as the difference in temperature between inside the city and the surrounding areas. The magnitude of the urban heat island is, in general, proportional to the size of the city. Urban areas also cause considerable intensification of rain, hail and thunderstorms. Due to these factors and to their location by rivers or in coastal zones, cities are particularly prone to floods.

This Working Paper will focus on the potential impacts of climate change on the health of urban populations in the SEA Region. Currently, populations in cities are having to deal with a range of environmental hazards (Gupta and Mitra, 2002; Bull-Kamanga et al., 2003) and global climate change is likely to exacerbate many of these problems. We have reviewed the published literature for the health effects of climate and weather (including extreme weather) in urban settlements in South-East Asia. We will discuss these environmental health hazards in the context

of future social and environmental changes, and regional climate changes in particular.

Adapting to climate change in cities in low- and middle-income countries is now an additional concern for local governments (Satterthwaite et al., 2007). The paper will outline some of the key public health interventions that can reduce the current impacts on health of weather and climate. Priority should be given to adaptation measures that provide immediate improvements to the health of urban populations.

## **Climate change and health**

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) was published in 2007. The report confirms that climate change is already taking place (IPCC, 2007) and also assesses future changes in climate at the regional scale. Very few city-level projections are available, as confidence in the output of climate models decreases rapidly as one moves from regional to local scale projections.

With respect to urban populations and human health in South-East Asia, the key results of the IPCC report are:

- regional freshwater resources will be strongly affected by, and vulnerable to, climate change in dryland areas;
- increased rainfall intensity, particularly during the summer monsoon, in temperate and tropical Asia;
- increased risk of weather disasters, particularly flood events; and
- vulnerability of coastal cities due to climate change and sea-level rise.

The greatest concern about the impacts of climate change on human health is regarding changes in freshwater resources, food supplies and increases in extreme weather events such as floods and droughts and heatwaves (Table 1). Climate change is likely to affect many aspects of urban infrastructure, including water supply, water quality, flood control, transportation, energy and public health (Kirshen et al., 2006). Cities in low-and middle- income countries are particularly vulnerable to climate change because of an inadequate infrastructure (McGranahan, 2007). A range of environmental risks to coastal megacities are associated with sea-level rise. Historically, cities in South-East Asia have been most affected by storm surges in terms of numbers of deaths (Nicholls, 2003).

Assessments of vulnerability to climate change have been undertaken in Dhaka, Bangladesh (Alam and Rabbani, 2007) and in Cochin, India (Bindu et al., 2003).

**Table 1:** Summary of known effects of weather and climate on urban health

Health outcome	Known effects of weather
Heat stress.	Deaths in older people and people with chronic disease; increase with high and low temperatures. Heat-related illness and death due to heatwaves.
Air pollution-related mortality and morbidity.	Weather affects air pollutant concentrations. Weather affects distribution, seasonality and production of aeroallergens.
Health impacts of weather disasters.	Floods, landslides and windstorms cause direct effects (deaths and injuries) and indirect effects (infectious disease, loss of food supplies, long-term psychological morbidity).
Mosquito-borne diseases, tick-borne diseases (e.g. malaria, dengue).	Higher temperatures reduce the development time of pathogens in vectors and increase potential transmission to humans. Vector species require specific climatic conditions (temperature, humidity) to be sufficiently abundant to maintain transmission.
Water/food-borne diseases.	Survival of important bacterial pathogens is related to temperature. Extreme rainfall can affect the transport of disease organisms into the water supply. Outbreaks of water-borne disease have been associated with contamination caused by heavy rainfall and flooding, associated with inadequate sanitation. Increases in drought conditions may affect water availability and water quality (chemical and microbiological load) due to extreme low flows.

## Climate, water supplies and sanitation and health

Climate is the key determinant of water availability. Surface water availability depends on the timing and volume of precipitation. The current burden of disease as a result of inadequate access to improved water and sanitation has long been recognized, particularly the very high rates of infant mortality in deprived urban areas (Kosek et al., 2003). There are clear social and economic reasons for the lack

of access to improved water at the household level. However, cities in both high- and low-income countries have experienced failures in supply due to extreme drought events. It is also known that access to water within cities is not equally distributed, and any reductions in supply are likely to have a greater impact on impoverished populations.

Climate change may affect water supplies to populations in cities through a range of mechanisms. Rivers that are sustained by glacier melt in the summer season, for example in the Hindu Kush–Himalaya region, are likely to experience increased river flows in the short term as glaciers melt due to higher temperatures. However, the contribution of glacier melt will gradually decrease over the next few decades. Current trends in glacial melt suggest that the Ganges, Indus, Brahmaputra and other rivers in the northern Indian plains could become seasonal rivers in the near future (Cruz et al., 2007). Thus, cities that rely on glacial melt water will eventually lose this source and will have to seek alternatives, such as reservoirs or deep groundwater wells. Demand for groundwater may increase in other areas where the availability of surface water decreases.

For cities that rely on coastal aquifers, sea-level rise and any decrease in groundwater recharge levels will exacerbate saltwater intrusion. Inland aquifers are also at risk of saltwater intrusion from neighbouring aquifers, as groundwater recharge decreases. Shallow aquifers in dryland regions are at risk of salinization as a result of increased evapo-transpiration.

Climate-impact assessments are often conducted at the river catchment level and converted to water availability per capita or “withdrawal to resource” ratio. Such indicators are useful to some extent, but provide no information on the level of access to water, the quality of water or any differences between rural or urban areas. Climate change is likely to cause a decline in environmental water resource availability in certain cities, where water resource management is poor or non-existent. This will have a negative impact on water availability at the household level, particularly in households of the urban poor.

The impact of climate change on water availability is likely to be one of the most significant for the health of populations (Confalonieri et al., 2007). However, due to the complexity of factors that determine access to clean water (social, political, environmental), the impacts on health are not well addressed in the literature on climate impacts. A substantial amount of endemic diarrhoeal disease is transmitted via the faecal-oral route. Although disease rates can be reduced very cost-effectively by improvements in hygiene behaviour, such improvements require access to sufficient quantities of water. Interventions to improve water quality can

fail to deliver a reduction in diarrhoeal disease in places where water availability is limited (Esrey et al., 1991).

Heavy rainfall and flooding are also important issues for environmental health in urban areas as surface water is quickly contaminated during heavy rainfall events. Most metropolitan cities in Asia have poor urban drainage systems, which are easily blocked even during short spells of rain (Parkinson, 2003).

Urban poor populations often experience increased rates of infectious disease after flood events. Increases in cholera, cryptosporidiosis and typhoid fever have been reported in low- and middle-income countries (Ahern et al., 2005). For example, flood-related increases in diarrhoeal disease have been reported in India (Mondal et al., 2001) and in Dhaka, Bangladesh (Kunii et al., 2002; Schwartz et al., 2006).

There are relatively few studies that have investigated the effects of rainfall on morbidity, particularly diarrhoeal disease. A recent study using hospital visit data in Dhaka, Bangladesh found that rates of disease increased during both high and low rainfall extremes (Hashizume et al., 2007). The number of non-cholera diarrhoeal cases increased by approximately 5 per cent for every 10 millimetres (mm) increase in rainfall above a threshold of 52 mm (averaged over eight weeks). In addition, the number of cases increased by around 4% for every 10 mm below the same threshold. Diarrhoeal disease morbidity was also shown to increase at higher temperatures, particularly in the more deprived populations.

Leptospirosis is also associated with flood events. Outbreaks of leptospirosis were reported in children living in informal settlements after floods in Mumbai (Karande et al., 2002) and the prevalence of leptospirosis increased eight-fold following the major flood event in July 2005 (Maskey et al., 2006). Hospital-based observational studies found that the risk of disease was associated with children either playing in the floodwater or wading through it while going to school and, in some cases, with floodwater inside the house (Karande et al., 2003).

Flooding also may lead to contamination of water with chemicals, heavy metals or other hazardous substances, either from storage or from chemicals already in the environment (for example, pesticides) (Young et al., 2004). However, there is little published evidence demonstrating a causal effect of chemical contamination on the pattern of morbidity and mortality following flooding events because it is difficult to assess individual exposures. Increases in population densities and industrial development in areas subject to natural disasters increase the potential for mass human exposure to hazardous materials released during

disasters. The contamination of floodwaters (and the longer-term contamination of soil) is a particular problem for populations situated near factories and industrial areas.

Inadequate drainage resulting in stagnant water is also a cause of mosquito-borne diseases, such as malaria, in urban areas. The effects of climate on such disease transmission is well understood from laboratory studies – as temperatures increase, the extrinsic incubation period (i.e. the time the parasites need to mature) decreases. However, rainfall effects that drive the abundance of mosquitoes depend on the vector's local ecology. For urban vectors of dengue, the effects of rainfall patterns are more complex, and it is difficult to assess the implications of global climate change on urban arboviruses (Mackenzie et al., 2004).

## **High temperatures and heatwave events**

Heat is an environmental and occupational hazard. The risk of heat-related mortality increases with natural ageing, but persons with particular social and/or physical vulnerability are also at risk (Kovats and Hajat, 2008) . There are important differences in vulnerability between populations, depending on climate, culture, infrastructure (housing) and other factors. Episodes of extreme temperature can have significant impacts on health, and present a challenge for public health and local government services.

Human populations are “acclimatized” to their local climate, in physiological, behavioural and cultural terms, but there are clear limits to the amount of heat exposure an individual can tolerate. The capacity of populations to adapt to varied climates and environments is considerable, but people do not live comfortably in temperatures outside the range of 17–31°C. The tolerance range of an individual is usually much less than this, and will narrow with age or disability.

Global climate change is likely to be accompanied by an increase in the frequency and intensity of heatwaves, and by warmer summers and milder winters. Even small increases in average temperature can result in big shifts in the frequency of extremes. The impact of extreme summer heat on human health may be exacerbated by increases in humidity. There is little published information on the impacts of heatwaves on health in South-East Asia. Information from news reports indicated that daily wage earners such as labourers and rickshaw pullers were at risk, who have no option but to work outdoors under any conditions (Akhtar, 2007). National and state governments issued advice during heatwaves, such as to stay indoors and drink water.

High temperatures are also an important occupational health hazard. In order to cope with heat, an instinctive adaptive action by a worker is to reduce work intensity or increase the frequency of short breaks. Therefore, one direct effect of a higher number of very hot days is likely to be a “slowing down” in work and other daily activities (Mairiaux and Malchaire, 1985). This may result in “self-pacing” and a reduction in productivity, or it will incur risks to the health of workers unless proper occupational health management is implemented (Kjellstrom et al., 2007).

In general, urban populations experience the highest heatload in cities in the dry tropics (Jauregui, 1991; Jauregui, 2005). It is not clear how climate change will interact with local climate modifications due to the built environment, but clearly the two causes of increased temperature will increase the heatload for urban populations and will also increase the risks to health. A central question in estimating future heat-related mortality is the rate at which populations will adapt to a warmer climate. Populations are likely to acclimatize to warmer climates through a range of behavioural, physiological and technological adaptations. The initial physiological acclimatization to hot environments can take place in a few days, but complete acclimatization may take several years. The rate at which changes in infrastructure will take place is likely to be much slower, however, for cities in the tropics.

In tropical regions, very high heat load exposure in urban areas will become more frequent. Persons living in informal structures may be more exposed to high temperatures. In Europe, the prevention of deaths in the community as a result of extreme high temperatures (heatwaves) is now an issue of public health concern. It is likely that methods for addressing heatwave impacts on health will be developed in Asian cities, and some pilot projects are planning to be established in India.

Global climate change may also exacerbate outdoor air pollution in Asian cities. Urban environmental problems such as outdoor air pollution have, in general, been decreasing steadily in developed countries because of active control measures. In low-income countries, increasing traffic and exhaust as well as industrial emissions are raising concentrations of sulphur dioxide (SO<sub>2</sub>), nitrous oxide (NO), ozone (O<sub>3</sub>) and suspended particulate matter, which are known to be damaging to human health. Cities in South-East Asia experience high levels of urban pollution as a result of rapid industrialization and large numbers of small-scale industries in residential areas. Some improvement in air quality has occurred due to specific intervention measures. Trends in urban outdoor air pollution in the next few decades will depend on local government action.

## **Longer-term changes and the future health of populations in cities**

In recent decades, there have been improvements in the health of populations in cities, but these improvements are not equally distributed and high health burdens persist in the urban poor, particularly those living in informal settlements and slums.

The traditional approach to climate risk assessment — the top-down scenario-based approach — is undertaken at regional or national level. Very few city-level climate impact assessments have been undertaken. Larger-scale studies rely on national projections of economic growth and do not address important inequalities within countries (or cities), and so do not focus on the impacts on the most vulnerable populations.

One approach, in the near term, is to assume that current trends in household income and health status will continue. For slum populations, this would mean a decline in health status and an increase in vulnerability to climate change. In the longer term (projections to the 2050s), one might assume some improvements in health and an improved capacity to adapt to climate change. An assessment of future health impacts should be undertaken using both optimistic and pessimistic assumptions about future health status. It is also important to consider that there are likely to be limits to the amount of climate change that can be managed (or adapted to). In particular, limits to water availability as a result of overexploitation and environmental degradation are likely to cause significant negative impacts on health.

## **Responding to climate change: adaptation and health**

Urban populations, particularly poor urban populations, are currently not well adapted to climate and weather events. There is a particularly large burden of disease in urban poor populations due to temperature and rainfall extremes, and reducing this burden should be the priority for city governments. There will always be uncertainties about the magnitude of the adverse impacts of climate change, particularly relating to future changes in rainfall. More assessments of the impacts of climate change on health at the city level are needed in order to inform decision-making (Bigio, 2003).

Climate change represents a range of environmental hazards and will affect populations where the current burden of climate-sensitive disease is high, such as the urban poor in low- and middle-income countries. It is not the rapid development, size and density of cities that are the main determinants of

vulnerability but, rather, the increased populations in flood plains, coastal hazard risk zones, and in dryland areas vulnerable to water scarcity.

Scientific evidence, although limited for low-income populations, indicates that current weather extremes have significant impacts on human health, particularly the impacts of heatwaves, floods and heavy rainfall events. The methods for assessing the risks of climate change are undergoing development and there is a need to shift the focus from global and regional to local studies. Sectoral approaches to climate change impact assessments often ignore the effects on health. There is a need to better describe the risks to health as well as improve the effectiveness of public health interventions. Improving the resilience of cities to climate change also requires improvements in the urban infrastructure, and such improvements may not be achieved quickly enough to avoid an increased burden of disease due to global climate change.

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## Annex 6

# **“Increasing heat stress in occupational health due to climate change: Needs for research and prevention in South-East Asia”, Dr Tord Kjellstrom, National Centre for Epidemiology and Population Health, Australian National University, Canberra, Australia.**

## **Introduction**

Global climate change is very much discussed at this time and it will involve impacts on the planetary environment and many aspects of human life (IPCC, 2007). This includes various aspects of human health, some of which relate to the direct effects of increasing heat exposure on physiological and pathological processes (McMichael et al., 2003; Costello et al. 2009). Human physiology requires that the core body temperature stays close to 37°C while many living and working environments have higher temperatures creating a risk of over-heating of human bodies (Parsons, 2003). Muscle work during physical activity creates significant "waste heat" inside the body and working people are therefore at higher risk than people at rest. Sweating is the major way for the body to eliminate "waste heat", but for people working in a hot environment this may be insufficient as the core body temperature goes up (Bridger, 2003). The heat exposure of the body is not only dependent on air temperature, but also on air humidity, air movements (wind speed), and heat radiation (outdoors, primarily from sunlight).

Many tropical and sub-tropical places, including those in South-East Asia, regularly have high temperatures, high humidity and strong solar heat radiation. During the hottest parts of the day in the hottest months, particularly during heatwaves, the heat exposures will get so high that even people at rest may be seriously affected and even die from the heat. Working people are even more affected due to their internal "waste heat" production. Climate change will increase the length and intensity of heat exposure periods, but occupational health aspects have largely been ignored in the analysis of climate change impacts until now.

This paper provides brief information on this area of climate change and health and gives examples of the likely climate change impacts on heat exposures in the SEA Region, as well as examples of research on heat exposure and effects on working people in the Region. The aim is to assist improved planning for preventive interventions to reduce the occupational health impacts of heat and to encourage more research on climate change and occupational health in the Region. A companion paper with detailed hourly climate data from weather stations in eight capital cities in countries of the SEA Region was prepared at the same time.

## **Ongoing climate change**

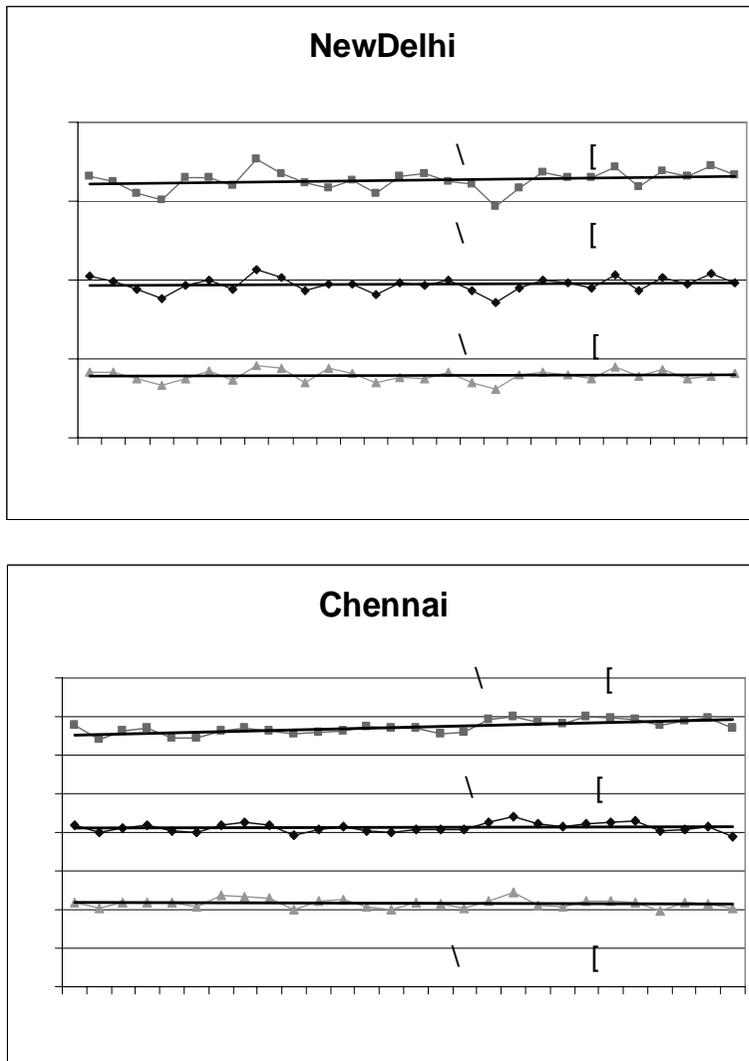
For selected cities within the SEA Region the climate trends are shown in Figure 1. The linear regression lines and equations are included in the figures with “Y” as degrees centigrade (°C) and “X” as the year (actual year minus 1980). A regression coefficient of + 0.0519 (average temperature increase, °C/year, as for Bangkok) is equivalent to a temperature increase of 5.2°C per century (or 0.52°C per decade; the increase is not likely to be linear for a whole century), which is almost three times the global average temperature increase in recent decades, 1.8°C/century (IPCC, 2007), and higher than the expected global average increase during the rest of the 21st century, 3.0°C/century.

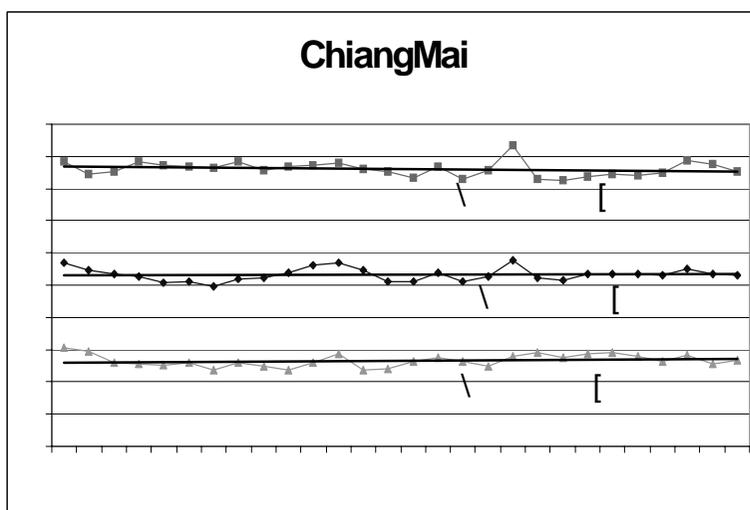
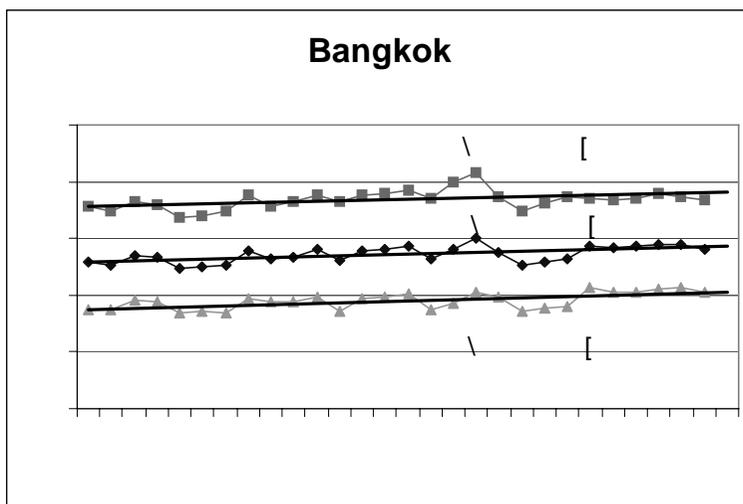
The Population Heat Exposure Profile (PHEP) model (Kjellstrom and Lemke, to be published) can now be used to produce time trends for any of the several thousand weather stations around the world using the daily weather database at the National Oceanic and Atmospheric Administration (US NOAA). It will be a powerful tool in future research to analyse time trends in disease patterns that may be associated with local heat exposure. In the companion paper to this one (Kjellstrom and Lemke, 2009) detailed climate and heat exposure data for the capitals of countries in the SEA Region are included.

Table 1 shows time trends for selected cities in the SEA Region, based on detailed PHEPs. Dew point trends are important as they show the changes of absolute humidity, which is of great importance for occupational heat exposure. Most cities have increasing trends of maximum and average temperatures. The strongest increase occurs in Kathmandu, Nepal (Table 1), but this site had only limited data available. Among the cities with more complete data, Bangkok, Thailand and Jakarta, Indonesia warmed the fastest (Table 1). In the analysis for other cities we found the fastest increase in Shanghai, China, 0.78°C/decade. The trends in four SEA Region cities of the SEA Region (Figure 1) show annual variations

as in the other regions we have analysed, but Chennai, India and Chiang Mai, Thailand display some of the smallest variations.

**Figure 1: Temperature time trends in cities of the SEA Region: Delhi, Chennai, Bangkok and Chiang Mai. (Source: WHO report by Kjellstrom, 2009)**  
 (The top curve is average of the daily maximum, middle curve is average of daily average, and lowest curve is average of daily minimum temperature; the equations relate to the fitted lines with  $x = \text{year}-1980$  and  $y = \text{temperature in } ^\circ\text{C}$ )





**Table 1: Time trend slopes of temperatures (°C/decade) based on linear equations for temperature trends 1980 - 2008 in selected cities of the SEA Region.**

City	Average	Maximum	Minimum	Dew point*
Delhi	0.05	0.20	0.01	0.88**
Kathmandu ^	2.0	2.7	1.3	---
Colombo	- 0.18	- 0.35	0.28	0.04
Male	0.20	0.12	0.34	0.38
Dhaka	- 0.05	0.10	0.44	---
Yangon	0.20	0.20	- 0.50	0.40
Bangkok	0.52	0.45	0.54	---
Jakarta	0.53	0.62	0.08	0.22

\* indicator of absolute humidity

\*\* the combination leads to an indoor wet bulb globe temperature (WBGT) increase of 0.38°C/decade (WBGT is a commonly-used occupational heat exposure indicator)

^ based on incomplete data; uncertainty about such high values

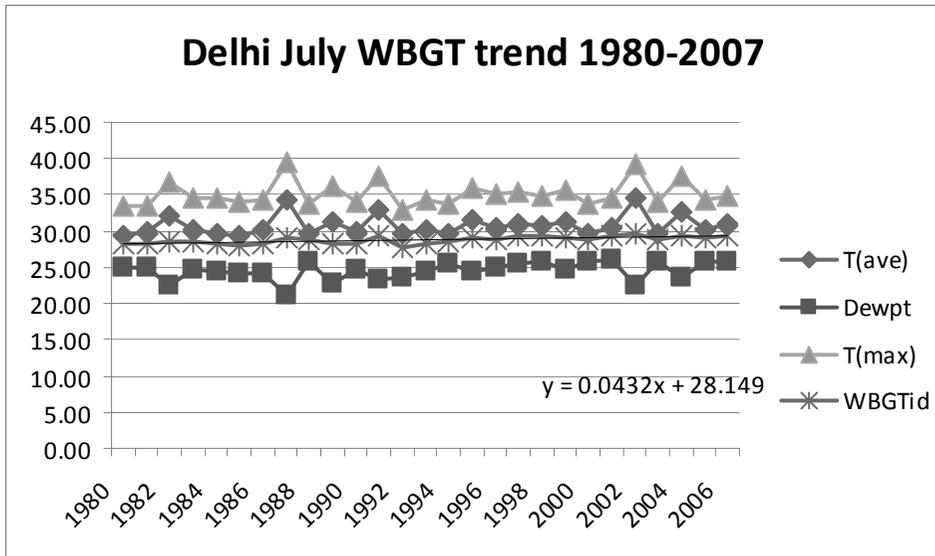
The weather stations in the NOAA database are often located at airports, which in some places were very rural in the past, but have now become surrounded by urban development. Other places have stayed rural and some places have been very urban all the time. It is outside the scope of this report to analyse the urban development at each site in detail. Any increase in temperatures over time may be caused by the "heat island effect" at a weather station rather than by the global atmospheric change. On the other hand, the measured climate variables at ground level are those that the local population is exposed to. For the purposes of human heat exposure assessment, the measured data should give us the best available area-wide estimate.

**Table 2: Monthly time trends ( $^{\circ}\text{C}/\text{decade}$ ) of temperature, dew point (humidity) and WBGT (indoors) in Delhi 1980 - 2008.**

Month	Temp(ave)	DewPoint	Temp(max.)	Temp(min.)	WBGTid
January	-0.35	0.41	-0.2	-0.34	-0.08
February	0.3	1.48	0.51	0.32	0.69
March	0.36	0.82	0.71	0.17	0.54
April	0.38	0.52	0.79	0.11	0.45
May	0.26	1.27	0.42	-0.05	0.62
June	-0.34	1.32	-0.42	-0.36	0.36
July	0.38	0.55	0.38	0.39	0.43
August	0.17	0.38	0.29	0.16	0.29
September	-0.20	0.93	-0.26	-0.02	0.31
October	-0.14	1.40	0.0	0.04	0.49
November	0.04	0.82	0.36	-0.09	0.34
December	-0.20	0.99	0.13	-0.21	0.23
Year	0.05	0.88	0.20	0.01	0.38

Occupational heat stress varies with the season and the analysis of climate change impacts should therefore ideally include estimates for each month of the year. Table 2 shows the time trends for Delhi: 1980 - 2008. The temperature and dew point increases during most months resulted in increasing the calculated WBGTs for all months except the coldest month, January. The WBGT is a well-established occupational heat exposure indicator (Parsons, 2003), which is used in the international and national heat exposure standards (ISO, 1989). The WBGT numbers presented here are based on calculations from climate data using the method of Liljegren et al., (2008). Figure 2 shows the trends for the month with the highest afternoon WBGTs, July. The increasing dew point level contributes to increase in WBGT, but a factor that has not yet been fully taken into account is the possibility of increasing cloudcover as humidity goes up.

Figure 2: **Time trends in Delhi for temperature, dew point and calculated WBGT (based on maximum temperature, which makes it similar to the afternoon heat stress levels)**



### Occupational heat stress in South-East Asia

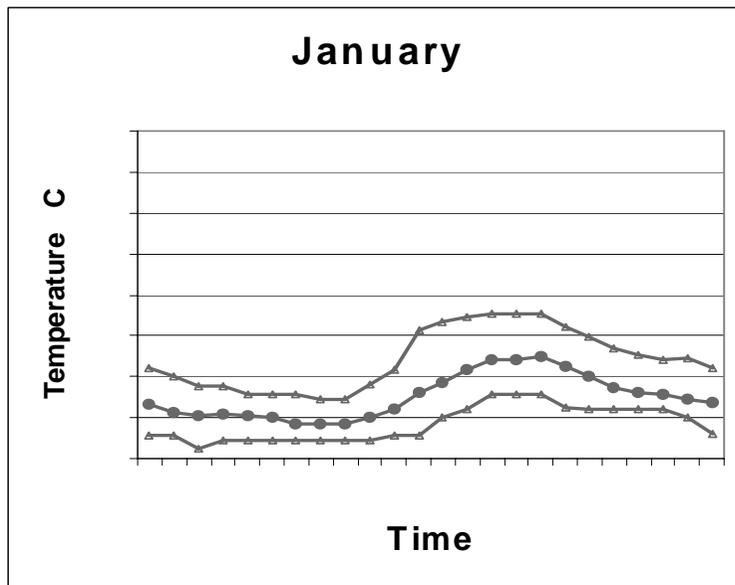
Heat stress is commonly measured with an index such as the WBGT (Parsons, 2003). This index combines measured data that represent air temperature, humidity, wind speed and solar radiation to create a heat stress index. The components are  $T_a$  (standard air temperature),  $T_g$  (globe temperature, measured inside a 150mm diameter black globe, and  $T_{nwb}$  (natural wet bulb temperature, measure by a thermometer inside a sock wetted with water). The WBGT outdoors =  $0.7 \times T_{nwb} + 0.2 \times T_g + 0.1 \times T_a$ . The WBGT indoors =  $0.7 \times T_{nwb} + 0.3 \times T_g$ . This index is commonly used in occupational health and the readings can be interpreted with an international standard (ISO, 1989). The unit for WBGT is °C and the readings are generally somewhat lower than the air temperature.

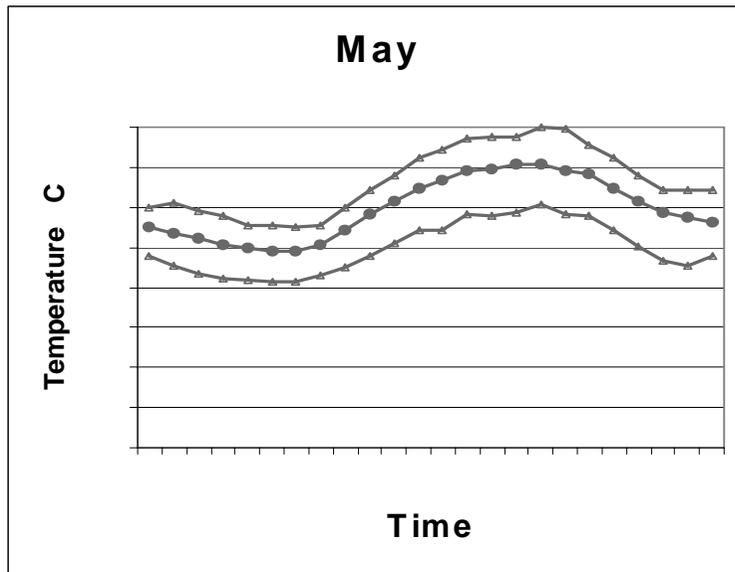
The time trend data in the figures and tables above indicate the levels of heat exposure that are currently occurring in the SEA Region, as well as the situation prevailing in the recent decades. We will discuss the health and productivity interpretation of WBGT values later on, but can indicate here that a level of 26°C is the one where the health effect risks start occurring for sensitive people working in heavy labour situations (500W metabolic rate). The afternoon WBGTs in Delhi exceed this level (Figure 2).

The average hourly temperatures in Delhi in January (the coldest month) do not reach above 17°C or below 10°C. No serious heat exposure can be expected. However, in May (the hottest month) the average temperature at night is higher than 30°C and in the afternoon the average is 40°C with occasional days above 45°C (Figure 3). Extreme heat exposure outdoors is common and heating of the local climate may cause very serious heat exposure and related health and human performance problems for the population.

**Figure 3: Hourly air temperatures, Delhi, for the coldest and hottest months, 1999 (middle curve is the hourly average for the month; also the top and bottom curves display the 95% "tolerance interval" within which lies 95% of observations;**

**Source: WHO report by Kjellstrom, 2009a)**





The dew point is an indicator of absolute humidity of the air. It is the temperature at which a particular air mass would turn into dew or fog due to water vapour in the air reaching the temperature when water condenses into little droplets of liquid in the air. The higher the dew point, the more humid the air is. January has the lowest level and September the highest. The humidity increases in June when the monsoon arrives, but at the same time increased cloudcover causes lower air temperatures than in May. The details of changes of the hourly climate data for Delhi (temperature, dew point, wind speed and solar radiation flux, etc.) are shown in the WHO report by Kjellstrom (2009a). Additional data for Delhi and other cities in the Region are available in the companion paper (Kjellstrom and Lemke, 2009).

June is the windiest month in Delhi and October the calmest. The hourly relative variation of wind speed in June in Delhi is greater than the relative variation of any of the other climate variables. The effect of higher wind-speed is to reduce WBGT and the effect of heat.

Solar radiation (both direct and diffuse) contributes significantly to outdoor heat exposure. While the impact of direct radiation can be minimized with a broad hat, it is more difficult to reduce the impact of diffuse radiation without compromising cooling via sweat evaporation. Solar radiation only contributes when the sun is up (e.g. 6.30 hours to 19.00 hours in August, and 7.30 hours to 18.00

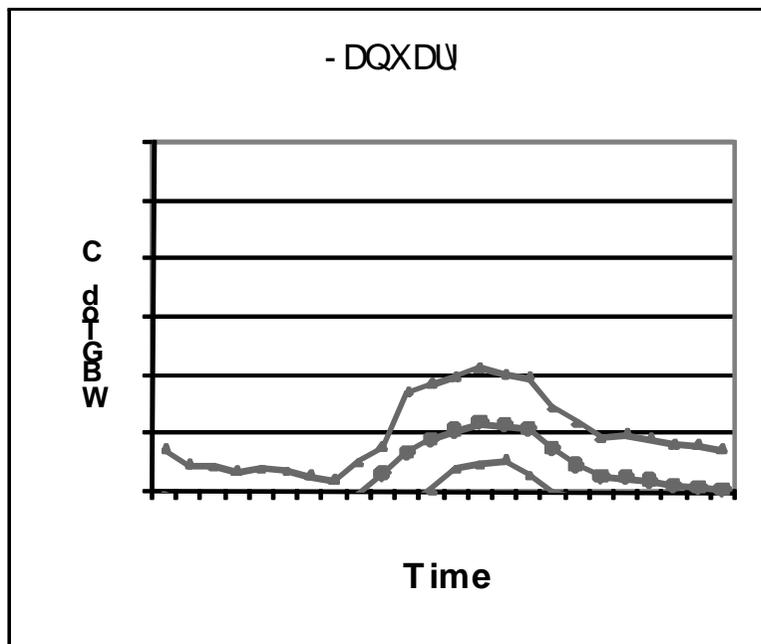
hours in December in Delhi) and is much reduced by cloudcover, so the rainy monsoon month of August has the lowest, while dry December has the highest solar radiation.

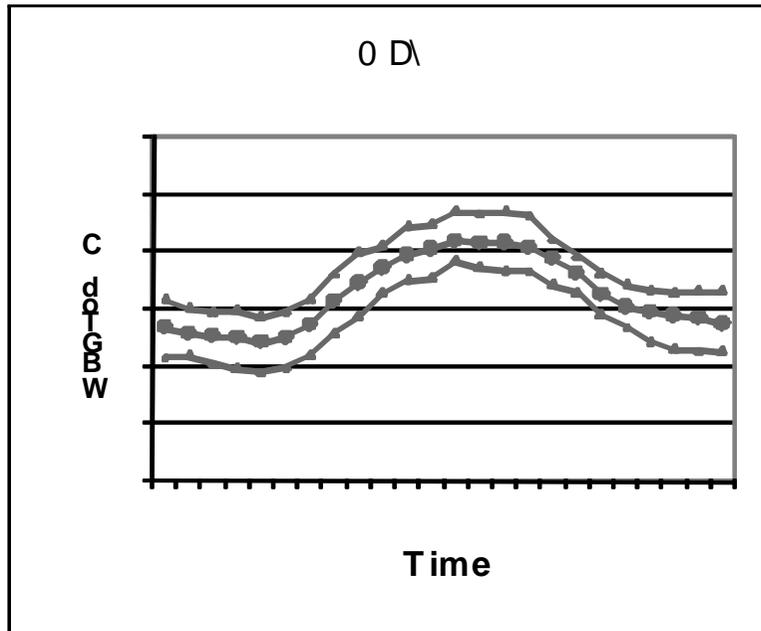
The data above from weather stations and website databases were used to calculate for each hour the WBGT heat stress index level in Delhi (Figure 4). The calculation method was one developed by Lemke and Kjellstrom (to be published), which is based on published formulas for the calculation of the two key components of WBGT, natural wet bulb temperature and black globe temperature (Liljegren et al., 2008). These formulae incorporate air temperature, humidity, wind-speed and solar radiation. The method can estimate both outdoor and indoor levels.

**Figure 4. Calculated hourly WBGT outdoors, in the sun, Delhi, 1999 (calculated with the method by Lemke and Kjellstrom; 10 °C set as a minimum in graph, as such low levels have no implications for heat stress). Middle curve is the hourly average for the month; also the top and bottom curves display the 95% "tolerance interval" within which lies 95% of observations;**

**Source: WHO report by Kjellstrom, 2009a)**

**(Note: WBGT = 26°C is the level where health and performance impacts may start for a person performing in heavy labour)**





The WBGT in Delhi in January does not reach the levels where an impact on work ability and other performance variables should be expected. However, in May most daylight levels on average exceed the WBGT level ( $26^{\circ}\text{C}$ ) where an impact starts occurring for heavy labouring tasks. These brief data on occupational heat stress in Delhi are included as examples of the situation that is likely to occur in much of South-East Asia during the hotter parts of each year. The documented increase of average temperatures since 1980 (Figures 1 and 2) indicates that these high-heat exposure situations are going to get worse in the future.

### Physiology of heat and associated health risks

One important feature of human biology is the maintenance of core body temperature ( $T_{\text{core}}$ ) close to  $37^{\circ}\text{C}$ , the temperature at which different biochemical and physiological systems function at their optimum. Basic metabolism, digestion of food, and muscle work all create “surplus heat”, which needs to be emitted from the body to avoid the  $T_{\text{core}}$  rising in hot environments. (Similarly, the body needs protection from too much cooling in cold environments). It is worth noting that hot-blooded animals have the same need to balance body heat, and studies have shown, for instance, that hot climates reduce milk production in cows and running performance of race horses.

The skin temperature ( $T_{sk}$ ) is normally  $33^{\circ}\text{C}$ . For a person who is naked or wearing very thin clothes, heat will be transferred from the skin to the air if the air temperature ( $T_a$ ) is lower than the  $T_{sk}$ , and from the air to the skin if the  $T_a$  is higher than the  $T_{sk}$ . The wind speed of the air around the skin also influences these heat flows. In addition, evaporation of sweat from the skin is a major cooling mechanism for the body in hot environments, but this mechanism becomes less and less effective as the humidity in the air around the skin increases. People who work in hot environments become acclimatized after approximately a week and can sustain higher heat exposures with less discomfort (Parsons, 2003). The physiological acclimatization is primarily an improvement of sweating efficiency (Parsons, 2003), but it also includes behavioural adaptations to the hot working environment (e.g. taking short rests in the shade, improving the flow of fans, and reducing physical activity by working slower, etc.). The difference in heat-exposure tolerance between an acclimatized and non-acclimatized person in terms of WBGT is approximately  $3^{\circ}\text{C}$  (ISO, 1989).

A working person creates internal body heat that needs to be emitted via the skin. In a hot and humid tropical environment there is a risk that the cooling mechanism of sweating is insufficient so the body temperature of the worker increases. If the core body temperature,  $T_{core}$ , goes beyond  $38^{\circ}\text{C}$ , the risk of heat strain increases, producing symptoms of fatigue and lack of concentration. If  $T_{core}$  goes beyond  $39^{\circ}\text{C}$ , more serious symptoms of organ damage, eventual unconsciousness (heat stroke), and even death can occur (Bridger, 2003), but acclimatized people can sustain such high  $T_{core}$  for some time. In India studies indicate that workers can continue working efficiently up to a  $T_{core}$  of  $39^{\circ}\text{C}$  (Nag et al., 1986). Clearly there are individual variations in the  $T_{core}$  changes in similar heat exposure situations. If  $T_{core}$  is raised on average to  $38^{\circ}\text{C}$ , the standard deviation of individual  $T_{cores}$  in a group of young men could be as high as  $0.7^{\circ}\text{C}$  (Bridger, 2003). Thus, 2.5% of the members of the group would have  $T_{cores}$  above  $39.4^{\circ}\text{C}$ . There is insufficient evidence about these population-based features of heat physiology and how the sensitivity to heat varies between different population groups.

A hard working person may sweat up to 10 litres per work shift, and this water loss has to be replaced in order to avoid dehydration, another serious hazard in hot working environments. If there is a net water loss of more than 2-3 litres during a day there is a risk of damage to the kidneys and other organs (Ramsey and Bernard, 2000). The protection of workers from excessive heat exposure and the provision of sufficient clean water for rehydration during work are essential elements of occupational health and efficient management in tropical countries. A dehydrated worker loses performance ability before the clinical effects are

observed. Thus, there are two mechanisms for performance loss and serious clinical disease due to heat exposure during work: (i) the increase of core body temperature, and (ii) the loss of body water through sweating.

The clinical manifestations of over-heating and dehydration can involve several organs (Ramsey and Bernard, 2000), and pre-existing disease or malnutrition makes the clinical status worse. Poor people in low-income tropical countries are at particular risk because they are living in a hot environment, often have pre-existing diseases (such as low nutrition level, and parasite infections, etc.), have insufficient access to primary health care services, and are required to carry out heavy labour jobs without proper occupational health protection.

Table 3 summarizes the various effects of excessive heat exposure on people. In high- income countries in temperate parts of the world the focus has been on clinical health effects and other effects during heatwaves, as it is assumed that most of the year the temperatures are not hot enough to cause heat-related effects. However, in tropical countries heat stress is occurring during very large parts of each year, and cultural practices (e.g. siesta, reduced work intensity, large hats) have provided effective ways to adapt to the hot environment. Acclimatization improves the ability to reduce body heat by sweating, but it has its limits and the increasing heat exposures due to climate change will create a need for further behavioural changes to reduce intra-body heat production and avoid the effects listed in Table 3.

**Table 3:** Health effects and related negative impacts of excessive heat exposure at work

Effect	Evidence; where described.	References (examples)
Death in heat stroke	South African mine workers; USA agricultural workers; etc.	Wyndham, 1965
Specific heat stroke symptoms	Many hot workplaces around the world .	Parsons, 2003
Clinical damage of organs	Heart overload and kidney damage; US military, El Salvador sugar workers.	Schrier et al., 1967
Injuries due to accidents	Increased accidents in heat; Europe.	Ramsey et al., 1983

<b>Effect</b>	<b>Evidence; where described.</b>	<b>References (examples)</b>
Mood/behaviour/mental health	Heat exhaustion; Australia.	Kjellstrom, 2009a
Physiological function	Specific changes; global.	Parsons, 2003
Work capacity	Low capacity; global.	Bridger, 2003
Economic loss	Impact of lowered productivity; low- and middle-income countries.	Kjellstrom et al., 2009

Dehydration is likely to be a particular issue for the elderly and infants, but may also occur among workers doing hard physical work in hot environments without sufficient water access (Schrier et al., 1967). Studies of military troops deployed in hot, arid climates have demonstrated an increase in the occurrence of kidney stones in relation to exposure to higher mean temperatures (Cramer and Forrest, 2006). A recent report on the incidence of kidney stones in hot parts of the USA (Brikowski et al., 2008) indicates what might be the ultimate effect on public health from heat exposure and associated dehydration. Differences in mean annual temperatures are estimated to account for 70% geographical variation in the distribution of kidney stone diseases in the USA. Dehydration increases the concentration of calcium and other compounds in the urine, which facilitates the formation of kidney stones. A hotter climate across the USA is predicted to create an additional 1.6-2.3 million new cases by 2050 (Brikowski et al., 2008).

During the severe heatwave in Chicago, USA in 1995, there was a significant increase of hospital admissions for acute renal failure and co-morbidity of renal disease (Semenza et al., 1997). Another study of hospital admissions during heatwaves in Adelaide, Australia, showed an incidence rate ratio of 1.10 for renal diseases and 1.26 for acute renal failure compared with non-heatwave days (Hansen et al., 2008). Interestingly, the highest incidence ratios occurred among men in the age group 15-64 years, raising the question about the role of physical activity during work as a cause of dehydration and renal problems. The heatwave health effect study in California (Knowlton et al., 2008) reported significant increases of emergency visits for diabetes (3% increase), cardiovascular diseases (2% increase), acute renal failure (15% increase), electrolyte imbalance (16% increase), and nephritis and nephrotic syndrome (6% increase).

Another group with renal disease problems potentially influenced by heat exposure is coastland male farmers in hot Central American countries. Chronic renal failure in El Salvador (Gracia-Trabanino et al., 2005) is surprisingly common (prevalence = 12.7% among adult farmers). The usual risk factors (e.g. diabetes and hypertension) were only present among a third of the patients and exposures to pesticides and alcohol did not appear to be important risk factors. One could hypothesize that repeated daily dehydration caused by heavy labouring work undertaken in very hot temperatures could be an important risk factor for renal disease in this population, as workers do not always have sufficient water to drink during work.

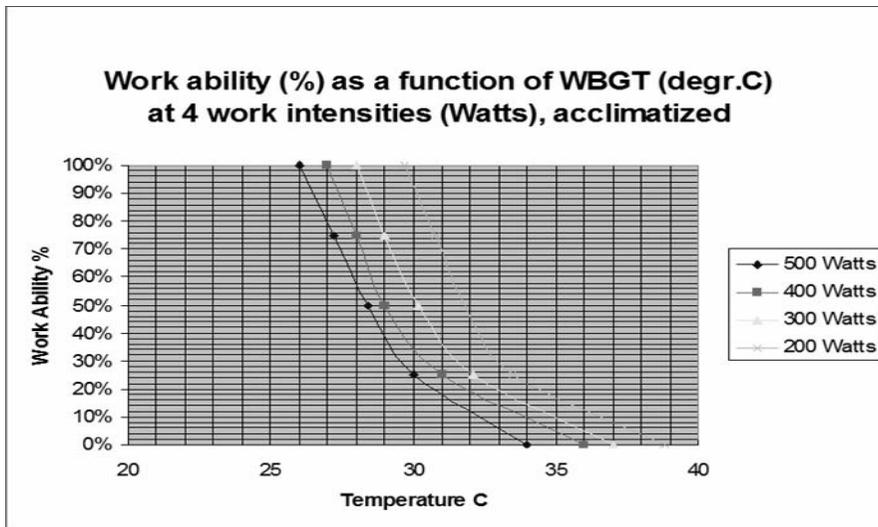
## **Suppression of productivity due to heat exposure**

Heat exposure and heat stress have a major effect on a persons' ability to carry out physical activity (Parsons, 2003), whether it is a part of the general daily activities (such as carrying things to and from the household or working in the family vegetable garden) or part of daily work. Heavy labour is most affected as it generates heat in the body. Work intensity is measured as "metabolic rate" in Watts (W). Light work in factories or vegetable gardens can be at 200W, while very heavy labour in agriculture (e.g. hand-cutting of sugar cane) or in construction (e.g. digging in heavy soil or carrying heavy building materials up ladders) can be at 500W. The difference in heat stress (as assessed by WBGT) between working at 200W and 500W is approximately 4°C (see Figure 5).

If the body cannot be cooled down sufficiently by sweating or other cooling mechanisms, the only way to avoid heat exhaustion or heat stroke is to work more slowly and reduce the work output (Pilcher et al., 2002). This has been pointed out in relation to workers in Sweden by Axelson (1974) and more recently by Staal Westerlund (1998). This heat-stress effect will have an impact on worker productivity or "work ability" (or "work capacity"; different authors use different terms): the "Hothaps" effect (High Occupational Temperature Health and Productivity Suppression) (Kjellstrom, 2000, 2009b). Using the common heat stress index WBGT (Wet Bulb Globe Temperature), the reduction of physical "work ability" due to increasing heat exposure based on international guidelines (ISO, 1989) can be seen in Figure 5. The physiological effects also reduce psychological performance with a risk of increased mistakes in daily activities and increased accidental injuries (Ramsey et al., 1983; Ramsey, 1995). They also affect sports performance (Corris et al., 2004).

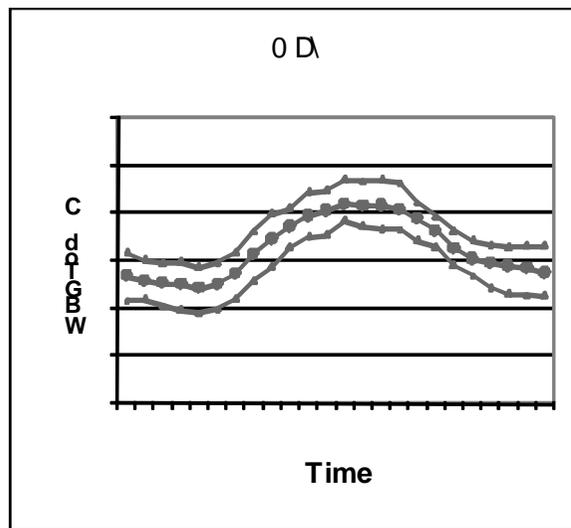
These relationships are based on the general physiological need to reduce core body heat in situations where internal heat production from work or other physical activity and external exposure to heat create a risk of increased core body temperature. The ISO (1989) standard aims to limit the core body temperature to 38°C for a typical average person and states that the "reference values are those at which almost all individuals can be ordinarily exposed without any harmful effect". The standard recommends increasing rest periods each working hour when the heat exposure is increased. The recommended percentage of rest per hour was used to quantify the impact of heat on work capacity at different work intensities as shown in Figure 5. The limit of 38°C is for the average T<sub>core</sub> in a working population, so, as mentioned earlier a proportion of workers would reach T<sub>cores</sub> much higher than that, and the ISO standard is aimed at protecting "almost all individuals". National standards are often based on the ISO standards, but in the USA, for instance, the permissible exposures are somewhat more stringent (OSHA, 1999: available at [http://www.osha.gov/dts/osta/otm/otm\\_iii/otm\\_iii\\_4.html](http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_4.html) ).

**Figure 5: The reducing work capacity (ability) due to heat exposure at different work intensities (200 W = office work, to 500W = very heavy labouring) (Kjellstrom, 2000)**

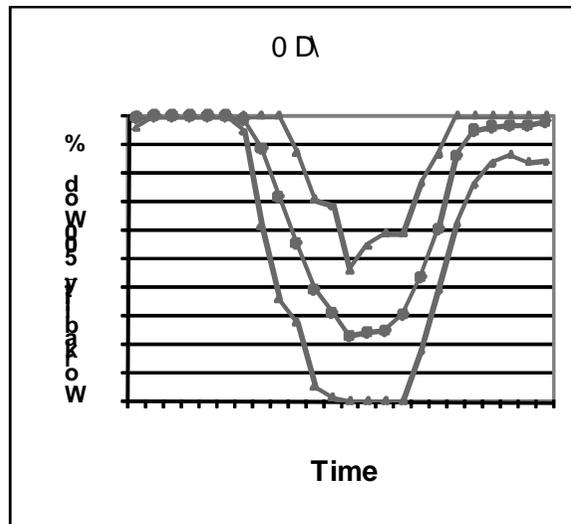


**Figure 6: Calculated hourly WBGT outdoors, in the sun and resulting hourly "work capacity" for workers in heavy labour jobs (500W), Delhi, 1999 (Kjellstrom, 2009a) (middle curve is the hourly average for the month; also the top and bottom curves display the 95% "tolerance interval" within which lies 95% of observations;  
Source: WHO report by Kjellstrom, 2009a)**

WBGT outdoors



Work capacity (%) when working at 500W intensity



Using the hourly data from weather stations and the "Population Heat Exposure Profile" (Kjellstrom and Lemke, to be published) it was shown that in places like Delhi during the hottest month (May), the WBGT is extremely high and the resulting work ability for heavy labour outdoors is very low (Figure 6). Using calculated WBGT values for each hour (Figure 6) and the corresponding "work capacity" values in Figure 5, one can calculate the resulting work ability for each hour. As Figure 6 shows, there is limited work ability left between the 10.00 hours and 16.00 hours during typical May days. This fits with the work practices observed by the author in India, where, for instance, outdoor construction workers take a five-hour "lunch-break" each day in order to cope during the hottest season. These extreme heat exposures are primarily a problem in tropical countries and are not likely to occur in Sweden, but in southern Europe some days may reach similar conditions as Delhi. Climate change will, of course, make the situation worse.

One feature of high direct heat exposure that has not been analysed in relation to climate change is the impact of reducing daily or weekly physical activity for exercise purposes (and the potential increase in obesity). This is not a concern for people with heavy labour type jobs in the SEA Region, but the increasing number of people working in sedentary jobs in air conditioned spaces need to get their daily exercise somehow. Hot external environments can certainly discourage daily exercise, which is very important for obesity prevention and general health promotion. A recent review (Brotherhood, 2008) highlights that for sports people the thermal environment guidelines used for workplace exposures (WBGT) may not be the most appropriate. Further research on this issue is needed. Another impact of heat exposure that is not well quantified is the more severe clinical status that many people with pre-existing diseases, chronic or acute, are likely to experience.

In order to consider the health impacts in a comprehensive manner, it is important to include these physiological and clinical effects, particularly because they will be repeated every day during the hot season when the threshold for these effects has been reached (Hales and Richards, 1987). A series of papers on this issue, including a paper from India, will be published in the web-journal *Global Health Action* in November 2009 (Kjellstrom, 2009b).

## **India – substantial evidence available on local heat and work issues**

Substantial research has been carried out at the National Institute of Occupational Health in Ahmedabad. One of the earliest papers on the topic of occupational health in hot working environments (WBGT up to 31°C) analyzed the workload (using oxygen uptake rate) among agricultural workers in that part of India and

found that approximately 20% of the body heatload was related to external heat exposure, while 80% was due to the metabolic heat due to high workload (Nag et al., 1980a). It was concluded that the best way to reduce the risk of heatstroke among workers would be to reduce the workload or have more breaks (which also reduces the average workload). In another paper from the same year (Nag et al., 1980b) it was shown that for heatloads at different levels of workload the required sweat evaporation to maintain core body temperature exceeded the maximum sweat rate 3-7 times. This finding also supported the need to limit workloads in hot working environments.

Core body temperature ( $T_{core}$ ) is the key indicator of excessive heat strain and one study of 13 young healthy male farmers exposed in an experimental chamber (Nag and Pradhan, 1985) showed that the  $T_{core}$  increased by 0.02 - 0.09°C/min depending on the heat exposure. Due to heat impact the exposure was only for 25 minutes, but this short period could increase the  $T_{core}$  by as much as 2°C. Another experiment on four men measured skin temperature ( $T_{sk}$ ) as well as  $T_{core}$  (Nag et al., 1986) and found that as heat exposure increased the difference between skin and core body temperature decreased. This reduces the ability of the body to release heat by sweating, and at the time when this temperature difference is only 1°C it was decided that the "point of tolerance" had been reached. This point is also defined by a maximum  $T_{core}$  of 39°C and it was later used as a limit where experiments are discontinued and it is also an indicator of the degree of heat sensitivity of individual workers.

In one study of six women the impact of heat exposure on work output was measured (Nag and Nag, 1992). The women were tobacco workers (whose normal work was rolling *beedis* by hand) and they carried out their usual work inside the heat-exposure chamber at a self-controlled and "comfortable" speed. Instead of WBGT, the indicator Effective Temperature (ET) was used, but this is very similar to WBGT (approximately 5% lower). The time series of ET, heart rates, sweat loss,  $T_{core}$  and thermal comfort experience of the women showed, as expected, an increasing sweat rate and heart rate over time. After two hours of work in the hot environment (ET = 26 - 36°C),  $T_{core}$  reaches 38°C and then it starts to go up faster. At this point, thermal comfort complaints also increase and between ET 32°C and 36°C the hourly *beedi* production goes down from 85 to 55, a 35% loss, or 9% loss per degree of ET increase (Nag and Nag, 1992). This is useful field evidence of the loss of productivity from increasing heat exposure.

The issue of the "point of tolerance" or "tolerance level" was further studied with detailed physiological analysis in the experimental chamber (Nag et al., 1997). A study on 11 healthy males (motivated volunteers) created ET exposures in the

range 32 - 40°C. The workload was up to 60% of maximum and the "tolerance level" of work exposure time was the time when T<sub>core</sub> had reached 39°C or the worker was at "incipient collapse". Thus, the tolerance level is not a level of heat and work exposure that can be used as a limit for an average population of workers, which contains many people more sensitive to heat than those 11 volunteers, and requires a margin of safety before the individuals reach "incipient collapse". In an industrial, construction or agricultural work situation a "collapse" can also lead to very serious injuries or even death from machinery, animals and chemicals, etc. in the workplace. In any case, the time limit for reaching the "tolerance level" at ET = 36.5°C was 40-45 minutes when T<sub>core</sub> had reached 39°C (Nag et al., 1997).

In two studies (Nag and Patel, 1998; Nag and Nag, 2001) the issue of heat impacts on accident and injury rates in industry was studied. Statistics of injuries in textile industries was reviewed and it was shown that the hottest part of the year (May-September) had the greatest number of accidents per employee (Nag and Patel, 1998). However, the hottest hours of the day did not have the highest accident rates (per employee) and this inconsistency may be related to the hourly distribution of work and workload: workers may take "siesta" during the hottest hours (the accident risk should ideally be calculated in relation to the actual work hours carried out). The other study (Nag and Nag, 2001) showed that the highest accident risks occurred at the end of shifts when workers were exhausted. It also showed that permanent nightshift workers had lower "tolerance levels" for heat exposure than those who worked in day shifts, possibly due to acclimatization. However, the differences were not large.

Finally, a very detailed study of 26 young, healthy, male farmers in an exposure chamber showed in more detail how "tolerance level" was influenced by WBGT (Nag et al., 2007). The volunteers were exposed to different workloads and heat exposure levels for up to three hours on six different days. The workload mimicked farm work at moderate and heavy work levels, and heat exposure was at WBGT in the range 34 - 42°C. At the end of the exposure period (less than three hours; exposure was stopped at tolerance limit; T<sub>core</sub> = 39°C, narrowing of T<sub>core</sub> and T<sub>sk</sub> gap – or "incipient collapse") a number of measurements showed the physiological impacts. The heart rate goes up 1-1.5 heart beat per minute for every additional degree of WBGT, but the heavy workload had a higher impact (added 20 beats per minute compared with moderate workload). Sweat loss went up in a similar manner for moderate and heavy work: from 15 g/min at WBGT = 34°C, to 20 g/min at WBGT = 42°C. The core body temperature (T<sub>core</sub>) went up 0.06°C/min at WBGT = 34°C and 0.12°C/min at WBGT = 42°C. As a result, the "tolerance time" until T<sub>core</sub> reaches 39°C is reduced with increasing WBGT. For

moderate work, the tolerance time was 80 minutes at WBGT = 34°C and for heavy work it was 50 minutes. At WBGT = 42°C the tolerance time was reduced to 25 minutes for either workload (Nag et al., 2007). Thus, in moderate work the tolerance time reduced from 80 to 25 minutes or 70% in an 8 degree WBGT-range (9% loss of tolerance time per degree WBGT) and in heavy work the reduction was 50% (6%/ °C WBGT). One can assume that these losses of tolerance time would be similar to losses of productivity due to heat exposure.

These detailed data from India are of great importance for the development of assessments of the occupational health impact of climate change in the SEA Region. The data can be used to quantify the impacts on health and productivity as well as to develop prevention programmes for the Region, but further research that links the risks to climate change is needed.

## **Thailand – a case study of occupational health exposure and effects**

In Thailand some research has also been carried out, but not to the same extent as in India. The rise in global temperature causes Thailand to experience a similar trend. Observing the changes in temperature of the two hottest months in Bangkok over time shows a steady increase of temperature (Figure 1).

Research has shown that the rise in temperature is a major feature of climate change that has become a major concern among the international community. Thailand recognizes the adverse impact of climate change and has joined many countries in placing this important issue on the national agenda. Among many measures, Thailand actively participates in the WWF Greater Mekong Programme (WWF-GMP) that involves the investigation of the social, economic and environmental impact of climate change in countries in the Greater Mekong region (Thai Government, 2003; 2006). Moreover, the Bangkok Metropolitan Administration (BMA, 2009) recently released its assessment on the climate change's impact on the city of Bangkok.

In the academic arena, only a small number of studies have been done on the effects of climate change; most have dealt with the environmental impact with some focusing on the subsequent effects on health of the population at large. Studies on the impact on occupational health have been sparse with indirect reference to the effects of climate change. Searching through the database for research that may have some reference to the effects of climate change on occupational health, one found only three studies that investigated the effects of heat in an occupational setting. Two studies (Yoopat et al., 1998 and Yoopat, 2002)

compared the physiological reactions to heat and cardiovascular loading during work between Thai workers and their western counterparts.

The heart rate of Thai workers could be 25% to 30% higher than that of the Europeans at equal levels of oxygen consumption (Yoopat, 2002). Another study (Makkonggaew, 2002) showed that the incremental heart rates in the subjects while performing heavy, moderate and light work were related to the WBGT heat index. The apparent physiological differences between Thai and Western worker indicate the potential need for a review of the Thailand heat exposure standards, which currently are similar to the American Conference of Governmental Industrial Hygienists (US ACGIH) recommendations for WBGT (The Secretariat of the Cabinet, 2003 and 2006). Results of these few studies highlight the need for further study.

## **Increasing occupational health challenges due to climate change**

The climate has been getting hotter during recent decades

The recent report of the Intergovernmental Panel on Climate Change (IPCC, 2007) concludes that the global average temperature is already going up, which is supported by our data in Figure 1 and Table 1. The rainfall distribution is changing with some places getting drier and some getting wetter. The increasing dew point levels in cities of the Region (Table 2) indicate that the absolute humidity is going up.

A range of health effects from the changing climate until the year 2000 have already been recorded (McMichael et al., 2004): for instance, heat stroke including mortality during heatwaves; malaria spreading to new places; malnutrition because of negative impacts on local food production; diarrhoeal disease due to lack of water; injuries due to storms and floods; and effects of increased ozone in urban air pollution.

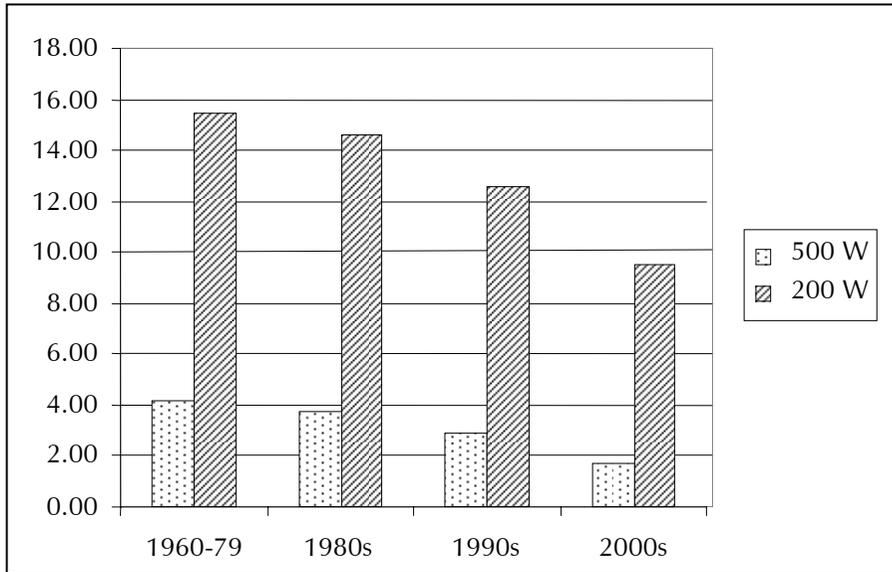
Daily weather data can be downloaded for free from a NOAA website and a recently developed "Population Heat Exposure Profile" calculation procedure (Kjellstrom and Lemke, to be published) is used to convert weather station data to indicators of heat exposure and effects on work ability. Figure 2 and Table 2 showed how the climate variables have been changing since 1960 in Delhi, India, and other cities in the SEA Region. Increasing heat exposure has an impact on average work capacity for people working in jobs that cannot be air conditioned or cooled in other ways.

The impact in Delhi over the last four decades is displayed in Figure 7. The maximum temperature and humidity are increasing over time (Figure 2) leading to an increase in daytime WBGT: outdoor in moderate sunlight and light wind conditions, while the average temperature has not changed and windspeed has decreased. The changes look small, but even the limited shift in WBGT average has great implications.

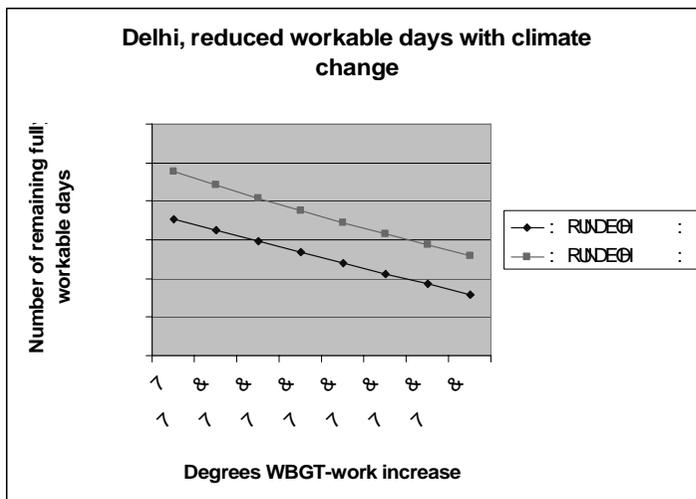
The number of "fully workable" days in outdoor work during the hottest month in Delhi (June) is decreasing (Figure 7). These numbers were calculated from the relationships described earlier, and the effect is much greater for heavy labouring work (500 W) than for light work (200 W). During the cooler months in Delhi, heat exposure is not a problem, but the impact on productivity during hotter months would be considerable.

The calculations in Figure 7 are tentative and need further refinement before they can be interpreted in a really quantitative manner, but they indicate the work capacity losses that may already be occurring in hot places and how these are getting worse during the ongoing heating of the climate in the SEA Region. This figure shows the results just for one month, and the accumulated effect over a year needs to be calculated, based on the detailed monthly and hourly data.

**Figure 7: Equivalent number of workable days in June by decade, Delhi, based on ISO-standard for work-rest distribution at different temperatures and changing daytime WBGT (assumptions: outdoor work in moderate sun and light wind). Two work intensities, metabolic rate 500 W and 200 W. (Source: Kjellstrom and Lemke, unpublished)**



**Figure 8: Impact of climate change on the annual number of "fully workable days" (out of 365 days) in Delhi. (source: Kjellstrom and Lemke, unpublished)**



## Global climate change means worse is to come

The IPCC (2007) report states that the global climate is likely to get warmer. The estimated average temperature increase in different places varies, and the greatest increases are expected to happen at the poles. In many tropical areas the temperature increase may be in the range of 1-2°C by 2050 and 2-4°C by 2090. However, it should be noted that the "heat island effect" may add several degrees to these increased temperatures in urban areas. At the same level of absolute humidity, these increases of air temperature will create similar increases of WBGT. Climate change will increase this occupational hazard that reduces performance and threatens health in tropical countries, unless all workers are provided with airconditioned or otherwise cooled workplaces, which is not very likely, particularly for outdoor workers. The outcome in terms of "fully workable days" during a year in Delhi is shown in Figure 8.

These effects have been discussed very briefly in the IPCC (2007) report. However, the lack of quantitative empirical evidence of the productivity effect is an impediment to estimates of the economic costs of climate change in different settings. The IPCC calls for further research in this area. The impacts of gender distribution of workload and social equity issues are other concerns that have not been sufficiently investigated. Household tasks, such as firewood and water collection may also take longer time during heat stress, reducing the time available for other subsistence tasks.

**Table 4:** Sensitivity of results to assumed labour trends and projected climate change, as the incremental per cent changes in days compared to baseline, for A2 climate change model in 2050s. Negative numbers indicate days lost and positive numbers indicate days gained. (Kjellstrom et al, 2009)

Change in available workdays compared to baseline for A2 in 2050s			
Region <sup>1</sup>	Constant labour, changing climate	Changing labour, constant climate	Changing labour and climate <sup>2</sup>
AP_HI	-0.8%	+0.2%	-0.2%
As_C	-0.7%	+0.1%	-0.4%
As_E	-7.0%	+5.1%	-0.4%
As_S	-11.5%	+6.7%	-4.4%
As_SE	-18.2%	+21.6%	-2.0%

<b>Change in available workdays compared to baseline for A2 in 2050s</b>			
<b>Region<sup>1</sup></b>	<b>Constant labour, changing climate</b>	<b>Changing labour, constant climate</b>	<b>Changing labour and climate<sup>2</sup></b>
Au	-0.2%	0.0%	-0.2%
Ca	-11.7%	+4.0%	-7.7%
Eu_C	-0.6%	+0.1%	0.0%
Eu_E	-0.3%	0.0%	-0.4%
Eu_W	-0.1%	0.0%	0.0%
LA_A	-4.1%	+0.6%	-3.2%
LA_C	-18.6%	0.0%	-18.6%
LA_S	-0.3%	+0.1%	-0.1%
LA_T	-3.6%	+8.3%	+6.0%
NA_HI	-3.4%	0.0%	-3.4%
NA_ME	-0.6%	0.0%	-0.6%
Oc	-15.2%	+15.1%	-3.1%
SSA_C	-15.4%	+11.5%	-0.8%
SSA_E	-8.1%	+2.1%	-4.0%
SSA_S	-2.8%	+1.6%	+0.4%
SSA_W	-15.8%	+13.0%	-3.4%

<sup>1</sup> Abbreviations of different regions will be added in final draft of this paper. As\_SE = South-East Asia Region

<sup>2</sup> This equals the bottom line of the 6<sup>th</sup> column in Table 2.

Data from a recent analysis by Kjellstrom et al, (2009) may also be used to assess global impacts. Table 4 shows the change in full working days lost until 2050 in different regions of the world due to climate change and due to expected labour force distribution changes (less people in agriculture and manual jobs, more people in service and white-collar jobs). South Asia (As\_S) and South-East Asia (As\_SE) stand to experience huge losses due to climate change, while labour force changes

would go in the opposite direction as heat-related suppression of productivity is lessened. The combined effect would still be negative (Table 4).

## **Planning for adaptation can prevent impacts on health and wealth**

Excessive heat exposure is already a reality for millions of workers in the tropics, so preventive measures are an immediate priority. This involves the analysis of each work situation for heat stress, the provision of cooling methods and rest periods, and most importantly, the provision of sufficient potable water during the whole workday to avoid dehydration.

For investment banks and economic planning agencies there is a need to incorporate consideration of the “Hothaps” effect into planning for future investments in agriculture, industry or urban development, in order to seek ways to design workplaces and living places that can avoid excessive heat exposure. The list below indicates preventive actions that need to be considered, but further research to develop and assess different actions is needed. A review of what is currently used in countries of the SEA Region would also be helpful.

Preventive policies and actions that may provide efficient protection against occupational heat-stress effects:

- Raising the awareness about this occupational health hazard among employers, workers and communities.
- Developing national heat-prevention plans for current exposures and for climate change impacts.
- Setting national standards for maximum heat exposures and rest-period requirements in jobs at different work-intensity levels.
- Developing and applying occupational health management procedures for preventing dehydration and other heat effects in workers.
- Designing workplace buildings and their surroundings to reduce heat exposure and limit the need for air conditioning.
- Supporting interdisciplinary research to quantify the local problems in each country and to develop and test preventive interventions.
- Incorporating teaching of heat physiology, ergonomics, and preventive methods into training programmes for health service professionals, industry leaders, architects, town planners and others.

## **Proposed research agenda to meet the challenges of climate change and occupational health**

There is an urgent need for research to establish: how common is heat exposure in workplaces in developing countries, which prevention methods are already applied, the effectiveness of these prevention methods, and the effects of heat on productivity and worker health. The research agenda could include:

- (a) Empirical validation of the Hothaps effects in urban industrial and rural agricultural settings in different regions of the world; analyse both the performance effects and clinical health effects, and the local awareness of these effects.
- (b) Estimation of economic and social costs of the Hothaps effects and their importance in relation to other climate-change impacts in different regions.
- (c) Review of existing adaptation measures and their effectiveness in reducing climate impacts; what can we learn for climate-change adaptation.
- (d) Undertake pilot studies for integration of adaptation to climate change induced heat stress into economic development projects and planning.
- (e) Develop projections of the impacts of these heat stress effects on social institutions and development; analyse gender and equity aspects of the effects.
- (f) Develop and test methods for monitoring if preventive adaptation measures are successful.

## **Conclusions and recommendations**

- (1) Occupational heat stress is a definite health risk; it affects millions of workers, often unreported or underreported.
- (2) Research on heat stress has made it possible to develop heat-stress indices for maximum exposures to heat in workplaces. Preventive methods are also available, but developing and testing of new approaches would be very useful.

- (3) Tentative estimates of the burden for some places in the SEA Region indicate that this occupational hazard may be already a major problem and there is a need for urgent action to protect worker's health.
- (4) Climate change will make the situation worse for people who are in jobs where air conditioning or other effective cooling methods cannot be applied.
- (5) In view of the IPCC-predicted changes, much more needs to be done with regard to more prolonged and more intense heatwaves, though daily heat exposures at "normal" levels also create health and productivity risks.
- (6) A regional research agenda needs to be developed and implemented. Examples of possible topics for research have been mentioned in this report.

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## **Annex 7**

### **“Progress report on the status of implementation of the New Delhi Declaration 2008”, Alexander von Hildebrand, Regional Adviser, Environmental Health and Climate Change, World Health Organization, Regional Office for South-East Asia**

The consequences of climate change on health are significant and the resulting maladies include: heat stress, strokes and cardiovascular disorders; respiratory disorders; injuries, disability and drowning; malnutrition and hunger; water- and food-borne diseases; vector-borne diseases; and psychosocial stress.

As already observed in the report on the Twenty-sixth Meeting of Ministers of Health, the population most vulnerable to climate change and related health hazards was the poor. Coastal flooding, glacial melting, land degradation and poor harvests would trigger migration and social conflicts, with an important impact on mental well-being.

The recommendations made and actions taken on the New Delhi Declaration are:

- (1) Implement the World Health Assembly resolution WHA 61.19, on climate change and health and the regional framework for action to protect human health to develop and implement effective and efficient strategies and measures relating to climate change. A Working Group (WG) on Protecting Health from Climate Change has been established in the SEARO to effectively support countries in the SEA Region in mitigating and adapting to the adverse health impacts from climate change and support the implementation of the relevant World Health Assembly and Regional Committee resolutions. A SEAR plan of action to protect health from climate change has been developed to support the implementation of the New Delhi Declaration 2008. The plan takes into account the main aspects related to World Health Assembly resolution 61.19 and to the Regional Framework for Action. The thrust areas include: strengthen health systems capacity to address the challenges

posed by climate change; increase awareness of health consequences of climate change within the health sector and with other key sectors; promote applied research and pilot projects to assess health vulnerability to climate change; support the empowerment of local communities to become more climate change resilient; collaborate with other key sectors to assess health impacts of adaptation and mitigation measures and ensure that health concerns are integrated in an appropriate manner.

- (2) Strengthen health systems capacity and notably that of public health programmes that are already addressing health effects of climate change.
  - Developed a tool to assess the vulnerability of population's health to climate change which has since been field-tested in India and Indonesia (ongoing);
  - Supported the Ministry of Health in preparing national health plans addressing mitigation and adaptation to climate change in: Bangladesh, Bhutan, India Indonesia Maldives and Nepal.
- (3) Increase awareness of health consequences of climate change within the health sector and in collaboration with other key sectors such as education, but also with nongovernmental organizations, in particular youth groups and consumer organizations and networks.
  - Translation and printing of SEARO awareness materials into three languages, dissemination thorough ministries of environment and of education and civil society organizations (ongoing)
  - Worked with Youth Networks on Climate in support of advocacy
  - Prepared and disseminated educational videos
  - Development of database containing climate change-related articles from various sources (ongoing);
  - Developed advocacy/awareness activities related to child and environmental health (ongoing);
  - Peer education programme for behaviour change: developed and field-tested information materials for adolescents on climate change and health impacts in Bhutan and India(ongoing);

- Reviewed existing school curricula to include climate change and its health impacts in Bangladesh, Bhutan, India, Maldives, Nepal and Timor-Leste (ongoing);
  - Organized national workshops to orient schoolteachers on the effects of climate change and to promote mitigation measures through school settings in Bangladesh, Bhutan, Maldives and Timor-Leste (ongoing).
- (4) Develop the capacity of health sector professionals in addressing the challenges posed by global warming and climate change.
- Developed the regional training course for health professionals on Climate Change and Human Health;
  - Field-tested the training course for health professionals on Climate Change and Human Health in India (ongoing);
  - Developed, field-tested and reviewed the regional environment and health impact assessment training course with the WHO Collaborating Centre for Integrated Management of Disease Vectors (IMDV) , Mahidol University, Bangkok;
  - Developed, reviewed and edited the Integrated Vector Management (IVM) training course for 2009 regional training of programme managers with the WHO Collaborating centre Vector Control Research Centre (ongoing), Puducherry, Tamilnadu, India;
  - Conducted training for all environmental health focal points in WHO country offices of the SEA Region on Climate Change and Human Health (ongoing);
  - Conducted training of the SEA Region's official climate change focal points, including from the ministry of health (ongoing);
  - Contributed to the revision of the course on climate change and human health for municipality workers developed by the Kobe WHO Collaborating Centre (ongoing), Japan.
- (5) Promote applied research and pilot projects to assess health vulnerability to climate change and the scale and nature thereof.
- Recruited a Temporary International Professional (TIP) in SEARO to supervise the research activities and support implementation of the Regional Office actionplan to protect health from climate change;

- Organized a meeting of experts on climate change and human health research to identify knowledge gaps and prioritize regional research topics;
  - Research project related to climate change impacts on workers' health (ongoing);
  - Research project for better characterization of direct and indirect health effects from climate change due to long-term increase in droughts and decline in freshwater resources, with particular focus on children and other vulnerable groups;
  - Developed and field-tested the generic protocol to study the impact of climate change on vector-borne diseases (ongoing);
  - Finalized and field-tested the generic protocol to study the impact of climate change on diarrhoeal diseases in the WHO SEA Region (ongoing).
- (6) Engage in supporting the empowerment of local communities to become more climate-change resilient and thus reduce the potential burden of disease linked to it.
- Supported Integrated vector management and Integrated pest management pilots;
  - Technical support to strengthen kala-azar elimination and implementation of elimination activities in endemic districts (ongoing);
  - Integrated climate change resilience in existing community preparedness plans (ongoing);
  - Developed guidance for increasing climate change resilience in primary health centres (ongoing);
  - Organized a workshop for Small Island States in Maldives on strengthening climate resilience to protect the health of local communities(ongoing);
  - Implemented water safety plans in Bhutan, India, Indonesia and Sri Lanka(ongoing);
  - Conducted pilots on ecological sanitation in Bhutan and Nepal (ongoing);
  - Promoted the concept of Healthy and Resilient Island in Maldives (ongoing).

- (7) Collaborate with other key sectors to assess health impacts of preventive and corrective measures undertaken and ensure that health concerns are integrated in an appropriate manner.
  - Revised the Red Cross/Green Crescent training materials on climate change resilience at community level (ongoing);
  - Collaborated with FAO and UNEP in supporting integrated approaches for community development.
- (8) Increase awareness on health consequences of climate change and reduce the health sector's carbon footprint.
  - Updated the 2008 Report of the Assessment of Carbon Foot Print and Environmental Impact of SEARO
  - Monitoring of indicators for EMS "Greening SEARO", version 18.02.2009
- (9) Participate in national and international processes such as United Nations Framework Convention on Climate Change (UNFCCC), fostering cross-disciplinary partnerships and ensuring monitoring and evaluation of delivery.
  - Climate change focal points designated in ministries of health in countries of the WHO SEA Region (ongoing);
  - Collaboration with national focal points of the UNFCCC in the SEA Region countries (ongoing);
  - Two senior staff members from Ministry of Health, Bhutan, have been designated to join the official national delegation attending the COP15 (ongoing);
  - The Regional Office gave key inputs for the official submission made by WHO to UNFCCC "Protecting the health of vulnerable people from the humanitarian consequences of climate change and climate related disasters" in collaboration with the International Organization for Migration (IOM), World Vision (WV), the United Nations High Commissioner for Refugees (UNHCR) and the International Federation of Red Cross and Red Crescent Societies (IFRC).

## **Annex 8**

### **Agenda**

- (1) Opening Remarks & Introduction
- (2) Evidence and experiences at regional and national level on the health impact from climate change and mitigation, and adaptation thereto
- (3) Scientific evidence on the impact of climate change on health
- (4) Research gaps in protecting human health from climate change in the South-East Asia Region
- (5) Conclusions and recommendations
- (6) Closing

## Annex 9

### List of participants

#### Bangladesh

Dr Md. Abdul Jalil  
Joint Secretary  
Ministry of Health & Family Welfare  
WHO-I Section  
Dhaka  
Email: jshosp@mohfw.gov.bol

Dr Syed Khairul Anam  
Civil Surgeon  
Bhola  
Bangladesh  
Tel. +0491-61422

#### Bhutan

Mr Gyembo Dorji  
Programme Officer  
Environment Health Programme  
Department of Public Health  
Ministry of Health  
Thimphu  
Tel. +975-2-322608  
Email: gyemdorji2003@hotmail.com

Ms Kezang Lhamo Dorji  
District Environment Officer  
Thimphu District  
Thimphu  
Tel. +975-2-336278 (O)  
Tel. +975-2-17115117 (M)  
Email: kezanglhamo@hotmail.com

Dr Kipchu Tshering  
General Duty Medical Officer  
Dagapela Hospital  
Dagana  
Tel. +975-2-17628245  
Email: kippsbt@yahoo.com

#### India

Dr R.S. Shukla  
Joint Secretary  
Ministry of Health & Family Welfare  
Nirman Bhawan  
New Delhi – 110 011  
Email: rs.shukla@nic.in

Dr Sharat Chauhan  
Director (I.H. Section)  
Ministry of Health & Family Welfare  
Nirman Bhawan  
New Delhi – 110 011  
Email: csharat@ias.nic.in

#### Indonesia

Mr Nanang Besmanto  
Directorate of Environmental Health  
Ministry of Health  
Jakarta  
Email: besmanto@yahoo.com

Dr Budi Rahajum MPH  
Head of Division  
Communicable Disease  
Control and Environmental Health  
East Java Province Health Office  
Email: brhabibie@yahoo.com

Dr Budi Haryanto, MSPH, MSc  
Head, Department of Environmental Health  
Faculty of Public Health  
University of Indonesia  
Jakarta  
Tel. +62-8557896968  
Email: bharyant@cbn.net.id

### **Maldives**

Mr Simad Saeed  
Member  
Presidential Advisory Council on Climate  
Change  
Male  
Email: simad@cde.com.mv

Mr Mareer Mohamed Husnee  
Environment Analyst  
Ministry of Housing, Transport and  
Environment  
Male  
Tel. +960-3324861  
Email: mareer.husny@mhte.gov.mv  
secretariat@environment.gov.mv

Ms Nahida Ahmed  
Public Health Programme Coordinator  
Centre for Community Health Disease and  
Disease Control  
Male  
Tel. 9607857826  
Email: nahidha@dph.gov.mv

### **Myanmar**

Dr (Ms) Mi Mi Khin  
Deputy Divisional Health  
Director, Sagaing Division  
Sagaing  
Tel. +95-7221103 & +95-721186

Dr Than Htut  
Deputy Director  
Occupational Health  
Department of Health  
Yangon  
Email: thanhtut@21gmail.com

### **Nepal**

Dr Babu Ram Marasini  
Senior Health Administrator  
Ministry of Health & Population  
Ramshah Path  
Kathmandu  
Nepal  
Email: marasini2@yahoo.com

Mr Mohamed Daud  
Senior Public Health Administrator  
District Health Office  
Dhading  
Nepal  
Email: sheikh-daud@yahoo.com

Dr Kedar Narasingh K.C.  
President  
Nepal Medical Association  
Kathmandu  
Nepal  
Email:

Dr Bandana Pradhan  
Associate Professor  
Department of Community Medicine and  
Health  
Institute of Medicine  
Kathmandu  
Nepal  
Email: bandana@healthnet.org.np

### **Sri Lanka**

Dr (Mrs) S.J. Balasingham  
Environment Unit  
Ministry of Healthcare & Nutrition  
Colombo – 10  
Email: sherinejb@gmail.com

Dr Sanath de Silva  
Regional Director  
RDHS Office  
Matara  
Email: matarardhs@yahoo.com

### **Thailand**

Dr Twisuk Punpeng  
Public Health Technical Officer  
(Health Promotion)  
Advisory Level Bureau of  
Technical Advisors  
Department of Health  
Ministry of Public Health  
Tivanond Road  
Nonthaburi 11000  
Email: twisuk@health.moph.go.th

Miss Prattana Meesincharoen  
Environmental Officer,  
Professional Level  
Office of Climate Change  
Coordination: OCCC, ONEP  
Ministry of Natural Resources  
and Environment  
60/1 Soi Phibollwattana 7  
Rama VI Rd, Phayathai  
Bangkok - 10400  
Email: prattana71@gmail.com  
prattana@onep.go.th

Miss Siriwan Chandanachulaka  
Director of Sanitation and Health  
Impact Assessment Division  
Department of Health  
Ministry of Public Health  
Tivanond Road  
Nonthaburi 11000  
Email: siriwan9@gmail.com  
schandan@health.moph.go.th

#### **Temporary Advisers**

Dr Colin Butler  
Associate Professor  
National Centre for Epidemiology and  
Population  
Health, College of Medicine Biology and  
Environment  
Australian National University  
Canberra, ACT  
Australia  
Email: colin.butler@anu.edu.au

Ms R. Sari Kovats  
Lecturer  
Public Health and  
Environment  
Research unit (PEHRU)  
London School of Hygiene and  
Tropical Medicine  
Keppel St.  
London WC1E 7HT  
Email: sari.kovats@lshtm.ac.uk

Dr Alistair Woodward  
School of Population Health  
The University of Auckland  
Private Bag 92019  
Auckland 1142  
New Zealand  
Tel. +6493737599  
Email: a.woodward@auckland.ac.nz

Dr Fang Jing  
Gender and Health Specialist  
EcoHealth Project – Water,  
Hazard and Environment  
Management (WHEM)  
International Center for Integrated Mountain  
Development (ICIMOD)  
Kumaltar, Lalitpur, GPO 3226  
Kathmandu  
Nepal  
Email: jfang@icimod.org  
[fangjing07@126.com](mailto:fangjing07@126.com)

Dr Tord Kjellstrom  
Health and Environment  
International Trust  
168, Stafford Drive  
Mapua, Nelson 7005  
New Zealand  
Email: kjellstrom@yahoo.com

Dr Habibullah Saiyed  
Occupational Health Expert  
B-5 Union Park Society 2  
Near Unit Hills Society  
Behind Prakash College  
Juhapura, Ahmedabad  
India  
Email: saiyedhn@gmail.com  
saiyedhn@yahoo.com

Dr Atiq Rahman  
Executive Director  
Bangladesh Centre for Advanced Studies  
(BCAS)  
House # 10, Road # 16-A  
Gulshan – 1, Dhaka  
Bangladesh  
Email: atiq.rahman@bcas.net

Dr R.C. Dhiman  
Scientist 'F'  
National Institute of Malaria Research (ICMR)  
Sector 8, Dwarka  
New Delhi – 110 077  
India  
Email: dhimanrc@icmr.org.in

### **International Partners**

Ms Sreeja Nair  
Research Associate, Centre for Global  
Environment Research  
The Energy and Resources Institute  
Darbari Seth Block  
India Habitat Centre  
Lodhi Road  
New Delhi – 110 003  
Email: sreejan@teri.res.in

Ms Sneha Balakrishnan  
Research Associated  
Centre for Global Environment Research  
The Energy and Resources Institute  
Darbari Seth Block  
India Habitat Centre  
Lodhi Road  
New Delhi – 110 003  
Email: sneha.balakrishnan@teri.res.in

Ms Urvashi Chandra  
Technical Specialist  
GTZ Health Sector Support  
Deutsche Gesellschaft fuer Technische  
Zusammenarbeit (GTZ) GmbH  
GTZ India Office  
B-5/1 Safdarjung Enclave  
New Delhi – 110 029  
Email: Urvashi.chandra@gtz.de

Ms Yasmin Zaveri-Roy  
National Programme Officer  
Embassy of Sweden  
Nyaya Marg  
Chanakyapuri  
New Delhi – 110 021  
Email: yasmin.zaveri-roy@foreign.ministry.se

Ms Ruma Tavorath  
Senior Environmental Specialist  
The World Bank Group  
70 Lodi Estate  
New Delhi – 110 003  
Email: rtavorath@worldbank.org

Mr Muthukumara S. Mani  
Senior Environmental Economist  
The World Bank Group  
70 Lodi Estate  
New Delhi – 110 003  
Email: mmani@worldbank.org

Dr Vikram Rajan  
Health Specialist  
The World Bank  
70 Lodi Estate  
New Delhi – 110 003  
Email: vrajan@worldbank.org

Dr A.K. Dash  
Health Coordinator  
Indian Red Cross Society  
1 Red Cross Road  
New Delhi – 110 001  
Email: abhaydash1@gmail.com

Mr Shantanu Mitra  
Team Leader  
Climate Change and Development  
Department for International Development  
(DFID), India  
B-28 Tara Crescent  
Qutab Institutional Area  
New Delhi – 110 016  
Email: S-Mitra@dfid.gov.uk

Ms Sabina Bindra Barnes  
HIV/AIDS Adviser  
Department for International Development  
(DFID), India  
B-28 Tara Crescent  
Qutab Institutional Area  
New Delhi – 110 016  
Email: S-Barnes@dfid.gov.uk

Dr Ravi Agarwal  
H-2 Ground Floor  
Toxics Link  
Jungpura Extension  
New Delhi – 110 014  
Email: ravig1@vsnl.com

## **WHO/HQ**

Ms Mellisa Joy Guillemot  
Technical Officer – Climate and Health,  
Department of  
Public Health & Environment  
Email: guillemotj@who.int

## **WHO Country Offices**

Mr A.K. Sengupta  
National Professional Officer  
New Delhi, India  
Email: senguptaak@searo.who.int

Mr Sharad Adhikary  
Environmental Health Adviser  
Jakarta, Indonesia  
Email: adhikarys@who.or.id

Dr Jagdish Barot  
Temporary International Professional  
Climate Change and Rainwater  
Harvesting  
Male, Maldives  
Email: barotj@who.org.mv

Dr Mathew Robert Burns  
Temporary International Professional  
(Entomologist)  
Kathmandu, Nepal  
Email: burnsm@searo.who.int

Dr Harishchandra Yakandawala  
National Professional Officer,  
Emergency Health Action  
Colombo, Sri Lanka  
Tel. +94-773171743  
Email: yakandawalah@whosrilanka.org

Dr Arun Mallik  
Technical Officer  
Nonthaburi, Thailand  
Email: mallik@searo.who.int

## **WHO/SEARO Secretariat**

Dr Poonam Khetrpal Singh  
Deputy Regional Director  
Email: singhpoonam@searo.who.int

Dr A. Sattar Yoosuf  
Director, Sustainable Development and  
Healthy  
Environments  
Email: yoosufa@searo.who.int

Dr Kunal Bagchi  
Regional Adviser – Nutrition and Food  
Safety  
Email: bagchik@searo.who.int

Dr Roderico Ofrin  
Regional Adviser – Emergency and  
Humanitarian Action  
Email: ofrinr@searo.who.int

Dr Davison Munodawafa  
Regional Adviser – Health Promotion and  
Education  
Email: munodawafad@searo.who.int

Ms Payden  
Regional Adviser – Occupational and  
Environmental Health  
Email: Payden@searo.who.int

Dr Salma Burton  
Regional Adviser – Occupational and  
Environmental Health  
Email: burtons@searo.who.int

Mr Alexander von Hildebrand  
Regional Adviser – Environmental Health  
and Climate Change  
Email: hildebranda@searo.who.int

Mr K. Ratnakaran  
Administrative Assistant  
Department of Sustainable Development  
and Healthy Environments  
Email: ratnakarank@searo.who.int

Mr C Jayaraman  
Administrative Secretary  
Environmental Health & Climate Change  
Email: jayaramanc@searo.who.int



The Sixtieth Session of the WHO Regional Committee for South-East Asia, held in New Delhi, India in 2008, requested WHO to hold a regional technical meeting on "Protecting Human Health from Climate Change" and to report the recommendations to the Sixty-first Session of the Regional Committee.

Technical Discussions on the subject were held in the Regional Office, New Delhi, India, from 18–21 August 2009 to share evidence and experiences at regional and national levels; to review the current scientific evidence on the impact of climate change on health; to identify research gaps; and develop an agenda for operational research in the Region.

About 30 participants from health and environment ministries of nine countries of the Region participated. This is a detailed report of the meeting.



**World Health  
Organization**

**Regional Office for South-East Asia**

World Health House  
Indraprastha Estate,  
Mahatma Gandhi Marg,  
New Delhi-110002, India



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