Human Health Impacts from Climate Variability and Climate Change in the Hindu Kush-Himalaya Region

Report of an Inter-Regional Workshop

Mukteshwar, India, October 2005

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Acronyms Used

DALYs :	Disability Adjusted Life Years Lost
ENSO:	El Niño/Southern Oscillation
GEF:	Global Environment Facility
GLOF:	Glacial Lake Outburst Flood
HKH:	Hindu Kush-Himalaya region
ICIMOD:	International Centre for Integrated Mountain Development
IPCC:	Intergovernmental Panel on Climate Change
UNFCCC:	United Nations Framework Convention on Climate Change.
MEA:	Millennium Ecosystem Assessment
SEARO:	Regional Office for South-East Asia, World Health Organization
UNEP:	United Nations Environment Programme
WHO:	World Health Organization
WMO:	World Meteorological Organization
WWF:	World Wildlife Fund

Executive Summary

The World Health Organization, the World Meteorological Organization, the United Nations Environment Programme, and the United Nations Development Programme organized an inter-regional workshop on Human Health Impacts from Climate Variability and Climate Change in the Hindu Kush-Himalaya Region. Held in Mukteshwar, India from 3rd to 7th October 2005, the objectives of the workshop were to:

- Inform government organizations, nongovernmental organizations and other relevant stakeholders about the impacts of climate variability and long-term climate change in mountain regions, and in the Hindu Kush-Himalaya region in particular;
- Identify specific human health risks linked to climate variability and change in the Himalayan mountain regions and identify vulnerable populations;
- Propose strategies for integrating health with relevant sectors (e.g. water resources, agriculture, forestry), interdisciplinary research and projects oriented towards action, and intercountry cooperation; and
- Achieve consensus on a draft framework for national action in the Hindu Kush-Himalayan mountain region.

National health and environment authorities were present from the Hindu Kush-Himalayan countries of Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and the Peoples' Republic of China.

The participants discussed the global environmental changes that are projected to result in rapid and profound changes in the Hindu Kush-Himalaya region over the coming decades. The projected increasing temperatures and changing precipitation patterns due to climate change are likely to profoundly influence ecosystems and the human populations that depend on them in these regions.

There is scant published information available on the possible health consequences of global climate change in mountain regions. However, it is likely that vector-borne pathogens could take advantage of new habitats in altitudes that were formerly unsuitable, and that diarroheal diseases could become more prevalent with changes in freshwater quality and availability. Excessive rainfall is likely to increase the number of floods and landslides. A risk unique to mountain regions is glacier lake outburst floods, which are projected to increase as the rate of glacier melting increases. These are associated with high morbidity and mortality. Because glaciers are the source of fresh water for many mountain regions and associated lowlands, the long-term reduction in annual glacier snowmelt is expected to result in water insecurity in both regions. The extent of the impacts will depend on the effectiveness of public health interventions and other adaptations.

The participants agreed that the basic issues that need to be addressed to assess the human health consequences of these changes include:

(1) Identifying the current distribution of climate-sensitive health determinants and outcomes in the region, quantify the relationship between climate and health, and calculate the burden of these health determinants and outcomes (with special emphasis on the most vulnerable populations).

(2) Identifying and evaluating the effectiveness of existing policies, awareness raising, and capacity building measures to reduce the burden of climate-sensitive health determinants and outcomes (adaptation baseline).

(3) Review the implications for human health of the potential impacts of climate variability and change on other sectors.

(4) Estimating future health impacts under different climate change and socioeconomic scenarios.

(5) Identifying additional adaptation measures needed to reduce estimated future negative health effects; and

(6) Identifying approaches to mitigate the emission of greenhouse gases by ensuring a stronger engagement of the heath sector in the national, regional and global climate change negotiations, and by minimizing greenhouse gas emissions from the health sector itself (such as energy efficiency, alternative fuel supplies).

The workshop participants noted that while adaptive measures and interventions to protect human health from the consequences of climate change require immediate attention, mitigation measures, in the form of reduced emissions by all countries, are vital. Countries that have contributed the majority of greenhouse gas emissions should acknowledge their responsibility for generating climate change and consequent health impacts, reduce their emissions, and support mountain regions in adapting to climate change, to help ensure the long-term sustainability of mountain regions.

The participants made recommendations to address the following areas: data, research, and resource needs; policy; adaptation options; awareness and capacity building. The participants also agreed on the immediate steps to be undertaken at country level to facilitate the implementation of the framework contents. Further activities should focus on those populations and areas that are most vulnerable to climate-sensitive health determinants and outcomes.

1

Official Presentations

The participants were welcomed by representatives from The Energy and Resources Institute, India (TERI) - Ms R Uma, the World Health Organization (WHO) - Mr A K Sengupta, WHO Office, India and Mr Alexander von Hildebrand, WHO Regional Office South- East Asia, the World Meteorological Organization - Dr B Srinivasan, and the United Nations Environment Programme - Dr Bo Lim. The main theme of the welcome addresses was the importance of the workshop in addressing the potential health impacts of climate variability and change goals in the Hindu Kush-Himalaya mountain regions, and of considering strategies for improving adaptation in response to this threat.

The objectives of the workshop were to:

- Inform government organizations, nongovernmental organizations, and other relevant stakeholders on the impacts of climate variability and long-term climate change in mountain regions, and in the Hindu Kush-Himalaya region in particular;
- Identify specific human health risks linked to climate variability and change in mountain regions, and identify vulnerable populations;
- Propose strategies for integrating health with relevant sectors (e.g. water resources, agriculture, forestry), interdisciplinary research and projects oriented towards action, and intercountry cooperation; and
- Achieve consensus on a draft framework for national action in the Hindu Kush-Himalaya mountain region.

Dr R K Pachauri, Executive Director of TERI and Chairman of the Intergovernmental Panel on Climate Change, was unable to attend the workshop, but sent a special message to the participants for the closing session (Annex 1). Dr R K Pachauri emphasized the importance of implementing actions to reduce human health vulnerability to climate change in mountain regions, and urged participants to ensure that the health sector was engaged in the Second National Communications countries to the United Nations Framework Convention on Climate Change.

2 Introduction to Mountain Regions

2.1 Populations in Mountain Regions

As shown in Table 1, in 2000, the number of people living in mountainous regions was estimated to be more than 1.1 billion, with nearly half (46%) living in the Asia/ Pacific. Over 70% of the global mountain population lives below 1500 m, mostly in China. Of the global mountain populations, 90% live in developing and transition countries, one third of these in China and two-thirds in Asia and the Pacific.

Table 1: Mountain populations and proportion living in urban settings

Mountain area class, by elevation	Population ('000s)	Urban dwellers (percent)
≥ 4500 m	5,405	4.6
3500-4500 m	20,541	18.8
2500-3500 m	63,373	27.7
1500-2500 m	222,700	26.8
1000-1500 m	226,292	30.3
300-1000 m	574,797	31.4
Total	1,113,108	29.7

Source: Griddled Population of the World (GPW 3; CIESIN et al. 2004a and Global Rural-Urban Mapping Project GRUMP 1$^{\alpha}$; CIESIN et al. 2004b)

In common with other developing countries, countries with large mountain populations, such as Bhutan and Nepal, typically have young populations and shorter life expectancies. For example, the population of Bhutan in 2004 was 851,000 people, of which only 6.5% were 60 years of age or older (World Health Report 2004). Life expectancy at birth was 60 years for males and 62 years for females (compared with 78 years for Japanese males and 85 years for Japanese females). As shown in Tables 1 and 2, most mountain dwellers are rural (over 70%). Of those living above 2500 m, almost all are highly vulnerable to food insecurity. A combination of poverty and remoteness results in poor medical support and education systems in many mountainous regions.

2.2 Definition of a Mountain

There is no standard definition that distinguishes mountains from non-mountain environments. Absolute elevation alone is not an adequate criterion because the nature of the terrain also is important, especially the degree of the slope and how often it changes direction. Annex 1 provides the definition based on altitude and slope developed by the United Nations Environment Programme World Conservation Monitoring Centre. The workshop participants decided to define mountains for the purposes of the workshop as *the foothills and higher areas in the Hindu Kush-Himalaya region*.

Table 2: Number of vulnerable rural people living in different classes of mountain regions (millions of people), by developing and transition countries

Region	Mountain area class (metres above sea level)						
	300-1000	1000-1500	1500-2500	2500-3500	3500-4500	> 4500	Total
Asia and the Pacific	77.5	28.8	19.8	6.5	4.3	3.1	140.0
Latin America and Caribbean	9.9	5.0	8.9	4.9	4.0	0.2	32.9
Near East and North Africa	10.7	7.1	7.5	4.1	0.3	0.03	29.7
Sub-Saharan Africa	10.6	10.6	7.3	2.2	0.09	0	30.9
Countries in transition	7.7	1.9	1.0	0.4	0.2	0.02	11.2
Population							
Total vulnerable population (developing and transition countries, in millions)	116	54	45	18	9	3	245
Total rural mountain population (developing and transition countries, in millions)	242	98	105	32	10	4	490
Vulnerable in the class as share of total rural mountain population in the class (%)	48	55	43	57	87	82	-
Vulnerable in the class as share of total vulnerable (%)	48	22	18	7	4	1	100

**Vulnerable rural mountain people* were defined as those living in rural areas where rainfed cereal production was less than 200 kg per person per year and the bovine density index was medium to low, and included people living in closed forests or protected areas. Source: Huddleston et al. 2003, based on LandScan 2000 Global Population Database.

Mountains occur on all continents, in all latitude zones, and within all the world's principal biome types. Based on the United Nations Environment Programme World Conservation Monitoring Centre's Classes 1-7 of mountain regions, the global mountain area is almost 40 million km^2 (approximately 27% of the Earth's surface). Excluding Antarctica, the proportion of land area that is mountainous is around 24%. Table 3 lists mountain area statistics for Classes 1-6 by region and Figure 1 shows world mountains based on topography alone. By continent, the Eurasian landmass has the largest mountainous area (http://www.unep-wcmc.org/habitats/mountains/statistics.htm). The Tibet (Qing Zang) Plateau and adjacent ranges have the most extensive inhabited land area above 2500 m. All of the world's mountains above 7000 m in height are in Asia and all 14 peaks above 8000 m are in the Greater Himalaya range.

Figure 2a shows mountain areas by latitude zone. The greatest concentration of mountains is in the northern Hemisphere and in temperate-subtropical latitudes. Figure 2b shows the compression of thermal zones on mountains.

2.3 Mountain Climates

Dr Kristie L Ebi, Mr B Mukhopaday, India Meteorological Department, on behalf of the World Meteorological Organization

Mountains influence climate mainly in four ways: through their altitude, continental position, latitude and topography (Barry 1997). In general, air pressure, temperature, and humidity decrease with increasing altitude and solar radiation (especially UV) and wind speed increase. At 1500 m, the partial pressure of oxygen is about 84% of the value at sea level, falling to 75% at 2500 m, and 63% at 3500 m. Air temperature decreases, on average, about 5.5°C for every 1000 m increase in altitude (but varies diurnally, seasonally, latitudinally, and from region to region). Air holds less

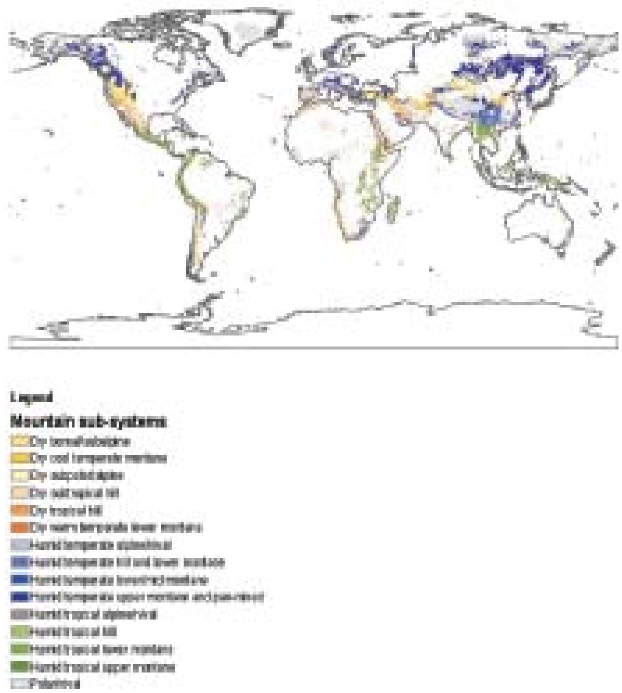
Table 3: Mountain area statistics by region (km^2)

Region	Mountain Class (metres above sea level)						
	> 4500m	3500–4500	2500–3500	1500–2500 & slope > 2°	1000–1500 & slope > 5° or local elevation range > 300 m	300–1000 & local elevation range > 300 m	Total
North America	197	11 417	200 830	1 092 881	1 104 529	1 840 140	4 249 994
Central America	38	968	67 127	353 586	259 367	412 215	1 093 301
Caribbean			32	2 809	5 528	38 322	46 691
South America	154 542	583 848	374 380	454 417	465 061	970 707	3 002 955
Europe		225	497 886	145 838	345 255	1 222 104	2 211 308
Africa	73	4 859	101 058	559 559	947 066	1 348 382	2 960 997
Middle East	40 363	128 790	339 954	906 461	721 135	733 836	2 870 539
Russian Federation	31	1 122	31 360	360 503	947 368	2 961 976	4 302 360
Far East	1 409 259	741 876	627 342	895 837	683 221	1 329 942	5 687 477
Continental South-East Asia	170 445	107 974	97 754	211 425	330 574	931 217	1 849 389
Insular South-East Asia	22	4 366	34 376	120 405	157 970	599 756	916 895
Australia				385	18 718	158 645	177 748
Oceania			41	7 745	29 842	118 010	155 638
Antarctica	17	1 119 112	4 530 978	165 674	144 524	327 840	6 288 145
Total	1 774 987	2 704 557	6 903 118	5 277 525	6 160 158	12 993 092	35 813 437

Source: http://www.unep-wcmc.org/habitats/mountains/statistics.htm (accessed 01.3.2006)

water vapour as temperatures fall with increasing altitude. In mid-latitudes, the dry and dust-free air at higher altitudes retains little heat energy, leading to marked extremes of temperature between day and night. Latitude influences day length and the seasonal distribution of solar radiation. Latitude and continental location together influence climate and local weather patterns: some mountains are almost permanently dry, others are wet, and others highly seasonal. Topography (slope and aspect) affects solar radiation, radiative processes, temperature and precipitation. There are, of course, differences between isolated mountain peaks that modify upstream and downstream air flow, and extensive mountain ranges that create barriers to air motion and generate their own climates. Valleys within uplands have 'enclosed' atmospheres that are diurnally modified by nocturnal cooling, especially in winter, and enhanced by daytime heating.

Figure 1: Mountains of the world (topographic and meteorological classification)

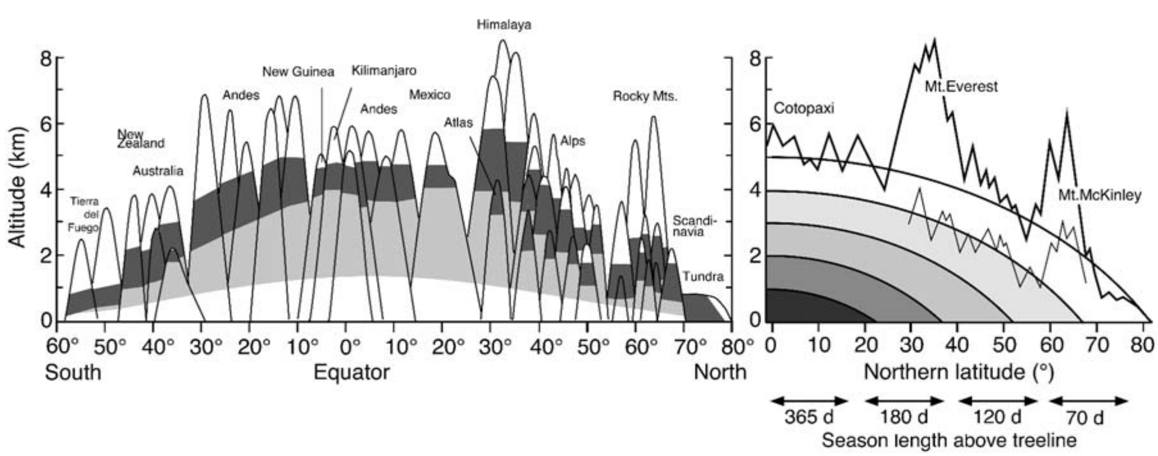


Source: (Kapos et al. 2000) ©UNEP-WCMC, Cambridge UK

The terms 'weather' and 'climate' are often used interchangeably, but they represent different parts of a continuum. Weather is the complex and continuously changing condition of the atmosphere considered on a time scale from minutes to weeks. Climate is traditionally viewed as the integration of discrete weather events and variables in a particular region over a particular time scale, including atmospheric and surface variables, such as temperature, precipitation, soil moisture, and sea surface temperature. The corollary is that the impacts of climate change cascade through all temporal and spatial scales. Climate variability is the variation around the average climate, including seasonal variations as well as large-scale variations in atmospheric and ocean circulation such as the El Niño/ Southern Oscillation (ENSO). Climate change operates over decades or longer time scales. Figure 3 shows the links between weather and climate.

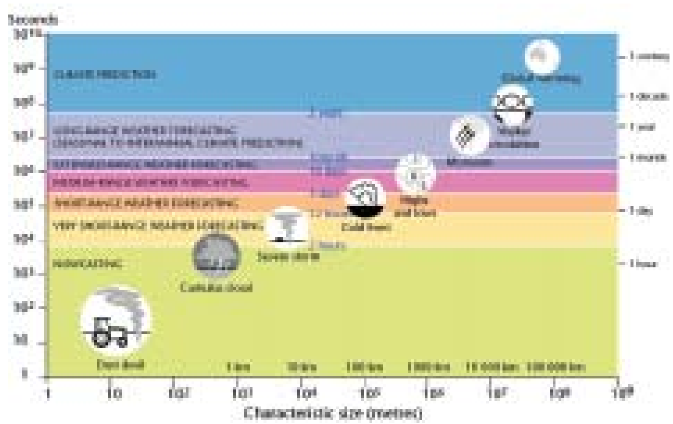
Changes in climate occur as a result of both internal variability within the climate system and external factors (natural and anthropogenic). Although climate is always changing, the climate over the past 10 000 years has been both relatively stable and warm.

Figure 2: (a) Classic Humboldt Profile of the latitudinal position of mountains across the globe. Grey is montane; black is alpine; white is nival belt. (b) Compression of thermal zones on mountains: altitude for latitude.



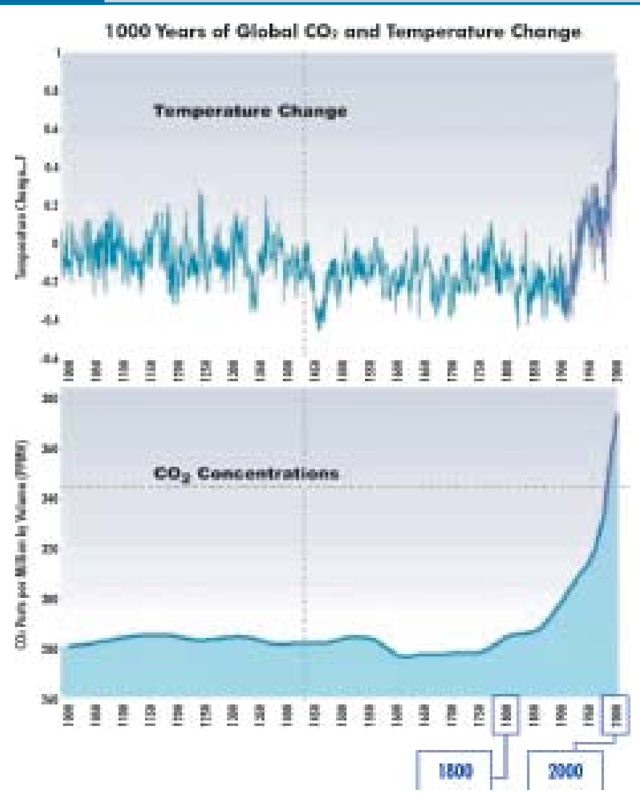
Source: Körner, 2003.

Figure 3: Linking weather to climate



Source: Dr Nyenzi, World Meteorological Organization, 2003.

Figure 4: 1000 years of average global carbon dioxide levels and temperature (expressed as change from the long-term mean)



Source: Albritton and Meira Filho, 2001

In order to determine the degree and rate of climatic trends, long-term data sets are required. Climatic knowledge specific to individual mountain regions is limited because of the paucity of data and insufficient theoretical attention to processes that affect climate in mountain areas. Relatively dense meteorological networks exist for the Alps and parts of North America. Elsewhere, problems of access and financial resources have limited the number of weather stations. In 1992, 19 of the 30 principal observatories in mountain regions were in Europe; none were in the Himalayas (Barry 1992).

Over the past decade, the fact that the world's climate is changing has become clear. In 2001, the Intergovernmental Panel on Climate Change concluded: *there is new and stronger evidence that most of the warming observed over the past 50 years is attributable to human activities*. The IPCC projected that the global mean temperature of the Earth would increase by the end of the 21st century by between 1.4 and 5.8°C. Global precipitation also would increase. This projected rate of warming is much larger than the observed changes during the 20th century and is very likely to be without precedent during at least the last 10 000 years. Figure 4 shows 1000 years of average global carbon dioxide and temperature (expressed as change from the long-term mean), with the largest increases occurring since the beginning of the Industrial Revolution.

Ambient temperatures have increased 0.6°C at the global level and 0.4°C in the Indian region. The spatial distribution of mean annual temperature trends over the period 1971-1994 in Nepal showed that temperature changes were higher in the uplands than the lowlands (Shrestha et al. 1999). Most of the country experienced increases in mean annual maximum temperatures, with larger increases (greater than 0.06°C per year) in most of the northern region, which includes the Trans-Himalayan and Himalayan regions, and central and western parts of the Middle Mountains. There were two areas of very high warming in the Middle Mountains (0.12°C or more per year). Most of the Siwalik and Terai regions showed less warming (less than 0.03 °C per year). There is already evidence of climate change stress in mountain regions in the form of glacier retreat. In addition, population pressures and urbanization are increasing stress on mountain regions.

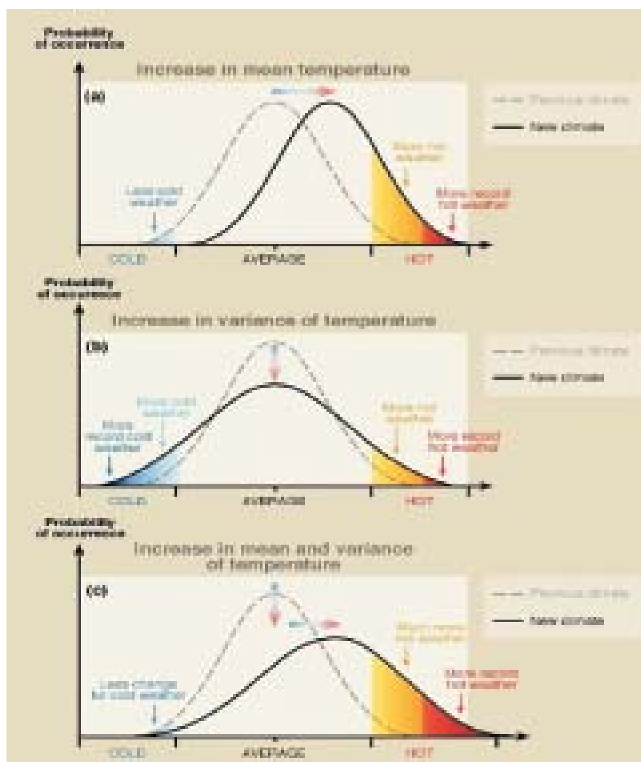
These trends are expected to accelerate over the coming decades. Globally, by 2100, atmospheric concentrations of carbon dioxide are projected to be between 490 and 1260 ppm (75 – 350% above the concentration of 280 ppm in the year 1750), with the global mean temperature increasing by between 1.4 and 5.8°C (Albritton and Meira Filho 2001). However, greater warming is projected in the high northern latitudes. It can also be expected that many mountainous regions will experience greater warming than the lowlands due to the albedo effect, although scenarios of climate change in mountain regions are highly uncertain because they have poor spatial resolution (even in the highest resolution models).

Interactions between changes in the mean and variability of weather variables complicate projecting possible future trends in extreme events. Assuming a normal distribution of surface temperature, one can envisage three scenarios of increasing temperatures (Figure 5). In the first scenario there is a simple increase in mean temperature without a change in the variance (e.g. the shape of the curve would remain the same). If this occurs there would be less cold weather and more hot and record hot weather. A second scenario is an increase in the variance without a change in mean temperature; this would result in increasing cold and hot weather, with a decreasing frequency of weather that could be considered average under the previous climate (e.g., the shape of the curve would become flatter).

Finally, if there is a shift in the mean *and* the variance of temperature, there would be slightly less cold weather and substantially more hot and record hot weather. The patterns for precipitation will be different because precipitation is highly variable. The projections are for a change in the frequency and distribution of rainfall, which could influence intensity. Tropical storms are expected to increase in frequency in some regions and desertification is projected to increase in others. There is growing concern that future weather patterns will resemble pattern (c) in Figure 5 and that what is currently considered an extreme event may become common.

A particular concern in tropical Asia is whether climate change will affect the monsoon season. The climate of tropical Asia is dominated by two monsoons: the summer southwest monsoon influences the regional climate from May to September, and the winter northeast monsoon influences the climate from November to February. The monsoons bring most of the region's precipitation and are critical for providing drinking water

Figure 5: Climate change will affect climate extremes, depending on the extent of change in the mean and variance of a climatic factor



Source: Folland et al., 2001

Box 1: Monsoons in the Indian Subcontinent

Nearly every summer the monsoons come to India, Bangladesh, and Myanmar. Farmers and economies depend on the monsoon's timely arrival. The intense rains are necessary for rice and other crops. As rivers overflow banks, water soaks into farmlands, leaving behind nourishing silt and algae as it recedes. Although annual rainfall amounts vary, monsoons provide, on average, about 80 percent of India's rainfall. During the record period of 1860-61, monsoon rains dumped 2,600 centimeters of moisture on the Himalaya foothills. In southern India, the Western Ghats mountain chain absorbs most of the monsoon's rains and then releases the water gradually over the rest of the year. As much as 9 metres of rain falls every year in some sections.

Monsoons also cause damage and death. In 1995 alone, over 1000 people died because of monsoons in Bangladesh, Pakistan, and Nepal. If the monsoons fail, drought occurs, affecting thousands of people.

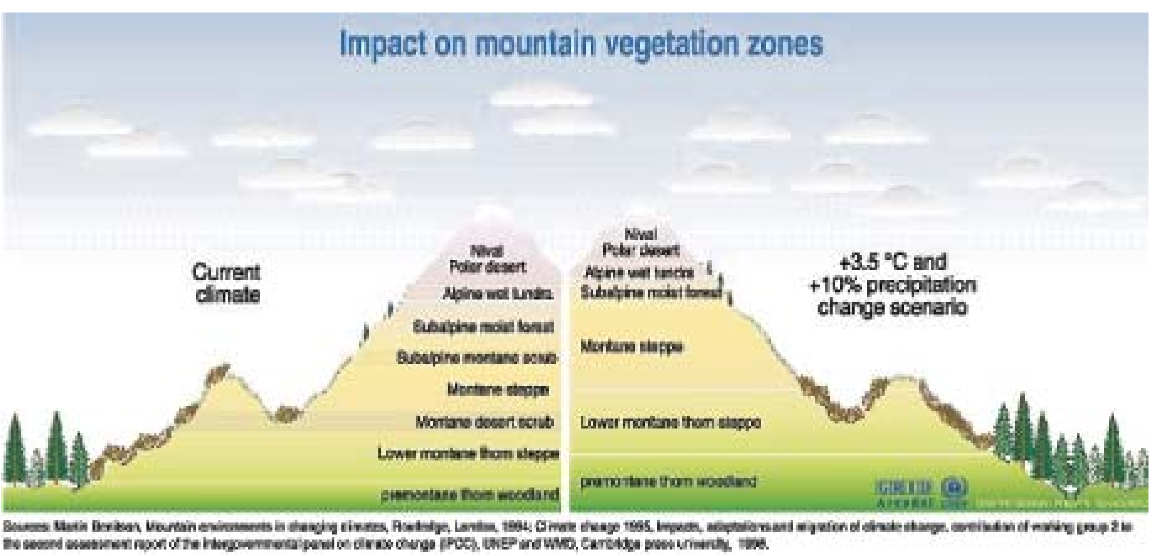
Source: http://java.nationalgeographic.com/studentatlas/clickup/monsoons.html (accessed 01.3.2006)

and water for rainfed and irrigated agriculture (Lal et al. 2001). Increases in rainfall during the northeast monsoon, as well as increases in the magnitude of extreme rainfall events, both of which have been projected with climate change, are expected to increase the frequency and intensity of flooding in the region. If the southwest monsoon arrives later or withdraws earlier, then soil moisture deficits could get worse in some areas.

2.4 Climate Change and Mountain Ecosystems

Global climate change poses a number of potential risks to mountain ecosystems, although scientists cannot predict the detail of the impacts with confidence. Mountain systems are particularly sensitive to changes in climate, with small changes having the potential to produce significant effects, particularly in marginal environments that are currently under stress. Figure 6 shows a comparison of current vegetation zones at a hypothetical dry temperate mountain site with simulated vegetation zones under one climate change scenario (increase in temperature of 3.5°C, with a 10% increase in precipitation). Paleologic records show that past climate warming caused vegetation zones to shift to higher elevations, resulting in the loss of some species and ecosystems (Beniston 2000). Simulated scenarios for temperate-climate mountain sites suggest that

Figure 6: Comparison of current vegetation zones at a hypothetical dry temperate mountain site with simulated vegetation zones under a climate change scenario



Box 2: Himalayan Mountain Systems in Global Biodiversity

Biodiversity is important to both the Hindu Kush-Himalaya region and is significant for global biodiversity. The wealth of biodiversity in the Hindu Kush-Himalaya is due to the variety of environments found in mountain ecosystems, with extreme biodiversity in species and genetics. As a result, the region is among those with the richest biological diversity in the world. The total number of plant species in the region is estimated to be as much as 25,000 or 10% of the world's flora (Pei, 1996). The botanical wealth includes more than 8000 species belonging to 200 families (Jain 1987; Khoshoo 1996), with about 30% of the flora endemic (Chatterjee 1939; Meher-Honji 1972). Nine thousand plant species have been reported in the virgin forests of Eastern Himalayas, of which 3500 (39%) are endemic to the region (Myers 1988).

Source: (www.icimod.org/focus/biodiversity/bio_global.htm) (Accessed 01.3.2006)

continued warming could have similar consequences (Albritton et al. 2001).

As detailed in the recently released Millennium Ecosystem Assessment (www.millenniumassessment.org), biodiversity is the foundation for human well-being; it provides not only materials needed for food, clothing and shelter, but also security, health and freedom of choice. Climate change will put additional pressure on species ecosystems, with the risks that those with limited climatic ranges could disappear, the frequency and intensity of forest fires could increase, and the distribution of water and the diversity of wildlife projected to change. All of these can have adverse consequences for current and future generations.

2.5 Climate Change and Retreating Glaciers

Although there are significant regional differences, worldwide there has been a retreat of glacier fronts in several stages of ever-increasing intensity, interrupted by intervals of stagnation or advance (Dyurgerov and Meier 2000). Recently, the rate of loss has been accelerating recently. In most mountain regions, it is expected that the geographic extent and volume of glaciers and the extent of permafrost and seasonal snow cover will continue to be reduced (White et al. 2001). The World Glacier Monitoring Service collects standardized observations on changes in the mass, volume, area and length of glaciers. Table 4 shows the area of the world covered by glaciers. In Asia, glaciers cover over 100,000 km^2, mostly in the Himalayas; the ice mass over this region is the third largest on Earth.

Changes in climate are already affecting many mountain glaciers around the world. Rapid mountain glacier retreat has been documented in the Himalayas, Greenland, the European Alps, Ecuador, Peru, Venezuela, New Guinea, and East Africa (WWF 2005, http://assets.panda.org/downloads/himalayaglaciersreport2005.pdf).

Changes in the depth of mountain snowpacks and glaciers, and changes in their seasonal melting, can have significant impacts on the communities, agriculture, and power generating stations that rely on freshwater runoff from mountains. For example, meltwater from Himalayan glaciers contribute a sizeable portion of river flows to the Ganges, Brahmaputra, Indus, and other river systems in south Asia (Smith et al. 2001). About 70% of the summer flow in the Ganges comes from melting glaciers. In China, 23% of the population lives in the western regions where glacial melt provides the principal dry season water source (Barnett et al. 2005). In addition, glaciers act as buffers that regulate runoff water supply from mountains to plains during dry and wet spells. Thus, glaciers are instrumental in securing agricultural productivity and livelihoods for millions of people.

Rising temperatures may cause snow to melt earlier and faster in the spring, shifting the timing and distribution of runoff. Projections are for a regression of the maximum spring stream-flow period in the annual cycle of about 30 days, and an increase in glacier melt run-off by 33-38% (Barnett et al. 2005). These changes could affect the availability of freshwater for natural systems and human use. Excessive melt water could cause flash floods. If freshwater runoff is reduced in the summer months because of earlier melting, soils and vegetation may become drier and the risk of wildfires

Table 4: Surface area of the world covered by glaciers

Region & Country	Area (km^2)		Region & Country	Area (km^2)
South America	25 908		Europe	53 967
Patagonian ice fields	21 200		Iceland	11 260
Argentina (north of 47.5° S)	1 385		Svalbard	36 612
Chile (north of 46° S	743		Scandinavia (with Jan Mayen)	3 174
Bolivia	566		Alps	2 909
Peru	1 780		Pyrenees/Mediterranean Mountains	12
Ecuador	120		USSR/Asia	185 211
Colombia	111		USSR	77 223
Venezuela	3		Turkey/Iran/Afghanistan	4 000
North America	276 100		Pakistan/India	40 000
Mexico	11		Nepal/Bhutan	7 500
USA (with Alaska)	75 283		China	56 481
Canada	200 806		Indonesia	7
Greenland	1 726 400		New Zealand / Subantarctic Islands	7 860
Africa	10		New Zealand	860
			Sub Antarctic islands	7 000
			Antarctic	13 586 310
			Total	15 861 766

Source: http://www.kms.dk/fags/ps09wgms.htm, accessed 22.11.2005

may increase. Changes in stream flow and higher water temperatures also could affect insects and other invertebrates that live in streams and rivers, with repercussions up the food chain for fish, amphibians, and waterfowl.

2.6 Glacial Lake Outburst Floods

Glaciers and glacial lakes are the sources of headwaters of many large rivers in areas such as the Hindu Kush-Himalaya regions of Nepal, India, Pakistan, Bhutan, and China (Tibet). A unique risk in mountainous areas is glacial lake outburst floods (GLOFs). Glacial lakes form on the terminus of a glacier as it retreats. Unstable moraines that were formed during the glaciations of the Little Ice Age dam the majority of these glacial lakes. GLOFs result when these moraine dams break, leading to the sudden discharge of large volumes of water and debris. GLOFS have caused catastrophic downstream flooding and serious damage to life, property, forests, farms, and infrastructure.

There is now growing concern as climate change-induced melting of glacial ice and snow has caused an increase in the accumulation of water in large glacial lakes. In the Himalayan region the frequency of GLOF events has risen during the second half of the 20th century (www.rrcap.unep.org/issues/glof); accessed 22 November 2005). Recently, GLOFs occurred in Nepal, India, Pakistan, Bhutan, and China. In the Lunana region of northwestern Bhutan, GLOFs occurred in 1957, 1969, and 1994, causing extensive damage to the

Punakha Dzong (a complex that serves as both a religious and administrative centre) (Lyngararasan et al. 2002). Five GLOF events occurred in Nepal between 1977 and 1998. In August 1985, a GLOF from the Dig Tsho (Langmoche) glacial lake in Nepal destroyed 14 bridges and caused about US$1.5 million in damage to the Namche small hydropower plant.

In 1999 the United Nations Environment Programme and the International Centre for Integrated Mountain Development –ICIMOD -documented the state of glaciers in Bhutan and Nepal (Lyngararasan et al. 2002). The study identified 3,252 glaciers and 2,323 glacial lakes in Nepal and 677 glaciers and 2,674 glacial lakes in Bhutan. Potentially dangerous glacial lakes were also identified on the basis of actively retreating glaciers and other criteria. Some glaciers in Bhutan are retreating at about 20-30 metres per year, creating many small glacier lakes. The study observed that groups of small closely spaced glacial lakes merge over time to form larger lakes. For example, the lake at Lower Barun Glacier in Nepal was not visible on a topographic map published by the Survey of India in 1967. By 1996, the lake was of considerable size. Other countries of the Himalayas are still to be studied. (More at: 3w.rrcap.unep.org/glofbhutan/Bhutan/Report/chap1/chap1.htm; accessed 21 November 2005).

In response to the risk of GLOFs, the United Nations Environment Programme (specifically the Environment Assessment Programme for Asia-Pacific and the Asian Institute of Technology in Bangkok) is working to establish an early warning system to monitor GLOF hazards in the Hindu Kush-Himalaya region in collaboration with the International Centre for Integrated Mountain Development, Nepal.

2.7 Mountain Regions and Sustainable Development

Mountains are fragile ecosystems that are globally important as the source of most of the Earth's freshwater, repositories of biological diversity, popular destinations for recreation and tourism, and areas of important cultural diversity, knowledge, and heritage. Intact mountain environments also provide food, energy, timber, flood and storm protection, and erosion prevention. Yet, many mountain environments have been degraded through deforestation and the excessive use of other natural resources, inappropriate infrastructure development, and the impacts of natural hazards. Many of the world's poorest and food-insecure populations live in mountain regions. Climate change is an additional pressure that may adversely affect mountains and the people who depend on the ecosystem services they provide. Consequently, there is a need to ensure the ecological health and the economic and social improvement of mountain areas for the sake of both mountain inhabitants, whose livelihood opportunities and overall well-being are at stake, and of people living in lowland areas (United Nations 58th General Assembly).

Sustainable mountain development was one of the issues addressed during the 1992 United Nations Conference on Environment and Development. Chapter 13 of Agenda 21 (Managing Fragile Ecosystems: Sustainable Mountain Development) stated:

> Mountains are an important source of water, energy, and biological diversity. Furthermore, they are a source of such key resources as minerals, forest products and agricultural products and of recreation. As a major ecosystem representing the complex and interrelated ecology of our planet, mountain environments are essential to the survival of the global ecosystem. Mountain ecosystems are, however, rapidly changing. They are susceptible to accelerated soil erosion, landslides and rapid loss of habitat and genetic diversity. On the human side, there is widespread poverty among mountain inhabitants and loss of indigenous knowledge. As a result, most global mountain areas are experiencing environmental degradation. Hence, the proper management of mountain resources and socio-economic development of the people deserves immediate action. (United Nations Conference on Environment and Development, 1992)
>
> And:
>
> Mountains are highly vulnerable to human and natural ecological imbalance. Mountains are the areas most sensitive to all climatic changes in the atmosphere. Specific information is essential on ecology, natural resource potential and socio-economic activities. Mountain and hillside areas hold a rich variety of ecological systems. Because of their vertical dimensions, mountains create gradients of temperature, precipitation and insolation. A given mountain slope may include several climatic systems – such as tropical, subtropical, temperate and alpine – each of which

> represents a microcosm of a larger habitat diversity. There is, however, a lack of knowledge of mountain ecosystems. The creation of a global mountain database is therefore vital for launching programmes that contribute to the sustainable development of mountain ecosystems. (United Nations Conference on Environment and Development, 1992)

Agenda 21 established programmes of action based on these declarations. The progress achieved was commended at the 2002 World Summit on Sustainable Development, held in Johannesburg, South Africa (United Nations 58th General Assembly). However, it was noted that significant challenges facing mountain environments and mountain peoples remain, and that concerted and coordinated actions are needed to develop and reinforce the institutional and human capacity to continue sustainable mountain development. In response, an alliance of national Governments, United Nations agencies, and NGOs announced that they would work in partnership to achieve mountain-specific goals on reducing poverty and food insecurity in mountain communities and on protecting the world's fragile mountain ecosystems from various threats posed to their freshwater systems and biodiversity. From this developed an International Partnership for Sustainable Development in Mountain Regions that will take forward the work begun. Further, at its 57th General Assembly, the United Nations designated 11 December as International Mountains Day.

Although progress has been made in understanding mountain ecosystems, little attention has been focused on the health risks faced by mountain dwellers as a result of ongoing and projected global climate change.

3

Assessing Human Health Vulnerability and Public Health Adaptation to Climate Variability and Change

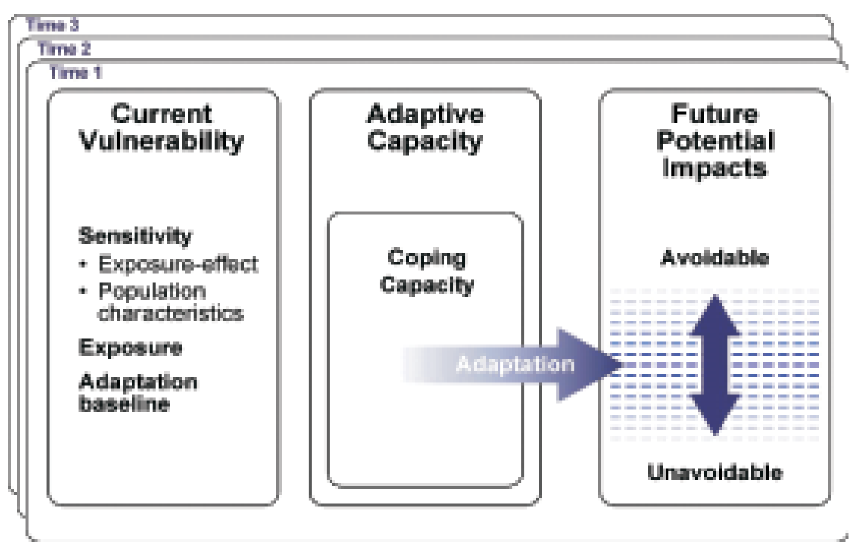
Dr Kristie L Ebi

3.1 Definitions of Vulnerability and Adaptation

Realistically assessing the potential health impact of climate variability and change requires understanding both the vulnerability of a population and its capacity to respond to new conditions. The terms vulnerability and adaptation are used by the climate change community and are analogous to the concept of prevention used in public health (Yohe and Ebi 2005). The relationships among vulnerability, adaptive capacity, and potential impacts are discussed below and shown in Figure 7.

The IPCC defines vulnerability as the degree to which individuals and systems are susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes (Smit and Pilifosova 2001). The vulnerability of human health to climate change is a function of:

Figure 7: Framework for vulnerability and adaptation.



Source: Ebi et al. 2005.

- sensitivity, which includes the extent to which health, or the natural or social systems on which health outcomes depend, are sensitive to changes in weather and climate (the exposure–response relationship) and the characteristics of the population, such as the level of development and its demographic structure;
- the exposure to the weather or climate-related hazard, including the character, magnitude and rate of climate variation; and
- the adaptation measures and actions in place to reduce the burden of a specific adverse health outcome (the adaptation baseline), the effectiveness of which determines in part the exposure–response relationship (Kovats et al. 2003).

Populations, subgroups and systems that cannot or will not adapt are more vulnerable, than those that are more susceptible to weather and climate variability. In general, the vulnerability of a population to a health risk depends on the local environment, the level of material resources, the effectiveness of governance and civil institutions, the quality of the public health infrastructure and the access to relevant local information on extreme weather threats (Woodward et al. 1998). Effectively targeting prevention or adaptation strategies requires understanding which demographic or geographical subpopulations may be most at risk and when that risk is likely to increase. Thus, individual, community, regional, and geographical factors determine vulnerability.

Adaptation includes the strategies, policies and measures undertaken now and in the future to reduce potential adverse health effects (Kovats et al. 2003). Adaptive capacity describes the general ability of institutions, systems and individuals to adjust to potential damages, to take advantage of opportunities and to cope with the consequences. The primary goal of building adaptive capacity is to reduce future vulnerability to climate variability and change. Coping capacity describes what could be implemented now to minimize negative effects of climate variability and change. In other words, coping capacity encompasses the interventions that are feasible to implement today (in a specific population), and adaptive capacity encompasses the strategies, policies and measures that have the potential to expand future coping capacity. Increasing the adaptive capacity of a population shares similar goals with sustainable development – increasing the ability of countries, communities, and individuals to effectively and efficiently cope with the changes and challenges of climate change.

Specific adaptation interventions arise from the coping capacity of a community, country, or region. These interventions, similar to all interventions in public health, are designed to maximize the number of avoidable adverse health effects. Adaptation can be anticipatory (actions taken in advance of climate change effects) or responsive and can include both spontaneous responses to climate variability and change by affected individuals and planned responses by governments or other institutions. Examples of adaptation interventions include watershed protection policies and effective public warning systems for floods and storm surges, such as advice on water use, beach closings, and evacuation from lowlands and seashores.

It is important to identify where populations are not able to cope with current climate variability and extremes (such as floods, droughts and heatwaves). This shows where additional interventions are needed now. Improving the capacity to cope with current climate variability will improve the capacity to cope with long-term climate change.

An adaptation assessment describes specific strategies, policies and measures that can be implemented to reduce current and future vulnerability as well as the resources needed (financial, technological and human capital) to implement them. The information generated from an adaptation assessment can be combined with a cost–benefit or other economic analysis to inform priority setting by policy-makers.

3.2 Steps in assessing Vulnerability and Adaptation

The steps in assessing vulnerability and adaptation include (Kovats et al. 2003):

1. Determine the scope of the assessment: the geographical region, time period and health outcomes to be included.
2. Describe the current distribution and burden of climate-sensitive diseases. Describe the associations between disease outcomes and

climate variability and change. If data and resources are available, quantify the relationships using epidemiological methods.

3. Identify and describe current strategies, policies and measures that reduce the burden of climate-sensitive diseases.
4. Review the health implications of the potential impact of climate variability and change on other sectors, such as agriculture and food supply, water resources, disasters and coastal and river flooding. Review the feedback from changes in population health status on these sectors.
5. Estimate the future potential health impact using scenarios of future climate change, population growth and other factors and describe the uncertainty.
6. Synthesize the results and draft a scientific assessment report.
7. Identify additional adaptation policies and measures to reduce potential negative health effects, including procedures for evaluation after implementation.

The available material and human resources will determine at what level vulnerability and adaptation can be assessed. A basic assessment could be conducted using readily available information and data, such as previous assessments, literature reviews by the IPCC and others, and available region-specific health data. Limited analysis may be conducted of regional health data, such as plotting the data against weather variables over time. Consultation with stakeholders would be fairly limited. The result may produce trends in disease rates, and the effects may be minimally quantified, if at all.

A more comprehensive assessment could include a literature search focused on the goals of the assessment, some quantitative assessment using available data (such as the incidence or prevalence of weather-sensitive diseases), more involvement by stakeholders, some quantification of effects, and a formal peer review of results. An even more comprehensive assessment could include a detailed literature review, collecting new data and/or generating new models to estimate impacts, extensive analysis of quantification and sensitivity, extensive stakeholder involvement throughout the assessment process, formal uncertainty analysis, and formal peer review.

No matter the degree of comprehensiveness of the assessment, valuable information can be obtained from other countries on how successfully (or not) they have dealt with similar issues. For example, the same degree of flooding does not have the same impact on different countries because of differences in vulnerability, degree of preparedness, effectiveness of early warning systems, etc. This information can be used to identify and prioritize possible adaptation options.

Assessments of the potential health effects of climate variability and change have used a variety of methods. Both qualitative and quantitative approaches may be appropriate depending on the level and type of information available. The outcome of an assessment need not be quantitative to be useful to stakeholders. An integrated approach is likely to be most informative because the effects of climate are likely to transcend traditional sector and regional boundaries, with effects in one sector affecting the capacity of another sector or region to respond.

The workshop participants used this framework to qualitatively assess the potential health impacts of and public health adaptations to climate change. The focus of the working group's breakout sessions was to understand the process of assessment and not to conduct a full assessment. Therefore, examples are given of the discussions about each step of the assessment.

4

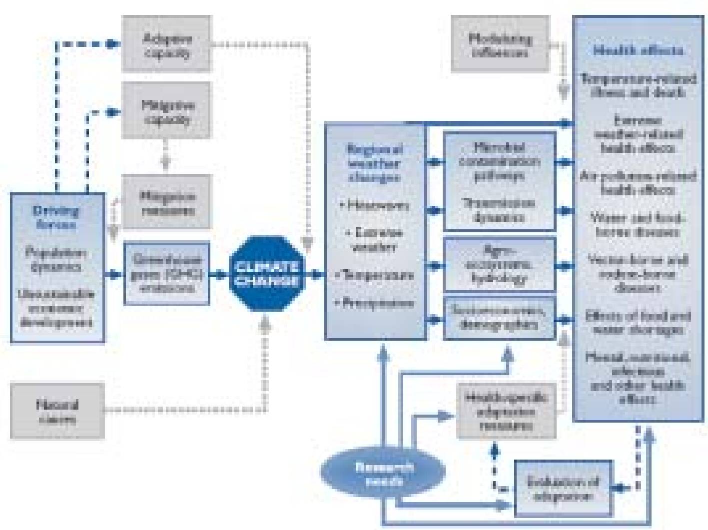
Vulnerability and Adaptation Assessment for the Hindu Kush-Himalaya Region

4.1 Overview of the Potential Health Impacts of Climate Variability and Change

Dr Carlos F. Corvalan, Coordinator,
Public Health and Environment,
World Health Organisation, Geneva:

Two well-recognized physical consequences of climate change are increasing global average temperature and extremes in the hydrological cycle. Each is projected to have negative impacts on health. The main categories of adverse health impacts of climate change have been widely discussed (e.g., McMichael et al. *Climate Change and Human Health: Risks and Responses* 2003). Three broad categories of health impacts are associated with climatic conditions: impacts that are directly related to weather or climate; impacts that result from environmental changes that occur in response to climatic change; and impacts resulting from consequences of climate-induced economic dislocation, environmental decline, and conflict. Changes in the frequency and intensity of thermal extremes and extreme weather events (i.e. floods and droughts) will directly influence population health. Indirect impacts will occur through changes in the range and intensity of

Figure 8: Potential health impacts of climate variability and change.



Source: McMichael et al. 2003.

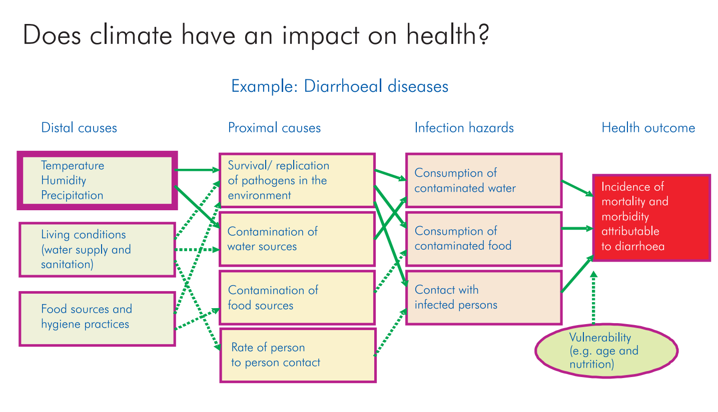
infectious diseases and food- and water-borne diseases, and changes in the prevalence of diseases associated with air pollutants and aeroallergens. More diffuse impacts are the health consequences of social and economic dislocation and of population displacement. Figure 8 illustrates some of the potential impacts of climate variability and change.

As an example, Figure 9 shows how climate change could affect diarrhoeal diseases.

Estimates by the World Health Organization suggest that the current health impacts of climate change are comparable to those of air pollution than the impacts of air pollution in South-East Asia and Africa (Figure 10).

Reducing emissions of greenhouse gases will reduce emissions of other air pollutants that have negative health effects, resulting in co-benefits to health of mitigation.

Figure 9: Does climate have an impact on health?



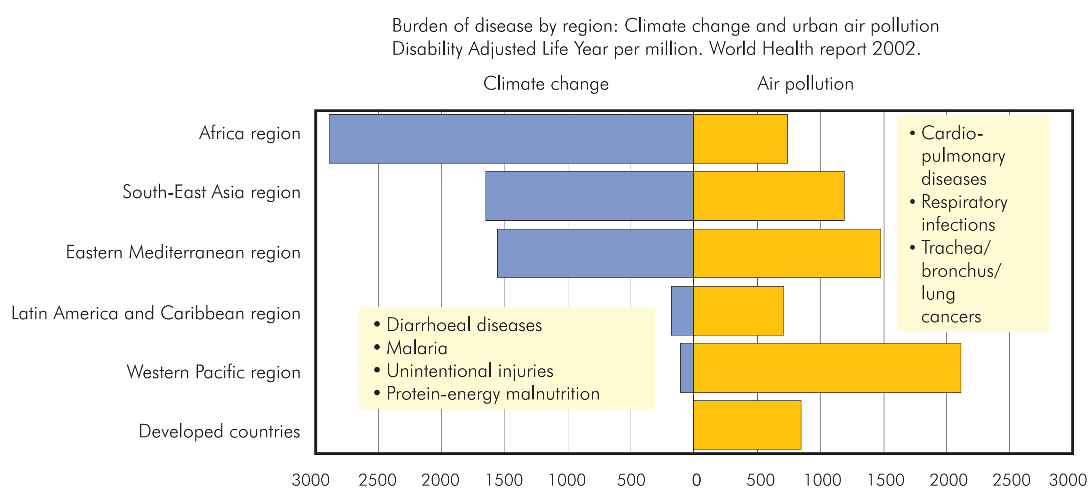
Source: Corvalan and Campbell-Lendrom, 2003.

4.2 What is the Current Distribution of Climate-sensitive Health Determinants and Outcomes in Mountain Regions?

Dr Kristie L Ebi, Ms R Uma, Coordinator, The Energy and Resources Institute, India Workshop participants

Understanding the impacts of climate variability and change at the local and regional level requires information from multiple sectors. However, because health surveillance data are not usually available at the local level, it is difficult to obtain

Figure 10: Does climate change have a large impact on health?



Source: Corvalan, 2003

detailed estimates of the burden of climate-sensitive diseases specific to mountain regions. Climate change-related impacts on mountain ecosystems could affect population health by creating favourable conditions for disease vectors; forest fires; avalanches, heavy snowfalls, major storms, floods, and droughts; depth and duration of snow cover and length of snow-free season; and changes in cloud cover and sunlight available, such as:

- Higher morbidity and mortality from extreme weather and climate events. Four types of floods are common in tropical Asia: riverine floods, flash floods, GLOFs, and breached landslide-dam floods. Flash floods are common in the foothills, mountain borderlands, and steep coastal catchments. Riverine floods occur along the courses of the major rivers, broad river valleys, and alluvial plains.

- Expansion of insect- and rodent-borne diseases. Many vector-borne diseases are sensitive to ambient temperature and precipitation. Even small changes in temperature and precipitation, or in vegetation, host populations, or water availability, may increase or decrease the distribution and abundance of vectors, especially at the margins of their distribution, thus potentially changing their range. For example, a number of research groups have modeled the potential for malaria to spread as a consequence of global climate change (Martens *et al*. 1999; Rogers *et al*. 2000; Tanser *et al*. 2003; van Lieshout *et al*. 2004; Ebi et al. 2005). These models include both climate suitability and data on populations at risk, and statistical and biological approaches to modeling. The model results are consistent in that most of the future spread of malaria is projected to occur at the edges of the current geographical distribution where climate affects transmission, generally because it is too cold for transmission to occur. Other vector-borne diseases in mountain regions include Bartonellosis and tick-borne encephalitis (Daniel et al. 2004; Chamberlin et al. 2002; Maguina and Gotuzzo 2000). In addition, temperature changes can affect the rate at which pathogens replicate within vectors. Climate, along with other factors, can facilitate the emergence and re-emergence of infectious diseases.

- Increased water-related diseases. Diarrhoeal diseases are one of the major causes of morbidity and mortality in developing countries. In 2002, worldwide, diarrhoeal diseases caused 1 767 000 deaths (out of a total of 57 027 000 deaths) and 61 095 000 Disability Adjusted Life Years Lost (DALYs) (out of a total of 1 491 416 000 DALYs) (WHO WHR 2003). In the mortality stratum in South-East Asia with high child and adult mortality, diarrhoeal diseases caused 559 000 deaths (out of a total of 12 428 000 deaths) and 18 695 000 DALYs (out of a total of 363 035 000 DALYs).

  In many mountain regions, the quantity, variability, and timing of runoff from snowmelt and glaciers can directly and indirectly affect the incidence and prevalence of water-related diseases. Water-related infectious diseases have four means of transmission: infections spread through water supplies (water-borne); infections spread through lack of water (whether clean or contaminated) for personal hygiene (water-washed); infections spread through an aquatic invertebrate host (water-based); and infections spread by insects that depend on water (Bradley 1977). These categories are not mutually exclusive; many diarrhoeal diseases have more than one means of transmission. All means of transmission are likely in mountain regions. The importance of diarrhoeal diseases in mountain regions has been shown in a number of recent studies (i.e. Pokhrel and Vivaraghavan 2004; Moffat 2003; Bohler and Bergstrom 1996; Pokhrel and Kubi 1996).

- Malnutrition resulting from disturbance in food production or distribution, but also from loss of agricultural land due to flash floods and to consequent soil erosion. More research is needed on how climate change could affect animal health, in particular the range and incidence of various diseases that could affect humans, either directly through disease or indirectly through food security.

There is considerable evidence that climate change will affect the beginning of the pollen seasons, and that it may affect the quantity of pollen produced, pollen allergenicity, and other factors that determine plant and pollen distribution. There is also some evidence of climate change-related impacts on other aeroallergens, such as mould spores. There are many research challenges to a more complete understanding of the impacts of climate change on aeroallergens and allergic diseases, such as asthma and hay fever, and to understanding how long-range transport of pathogens may change with climate change.

These health impacts are also influenced by changes in other sectors, such as deforestation, availability of safe water, and agriculture.

4.3 Climate Change and Health Vulnerabilities in the Hindu Kush-Himalayas

The following text boxes summarise some examples provided by the workshop participants of current vulnerabilities in the Hindu Kush-Himalayan countries.

The potential health impacts of climate change across the Hindu Kush-Himalaya region are not confined to morbidity and mortality from climate-sensitive health determinants and outcomes, but also include socio-economic impacts. For example, climate change-related changes in vegetation or snow cover can lead to alterations in the productivity of agriculture, logging, and hydropower, which, in turn, can affect the resources and lifestyle of indigenous populations.

A survey of climate change-related impacts on life and livelihood in Nepal found both positive and negative changes (Dahal 2005). For example, apples would grow larger and would have more flavour at high altitudes where it used to be too cold for apple farming. Older adults are finding their homes and villages more comfortable due to the warmer winters. Tourism is profiting from longer drought periods in post-monsoon months.

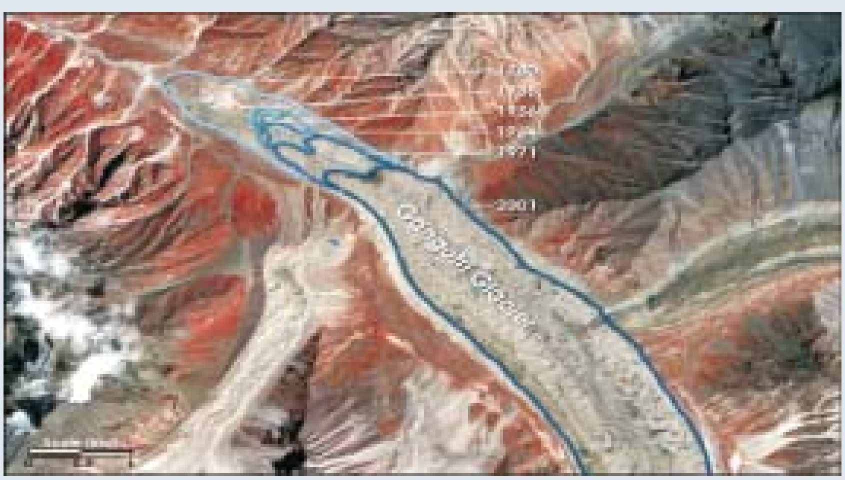
Climate change will exacerbate current environmental problems and these factors could negatively affect the quality of life and the potential for economic growth. These effects would be felt in both mountain regions

Box 3: India

Dr Ananthanarayan, Dir., All India Institute of Hygiene and Public Health, Kolkata, India

A major concern for India is the projected reduction in water availability as a result of reduced snowmelt from glaciers in the Himalayas, particularly from the glaciers that are the source of the Ganga. Gangotri is the longest Indian glacier (26 km) and is currently retreating at a rate of 20 metres per year, compared to 16 metres per year in the past.

If the present trend continues, the Ganga will initially swell in volume (due to increased snowmelt), then shrink as snowmelt reduces in subsequent years. This will endanger the lives of 400 million people who live on the river's plains and depend upon it for water.



Retreat of the Gangotri Glacier, 1780 to 2001
(Photo credit: NASA at http://earthobservatory.nasa.gov/)

Recent climate emergencies in India included a super cyclone and heatwave in Orissa (1999 and 2004), a cold wave in Uttaranchal and Uttar Pradesh (2004), a tsunami affecting Tamil Nadu, Andhra, Kerala, and the Andaman-Nicobar Islands (2004), floods in Madhya Pradesh and Gujarat (2005), rains and floods in Maharashtra (2005), and a cyclone in Andhra Pradesh (2005).

Box 4: Kashmir, India

Dr Rais Akhtar, University of Kashmir, Srinagar, India

In the Kashmir region in Northern India, changes associated with changing environmental conditions, also because of urbanization, have been noted. These include:

- Temperature increases were pronounced during the 1990s, with 1997 recording the highest temperatures on record. The maximum and minimum temperatures have increased from 0.1 to 0.8°C over the past few decades.
- To date, only imported cases of malaria have been reported. However, there is concern that malaria may re-emerge in this region with increasing temperatures.
- In the last decade, heat events have been increasing: rainfall in Srinagar appears to have been declining, and Kashmir has experienced warmer than average winters, with snow melting as early as January and droughts occurring in the summer months of July and August.
- In the Kashmir valley, food and water shortages have been reported during what have traditionally been wet summer months, with water having to be trucked in on occasion. There has been an increase in water-borne diseases and skin problems due to water shortages.
- People use a basket (kangri) of charcoal for household burning. Charcoal burning now occurs less due to the increasing warmer winters, resulting in a decrease in respiratory diseases.
- Twenty years ago, families did not possess electric fans. Now almost all families (even poor ones) have acquired fans and refrigerators.

Box 5: Bhutan

Dr Wangchuk, District Medical Officer, Sarpang Hospital, Sarpang, Bhutan

The population of Bhutan is 851 000 (2004) with 75% of people living in rural areas. The majority of the country's income comes from agriculture (79%), with hydropower making a significant contribution. Both sectors are vulnerable to climate change. Bhutan is divided into three areas: foothills (hot summer, cool winter), inner region (cool summer, cold winter), and the greater Himalayas (cold/snow).

The key environmental stresses and vulnerabilities in Bhutan include:

- Glacial lake outburst floods (GLOFs) and their threats. GLOFs can release a huge amount of water and debris, often with catastrophic effects. There are 2674 glacial lakes and 562 glaciers in Bhutan. Of these, 24 are considered to be potentially dangerous. Glacial lake floods occurred in 1957, 1960, 1968, and 1994, leading to severe flooding and loss of life downstream. The Thorthorme and Raphstreng glaciers and their lakes are highly dangerous and are moving at the rate of 130 ft/year. The developing Thorthormi lake is 50-60 metres above the Raphstreng lake. This glacier complex is in imminent danger of bursting, which could release 50 million cubic metres of water, a flood reaching to northern India 150 miles downstream. A major glacial lake flood is projected by 2010. (More at: www.raonline.ch/pages/story/bt/btbg_glacier02a.html#lunana) A glacier lake early warning system has been instituted, but it is hampered by difficulties in gathering information, due to local climate, access, and other issues.
- Flash flood, landslides, and their impacts. Major flash floods/land slides occurred in 2000 (July-August), 2003 (August), and 2004 (July-August). The Kurichu hydropower project was damaged in the 2003 flood.

- The spread of vector-borne diseases (especially malaria and dengue) into new areas (particularly high elevations). Mosquitoes have recently been observed at higher altitudes. Other vulnerabilities are the loss of life from flash floods, glacier lake floods, and landslides. Decreasing safe drinking water sources may increase the incidence of water-borne diseases.
- Current activities to address vulnerabilities include a malaria control programme; clean water supply scheme (urban and rural); health hygiene campaigns; and preliminary work to establish an Emergency Medical Service. A disaster management office was created in January 2005.

The following projects have been proposed (ranked in order of priority for implementation):

- artificial lowering of the Thorthormi glacier lake;
- development of a national weather forecasting system;
- restoration of landslide-affected areas and flood prevention;
- integrated land and water management (especially in the Ranjung catchment);
- rainwater harvesting;
- glacial lakes hazard zoning in pilot river basins;
- an early warning system for glacial lake floods (such as for Phu-chu); and
- forest fire management scheme. In addition, vulnerable areas are being mapped to identify areas for resettlement.

Additional proposed adaptation activities include protection of water treatment plants to ensure current and increase future safe drinking water supplies; develop proper waste disposal methods; regular campaigns to clear mosquito breeding sites and the control of vector-borne diseases in new regions; and monitor air and drinking water quality.

Box 6: Nepal

Mr Risi Sharma, Senior Meteorologist, Department of Hydrology and Meteorology, Kathmandu, Nepal

Nepal is a landlocked mountainous country that has an elevation ranging between 60 and 8848 meters, and a population of 23.2 million living on an average annual per capita income of US$224. Agriculture is the source of income for 80% of the population. The climate ranges from sub-tropical to arctic. Annual rainfall varies from 250-5000 mm, with 80% falling during the monsoon months (June to September). Maximum temperatures can be 46°C in the plains. Ambient temperatures have been increasing by 0.041°C per decade. Extreme climatic conditions are believed to be increasing. In September 2005, about 36 people were killed by landslides and floods in the far-western area. At the same time, the rest of the country was experiencing drought.

There is rapid net shrinkage and retreat of glaciers and an increase in the size and number of glacial lakes. Glacier retreat in Nepal is around 1 sq km per year (0.22% per year). Water from melting glaciers is feeding glacial lakes. While 345 glacial lakes are growing, 12 new glacial lakes are forming. The Tsho Rolpa glacial lake has increased six-fold since 1957. There are about 20 glacial lakes that are considered to be potentially dangerous. Earthquakes pose a great risk in terms of damaging the side of lakes and causing GLOFs.

Human health and well-being are greatly affected by GLOFs, which wash out agricultural land and infrastructure such as bridges, and sever communication for extended periods for people living in the flood pathway. For example, a GLOF that originated in China washed out the road connecting China and Nepal: it took two years to replace it. A full risk assessment is being conducted of all glacial lakes in Bhutan and Nepal, after which the human impacts (which depend on the size and volume of lakes, as well as downstream topography) will be evaluated and mitigation activities prioritized.

Nepal: Retreating AX010 Glacier at Shrong Himal, Nepal.
(Photo credit: World Wildlife Fund –WWF, Nepal)

The diseases causing the largest health burdens are diarrhoea, dysentery, malaria, Kala-azar, and Japanese encephalitis. The incidence of Japanese encephalitis and Kala-azar are increasing across Nepal and malaria is decreasing due to control activities. Some regions are expected to become vulnerable to malaria, Kala-azar and Japanese encephalitis due to rapid climate change. Growing chemical resistance to insecticides used for vector control means this may soon not be effective. Nepal does not have a climate change and health institution.

Box 7: Afghanistan

Dr Gulam Abbasi, Ministry of Public Health, Afghanistan

Afghanistan's population is 22 million, spread across 54 provinces and 363 districts. The environmental condition of Afghanistan is in crisis. Access to safe water and sanitation is very low, and the mortality and morbidity rate of children and mothers is very high. Malaria, tuberculosis, and cholera are common diseases, with noise pollution a problem. There are no resources for managing toxic chemical waste. Following a three-decade war, the social and economic situation is very poor and the capacity is extremely low. Information about climate change and health is needed.

and in adjacent lowland areas where people rely on the resources that mountains provide, particularly water.

Research challenges to help in better understanding the relationships between climate change and health include that a particular weather pattern is associated with more than one health endpoint (e.g. high ambient temperature can cause heat stress, reduced crop yields that adversely affect crop security, etc.); lack of an unexposed group; lack of a baseline before anthropogenic climate change began; spatial and temporal variations in disease determinants and outcomes; and analytic challenges. There are additional challenges in generating and using climate and socioeconomic scenarios. Effectively analyzing vulnerability and adaptation to climate change requires working across disciplines and agencies. The remoteness of many mountain regions adds to the complexity. Further, these regions tend to have a poor health infrastructure, low income, and ecosystems under stress from multiple external factors.

The way forward to reducing the burden of climate-sensitive disease determinants and outcomes in mountain regions is through better dialogue between the assessment and analytic processes, and through action and intervention. Improvements in health surveillance, climate monitoring, geographical mapping, and estimating costs of climate change impacts are needed for assessment and analysis activities. Improvements in vector-control, disaster preparedness, institutional mechanisms, and integration of the environment and health sectors are needed for action and intervention. In addition, energy and environment polices should be assessed. Although there is much to be learned, lack of information cannot justify delaying action on climate change.

Public health has the opportunity to develop early warning systems based on improvements in weather forecasting. For example, El Niño can now be predicted a year or more in advance. The Pacific ENSO Application Centre used this information to design successful interventions to reduce disease burdens during the 1997/98 El Niño. (More at: http://lumahai.soest.hawaii.edu/Enso/)

The workshop participants qualitatively assessed the presence and current burden of climate-sensitive health determinants and outcomes in their countries and in mountainous regions in general. Table 5 summarizes the results of discussions on the presence of climate-sensitive diseases and Table 6 shows an example of an estimate of the current burden of disease. Table 7 summarizes discussions of which population groups in mountain regions are most vulnerable to the health determinants and outcomes of concern. It was decided after discussions of Table 5 and 6 to add filariasis to the list of vector-borne diseases of concern, so it is included in Table 7.

4.4 What are the Potential Future Health Impacts of Climate Change in Mountain Regions?

Many mountainous regions can be expected to experience an increasing burden of disease from climate-sensitive health determinants and outcomes. Future vulnerability is likely to exceed any response capacity unless the public health agencies and authorities take the threat of climate change seriously and begin implementing adaptation policies and measures to increase resilience, and initiate actions to reduce emissions of greenhouse gases. Studies are needed of the potential health impacts of climate change on mountain dwellers under different climate change scenarios, to prioritize action.

4.5 What Current Interventions are being used to Reduce the Burden of Climate-Sensitive Diseases? What additional Interventions are needed in Future?

Interventions for reducing the health impacts of climate variability include effective health education programmes, improvement of health care infrastructure, intersectoral disaster preparedness plans, integrated vector monitoring and control, and appropriate sewage and solid-waste management practices. For example, most of the countries represented have national disaster management committees that are comprised of all relevant ministries, including the ministry of health. Dissemination of

Table 5: Health determinants and health outcomes that currently exist in mountain regions or are related to mountains: Synthesis of country reports.

Country	Afghanistan	Bangladesh	Bhutan	China	Nepal	India
Heatwaves	+	+	–	+	+	+
Glacial lake floods	M	–	M	M	M	M
Flash floods	M	+	M	M	M	M
Riverine (plain) floods	+	+	–	+	+	+
Malaria	+	+	+	+	M	+
Japanese Encephalitis	–	+	–	+	+	+
Kala-azar	+	–	–	–	+	+
Dengue	–	+	+	+	–	+
Water-borne diseases	M	+	M	M	M	M
Water scarcity, quality	M	+	+	M	M	M
Drought-related food insecurity	M	+	–	M	–	M

An "M" indicates the health determinant or outcome is present in the mountainous region of the country (and also in the non-mountainous areas); a "+" indicates the health determinant or outcome is present elsewhere in the courtry; a "–" indicates the health determinant or outcome is not present.

Table 6: Example of estimate of current burden of disease for Bhutan.

Health determinant	Occurrence	
	C	M
Heat waves	0	0
Glacier lake floods	1	3
Flash floods	2	3
Riverine (plain) floods	2	0
Malaria	3	1
Japanese Encephalitis	0	0
Kala-azar	1	1
Filariasis	1	1
Dengue	2	0
Water-borne diseases	2	2
Water scarcity	1	1
Drought-related food insecurity	1	1

Where the burden is estimated for both the country (C) and mountain regions in that country (M), with the scale = none (0), low (1), medium (2), high (3).

information to individuals, hospitals, district medical offices, and others is through electronic and print media. A communication issue in mountain regions is that mountains often block signals for cellular telephones, limiting their usefulness.

For example, in India, programmes to address climate-sensitive disease determinants and outcomes include the following: Integrated Disease Surveillance Program, National Vector-Borne Disease Control Programme, National Water Quality Surveillance Programme, National Pollution Control Measures, National Disaster Management Plan, National Education Policy, National Water Policy, and National Population Policy. The Indian government has shifted disaster efforts from rescue and relief to preparedness, mitigation, reconstruction and sustainable development. Forecasting programmes include a cyclone detection tracking system, flood forecasting and warning systems and meteorological stations for drought monitoring, and a tsunami warning system.

The fact that the impacts of weather-related disasters on human health can be direct, indirect, multiple, simultaneous, and significant poses major challenges to governments, policy-makers, decision-makers, and resource managers. Hazard or risk mapping can be useful for the development of a disaster management plan. The map could include areas of important food sources, water sources, areas at risk of flooding, population centres, industrial sites and other areas determined to be important or at risk. For example, all countries represented are at risk of flooding and have begun or would like to begin monitoring of precipitation and water levels in regions known to be at risk.

The ability to predict climate variations on a seasonal or inter-annual scale presents communities with the opportunity to develop the capacity and expertise to deal with climate variability, which will also help communities prepare for the effects of climate change. An intervention that is gaining interest is the development of early warning systems for diseases or climatic events based on climate forecasts and environmental observations. Effective early warning involves developing appropriate response strategies, designing strategies for public dissemination of early warning information, and developing mechanisms for evaluating the effectiveness of the system. For example, Bhutan has established an inventory of glacier lakes to determine which ones are dangerous and has installed an early warning system for one lake region that is particularly at risk. The early warning system includes training for appropriate community responses when a warning is issued. It is obviously not possible to evaluate the effectiveness of this system.

When considering what additional policies and measures are needed to reduce the projected burden of climate-sensitive health determinants and outcomes, it can be useful to categorize interventions into ones that will be implemented in the short-, medium- or longer-term. One approach is to identify for each intervention the objectively identifiable indicators, the means of verifying these, and the assumptions made regarding the goal, purpose, output, and input. An example of a short-term goal would be to increase awareness of the impacts of weather and climate on human health. A medium-term goal could be to improve livestock management to decrease disease transmission. A long-term goal could be to modify water-resource management to reduce waterborne diseases.

Table 7: Vulnerable populations for climate-sensitive health determinants and outcomes.

Health determinant or outcome	Vulnerable populations
Heatwave mortality	Slum dwellers, elderly, children, agricultural and outdoor labourers, urban areas, crowded and unventilated workplaces, homeless people
Glacial lake floods	Elderly, poor, nomadic, children, disabled or infirm, women, independently living ethnic groups in remote areas
Flash floods	Everyone in the path of the floods
Riverine (plains) floods	Elderly, poor, nomadic, children, the disabled or sick, women, and people in poor housing, coastal areas, institutions, or on isolated islands
Malaria	Children, pregnant women, slum dwellers, homeless, migrants, poor environmental hygiene, independently living ethnic groups in remote areas
Japanese encephalitis	Farm workers (especially in paddy fields), children, people living with pigs
Kala-azar	People on ground floors of buildings in endemic areas, poor
Dengue	People in urban areas
Filariasis	Poor in coastal or high humidity areas
Food-borne diseases	Not noted
Water-borne diseases	Children, women, poor people, lack of access to clean water and sanitation, flood areas, people with poor access to health & hygiene
Water scarcity & quality	Children, women, poor people, lack of access to clean water and sanitation, flood areas, uneducated people (re health & hygiene)
Psychosocial stress	Not noted
Loss of livelihood	Not noted
Drought-related food insecurity	Children, elderly, pregnant women, women in general

Box 8: Heat/health problems in Shanghai associated with urbanization and climate change

Mr Tan Jianguo, Director of Shanghai Urban Environmental Meteorology Research Centre, Shanghai Meteorological Bureau, Shanghai, People's Republic of China

Annual mean temperatures have been increasing in China over the last 50 years, varying from 0.2°to 0.8°C across regions. Temperature increases have been greatest in the major cities. The average annual temperature increase during the period 1960-2004 in urban regions was 0.47°C per decade, compared to 0.19°C in the rural areas. Therefore, 0.28°C (60%) of the average decadal increase can be attributed to urbanization factors. Satellite images have shown an increase in the urban heat island in Shanghai (during the period 1992 to 1998). Since the Shanghai Council developed and implemented a policy of greening Shanghai, the intensity of the urban heat island has reduced.

The incidence of hot days in the last 30 years increased significantly. A heatwave watch-warning system has been developed: the meteorological department issues a warning via radio and television to the public about the strength of an upcoming heat event. Monitoring and evaluation of a heat wave warning system is essential to identify which parts of the system are effective.

4.6 What are the Health Implications of Climate Change in other Sectors?

Climate change will interact with and exacerbate other factors that contribute to the vulnerability of a particular region. For example, mountains act as 'water towers' by storing water in glaciers, permafrost, snowpack, and as soil and/or groundwater. Both the amount of water available and the timing of its release are dependent on the weather. Changes in mountain climate will have serious repercussions for water supply, particularly in the arid and semiarid regions of the tropics and sub-tropics because mountains supply nearly half of the human population with clean water, even in regions far away from mountains. Reduction in glacier volume will impact dry-season river flows in rivers fed largely by ice melt (Haeberli and Beniston 1998). This will very likely influence the provision of downstream water for drinking, irrigation, and hydropower.

Special efforts and techniques are needed to sustain agricultural production at altitudes close to the treeline. Mountain dwellers have generally developed productive agro-ecosystems, involving terracing, enclosures, and irrigation. Pastoralism and forestry are more adapted to mountain ecologies and are the predominant uses of mountain land in Hindu Kush-Himalaya regions. Maintaining and adapting such agroecosystems to climate changes in a sustainable manner could help prevent sharp increases in vulnerability to food insecurity, malnutrition, famine, and rural exodus.

Box 9: Climate change, land use transition and human health in Himalaya: current knowledge

Dr Mats Eriksson, International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal

It is important to have a watershed and land use perspective when considering the issues of climate change and health. The Himalayas are the source of many major river systems, and downstream issues need to be kept in perspective. In this region, there is projected to be an increasing difference between the wet and dry seasons, with wetter wet seasons (and increases in flash floods), drier dry seasons (increased stress on water resources, with implications for water quality), and an increase in the length of heat waves. The extent to which crops will be able to adapt to these polarized seasons is unknown. The Hindu Kush-Himalaya countries are currently quite vulnerable to floods; half of water-related disasters in the region are due to floods. Unsafe water quality kills more people than any other single factor. During the wet season, floods flush faeces into water sources. During the dry season, the lack of water availability increases the risk of water-borne diseases.

Land use change resulting in reduction of ecosystem services is causing stress on marginal populations. For example, widespread deforestation has led to increasing numbers of deaths from flooding. The draining of wetland areas removes the "sponge" effect of the landscape and hence the ability to store water during a season of plenty for use in drier seasons. Environmental hazards are likely to increase in future. Land use decisions taken today can aggravate or minimize environmental hazards. Land use decisions (cropping, deforestation, settlements, dams etc.) influence the availability of water.

It is important to address land use change and climate change together by, for example, utilizing land in ways that decrease discharge down steep mountain valleys from high rainfall events. Environmentally sound vegetated hill slopes (agriculture, natural forest) are better than terraced hill slopes, which are better than open plain slopes. Water harvesting can decrease the differences in water available between wet and dry seasons.

All arable land in Nepal is under cultivation and population growth is increasing. People are migrating from mountain areas to the plains to earn money to send back to their families. Other and better income sources are needed. Medicinal plants and high value crops could make it possible to utilize the land in a sustainable way. Although forests minimize landslides, improve the sustainable use of land, and improve water quality from a watershed, not deforesting comes at the cost of short-term local income sources. It is important to recognize the degree to which people downstream gain from the ecosystem services upstream, and determine how local populations could be financially recompensed for taking appropriate actions, such as not deforesting an area.

Box 10: The Global Environment Facility within the United Nations Development Programme

Dr Bo Lim, Principal Technical Adviser, United Nations Development Programme, Capacity Development and Adaptation, Global Development Facility, Energy and Development Group, New York, USA

The Global Environment Facility (GEF) was established in 1991 in response to the Rio conventions. The environment has innumerable dimensions, but to address problems plaguing the environment, scientists and policymakers divide them into aspects that are primarily local, national, regional, and global in nature. Although these aspects are interrelated, the GEF focuses on challenges that are global in scope: biodiversity; climate change; international waters; ozone depletion; and land degradation. The Earth's atmosphere, biosphere, and hydrosphere are the common heritage of humankind. The GEF is the only multi-lateral funding mechanism to address the burden of critical global environmental issues; it specifically addresses new and additional funds needed for adaptation over other development needs. US$1 billion was allocated for the pilot phase of the GEF (1991-1994). The GEF is now at the end of the 3rd replenishment (2002-2005) and there is agreement for a 4th replenishment (of some US$3 billion). Although it appears there has been an increase in funding across this period, the number of conventions that the GEF is servicing has increased, and in real terms the total funds have declined. Over the next 10-15 years, it has been estimated that US$60-90 billion will be needed to address and implement poverty-environment goals. For climate change about the same amount again is needed. Clearly, the funds available via the GEF are not nearly enough to fill this need, so the GEF resources need to be used as a catalyst for change. The health sector should be thinking: what are the priorities for GEF funds? How can existing resources be better used to reduce climate risks? Who should be doing this work?

5 Conclusions and Recommendations

The participants in the Inter-Regional Workshop on Human Health Impacts from Climate Variability and Climate Change in the Himalayan Region:

- became more aware of the rapid onset of climate variability and change in mountain regions and in particular the Hindu Kush-Himalaya;
- identified the potentially significant health impacts from the rapid climate change that is projected to occur over the next decades; and
- identified and proposed intersectoral and trans-boundary strategies for evidence-based and timely interventions for the most vulnerable populations.

The participants proposed a framework for action to prevent and adapt to the health impacts from increasing climate variability and change in the Hindu Kush-Himalaya mountain region.

The main objectives of the framework were to:

(1) Describe the exposure-response relationships between climate and health, identify the current distribution and calculate the burden of climate-sensitive health determinants and outcomes, with special emphasis on the most vulnerable populations

(2) Identify and review existing strategies, policies, and awareness and capacity building measures to reduce the burden of climate-sensitive health determinants and outcomes (adaptation baseline) and evaluate effectiveness of existing interventions.

(3) Review the health implications of the potential impacts of climate variability and change on other relevant sectors.

(4) Estimate future health impacts under different climate change and socioeconomic scenarios.

(5) Identify additional adaptation measures needed to reduce future estimated negative health effects.

(6) Identify approaches to mitigate the emission of greenhouse gases by: ensuring a stronger engagement of the heath sector in the national regional and global climate change negotiations, and by minimizing greenhouse gas emissions from the health sector itself (such as energy efficiency, alternative fuel supplies).

The participants noted that while adaptive measures and interventions to protect human health from the consequences of climate change require immediate attention, mitigation measures, in the form of reduced emissions by all countries, are vital. Countries that have contributed the majority of greenhouse gas emissions should acknowledge their responsibility for generating climate change and consequent health impacts, reduce their emissions, and support mountain regions in adapting to climate change, to help ensure the long-term sustainability of mountain regions.

The participants identified recommendations to address the following areas of action: data, research, and resource needs; policy; adaptation options; awareness and capacity building. The participants also agreed on the immediate steps to be undertaken at country level to implement the framework contents. Further activities should focus on populations and areas that are most vulnerable to climate-sensitive health determinants and outcomes.

Data, Research, Resource Needs

The current evidence supports the view that climate change accelerated by humans is now affecting mountain regions. Human health impacts are being experienced by local people, and by distant populations that rely on the ecosystem services provided by mountain regions (particularly water quality and quantity).

Climate-sensitive health determinants and outcomes of concern in the Hindu Kush-Himalaya regions include: glacier lake outburst floods; flash floods; landslides; riverine floods; malaria and other vector-borne diseases; water-borne diseases; water scarcity (quality and quantity); food insecurity; dust storms; and forest fires.

Populations that are particularly vulnerable in these mountain regions include the poor, children, women, the elderly and independently-living ethnic groups in remote areas.

The burden of some of these health determinants and outcomes is increasing. There may be other health determinants and outcomes of concern, but the evidence base is yet limited.

There is an urgent need to:

- Collect more accurate and comprehensive health, meteorological, environmental, and socio-economic data, and indigenous knowledge at appropriate local, regional, and temporal scales.
- Obtain political, financial, and technical support for long-term and ongoing data collection and analysis.
- Determine the current climate-sensitive population in each country.
- Conduct analysis to better understand the current relationship between weather/climate and health determinants and outcomes, and to use this more accurately to project the health impacts of climate change (positive and negative).
- Better understand the relationships between dust storms, air pollution, non-communicable diseases, and climate change.
- Better understand how climate change could interact with population growth and other drivers to affect water quantity and quality, and food security.
- Better understand the health-seeking behaviour of people in the Hindu Kush-Himalaya mountain region.
- Develop health and environmental indicators for monitoring and evaluating the health impacts of climate variability and change.
- Create partnerships that involve all relevant stakeholders (particularly climate/meteorology, environment, and public health/medical specialists) to develop and improve:
  - national and regional climate forecasting, and the downscaling of climate change projections
  - the response to climate variability and change in health impacts.
- Assess the health benefits of reductions in greenhouse gas emissions and emission sources.

Policy Advocacy

- Ensure that recommendations from this workshop receive full consideration in ongoing policy processes at the local, national, regional, and global levels.
- Ensure that messages regarding the health impacts of and possible adaptation measures to climate variability and change in mountain regions are directed at political, financial, and religious leaders.
- While adaptive measures and interventions to protect human health from the consequences of

climate change require immediate attention, mitigation measures, in the form of reduced emissions by all countries, are vital. Countries that have contributed the majority of greenhouse gas emissions should acknowledge their responsibility for generating climate change and consequent health impacts, reduce their emissions, and support mountain regions in adapting to climate change, to help ensure the long-term sustainability of mountain regions.

- The reduction of greenhouse gas emissions should occur at the individual, community, and national levels.
- Climate-sensitive health determinants and outcomes should be included in future reporting on the Millennium Development Goals.

Adaptation Options

- Adaptation measures are urgently needed to address the projected health impacts of climate variability and change in mountain regions. At a minimum, the existing infrastructure and interventions designed to minimize climate-sensitive health determinants and outcomes need to be strengthened.
- Ensure that the human health risks of climate variability and change are addressed in national emergency preparedness response plans.
- Use a systems-based approach to develop adaptation options that increase resilience to the full range of drivers that affect population health. Adaptations should be:
  - implemented over the short, medium, or long term
  - specific to the local health determinants and outcomes of concern
  - facilitate the development of community-based resource management, and
  - determine the costs and benefits of different interventions.
- Promote sustainable water resource use and management to prevent, mitigate, and adapt to the forthcoming water scarcity. Ecological sanitation solutions should be considered.
- As the estimated health impacts of climate variability and change are common to many mountain regions, regional collaboration is required to:
  - effectively and efficiently address cross-border hazards (for example, vector surveillance and control)
  - develop and install early warning systems for flash floods and glacier lake floods (including the collection, analysis, and exchange of data); and
  - improve disaster management and community preparedness and adaptation.
- Create, promote, and strengthen national, regional, and international working groups, non-governmental organizations, and civil society, to develop appropriate adaptation options.
  - Ensure that appropriate sectors, regions, and disciplines are included.

Awareness and capacity building

- Strengthen and integrate national information management on climatological, geo-hydrological, land-use changes, and disease statistics.
- Facilitate understanding of the scientific evidence and interdependencies among climate variability and change, human livelihood, disasters, and disease vulnerability in mountain regions at country and intercountry levels.
- Build awareness amongst political and financial leaders, including local and religious leaders, of the projected health impacts of climate variability and change on populations in mountain regions.
- Develop learning resource materials for local communities (particularly women and children), health and other relevant professionals, and the media on the potential health impacts of climate variability and change and on appropriate measures to reduce climate-sensitive health determinants and outcomes.
  - Develop materials for health education, health promotion, and behavioural change committees.

- Develop school and university curriculum.
- Ensure that school and media programmes are of sufficient length and frequency that critical information is communicated.
- Ensure that messages are communicated effectively, including translation into local languages.

• Seek training and technical assistance from the World Health Organization, World Meteorological Organization, United Nations Development Programme, the United Nations Environment Programme, and other international agencies on:

- Development of programmes on climate change and health, such as exchange programmes and short courses.
- Methods to determine the environmental burden of disease.
- Methods for cost-effective analysis of environmental health interventions specific to climate change and health.
- Measures for "greening" the health sector.

• Organize national and regional workshops with support from the World Health Organization and other relevant agencies to address all aspects of climate change and health, including mountain regions.

- Include in WHO/Ministry of Health work plans for 2006/2007.

The workshop participants agreed on the following next steps:

At the country level, the workshop participants, or a nominated person, will:

1. Submit a formal report on the workshop outcomes to the relevant authorities in each country.
2. Disseminate information through professional media, webpages, and relevant organizations.
3. Use the workshop recommendations as input for a national policy on climate change and health impacts.
4. Prepare, if possible through environmental health cells, a proposal detailing inter- and intrasectoral stakeholder meetings to highlight the issues raised in the workshop.
5. Prepare a national inventory of key stakeholders for addressing the health impacts of climate variability and change.
6. Identify available resources (people, materials, methods, and finances) to address health impacts of climate change.
7. Engage in local, regional, and national initiatives to reduce climate-sensitive health determinants and outcomes.
8. Encourage governments, when negotiating climate change issues, to include health concerns.
9. Become involved in the preparation of the regular National Communications under the United Nations Framework Convention on Climate Change.

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Glossary

Adaptation is the strategies, policies, and measures undertaken now and in the future to reduce potential adverse health impact.

Adaptive capacity describes the general ability of institutions, systems and individuals to adjust to potential damages, to take advantage of opportunities, or to cope with the consequences of climate change in the future.

Alpine zones are the treeless areas between the natural climatic forest limit and the snow line.

Attributable burden is the reduction in current burden that would have been observed if past levels of exposure to a risk factor had been reduced to zero. The attributable burden is the attributable risk multiplied by the disease burden.

Attributable risk is the proportion of disease burden in an exposed population that can be attributed to a specific risk factor.

Climate change is defined as a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer).

Climate is the average state of the atmosphere and the underlying land or water in a specific region over a specific time scale.

Climate-sensitive disease is a disease that is sensitive to weather or climate factors, with the current spatial distribution and seasonal transmission being affected.

Comparative risk assessment is defined by the World Health Organization as the systematic evaluation of the changes in population health that result from modifying the population's exposure to a risk factor or a group of risk factors.

Coping capacity describes the ability to implement new strategies, policies, and measures to minimize potential damage from climate variability and change.

Environmental burden of disease is the burden of disease caused by environmental factors estimated using methods described by the World Health Organization.

Montane zones extend from the lower mountain limit to the upper thermal limit of forest (irrespective of whether forest is present or not). This limit is at a growing season mean temperature of 6 $\pm$ 1°C globally; the mean temperature is closer to 5°C near the equator and closer to 7°C at high latitudes.

Nival zones are the terrain above the snowline, which is defined as the lowest elevation where snow is commonly present all year round.

Vulnerability is defined as the degree to which individuals and systems are susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes.

Weather describes the day-to-day changes in atmospheric conditions in a specific place at a specific time. More simply, climate is what you expect and weather is what you get.

Annex 1

Definition of a Mountain

The United Nations Environment Programme World Conservation Monitoring Centre developed a definition for mountain classes based on altitude and slope to represent the key components of mountain environments (Kapos et al. 2000). Six mountain classes were empirically derived:

Class 1: Elevation > 4500 m

Class 2: Elevation 3500 – 4500 m

Class 3: Elevation 2500 – 3500 m

Class 4: Elevation 1500 – 2500 m and slope > 2°

Class 5: Elevation 1000 – 1500 m and slope > 5° km or local elevation range (7 radius) > 300 m

Class 6: Elevation 300 – 1000 m and local elevation range (7 km radius) > 300m

A seventh class was introduced in 2002: isolated inner basins and plateaus less than 25 km^2 in extent that are surrounded by mountains but do not themselves meet criteria 1-6.

Annex 2

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Annex 3

Programme of the Workshop, 3-7 October 2005

Day One		
17.30	Opening session with welcoming addresses by India, TERI, WHO, WMO, UNEP, and other sponsors	Mr AK Sengupta, WHO India
18.30	Self-introductions and common dinner	
Day Two		
9:00	Welcome and arrangements of the meeting	TERI Representative and Mr A. von Hildebrand, WHO SEARO
10:00	Coffee/ Tea	
10:15	Overview of the potential health impacts of climate variability and change	Dr Carlos.Corvalan, WHO Geneva
10:30	Health impacts of climate variability and change in mountain regions	Dr Kris.Ebi, USA
11:15	The burden of climate-sensitive diseases in mountain regions	Dr Akhtar, India
12:00	Lunch break	
1:30	Challenges of climate prediction and its application in the health sector	WMO Representative
2:15	Country presentations on climate change in mountain regions	Country Delegates
3:00	Coffee/ Tea	
3:15	Country presentations on climate change in mountain regions	Country Delegates
4:00	"Climate Change and Human Health Impacts in Mountain Ecosystems: issues and challenges faced"	TERI , India
4.25	"Climate change, land use transition and human health in Himalaya: current knowledge"	Dr Mats Eriksson, ICIMOD, Nepal
4:50	"Climate change in mountain regions: case studies from other regions"	WMO Representative
5.15	"Climate change and human health: UNDP/GEF Activities"	Dr Bo Lim, UNDP
5:40 to 6.00	Discussion	

Day Three		
8:30	Breakout groups to discuss the relationships between climate-sensitive diseases and weather/climate	
10:30	Coffee/ Tea	
10:45	Report back from breakout groups and plenary discussion	
12:15	Lunch break	
1:30	Vulnerability and adaptation assessment	Dr K Ebi, USA
2:15	Environmental Burden of Disease	Dr Rosalie Woodruff, Australia
3:00	Coffee/ Tea	
3:15	Breakout groups to discuss vulnerability assessment	
5:00 to 6.00	Report back from breakout groups and plenary discussion	
Day Four		
8:00	Field trip	
1.30	Lunch	
2.30	Identification and prioritization of adaptation options	Dr K. Ebi, USA
3.15	Coffee	
3.45	TERI Activities	Ms R.Uma, TERI, India
4:15 to 5.30	Discussion	
Day Five		
8:30	Breakout groups to discuss adaptation options	
10:15	Coffee	
10:30	Report back from breakout groups and plenary discussion on research needs and capacity building	
12:15	Lunch	
2:00	Workshop recommendations	
3:15	Coffee	
3:30	Workshop recommendations, adoption	
4:00	Closure	Dr Pachauri, TERI, India