

## Vulnerability and Adaptation Assessment for the Hindu Kush-Himalaya Region

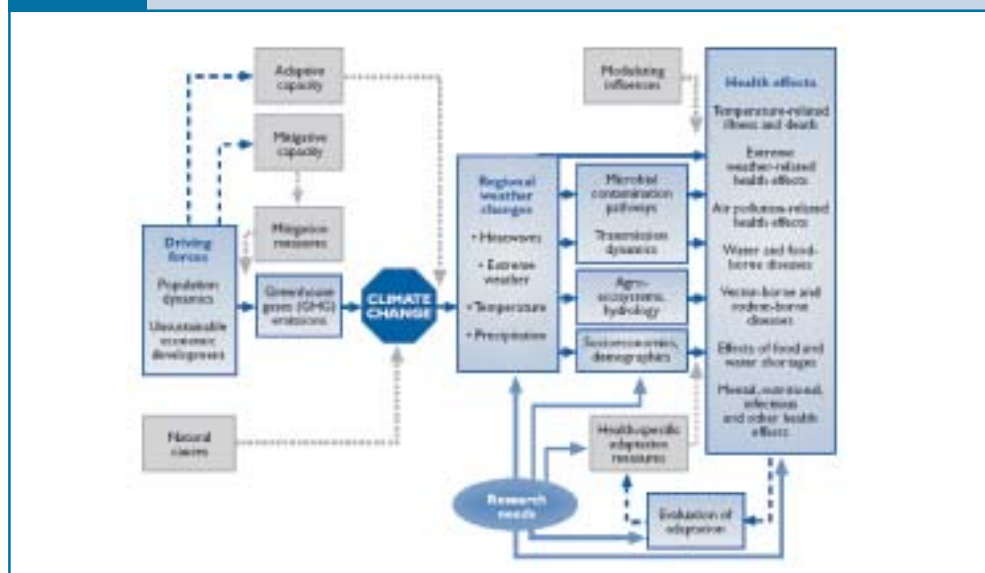
### 4.1 Overview of the Potential Health Impacts of Climate Variability and Change

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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.



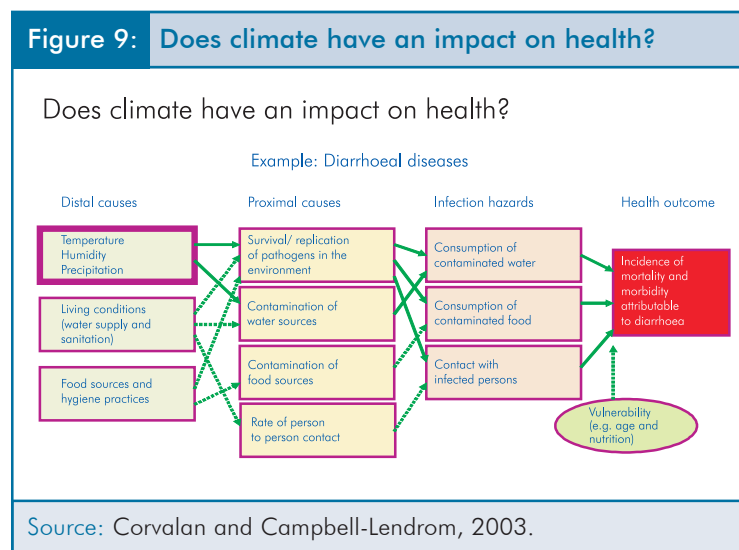
Source: McMichael et al. 2003.

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).

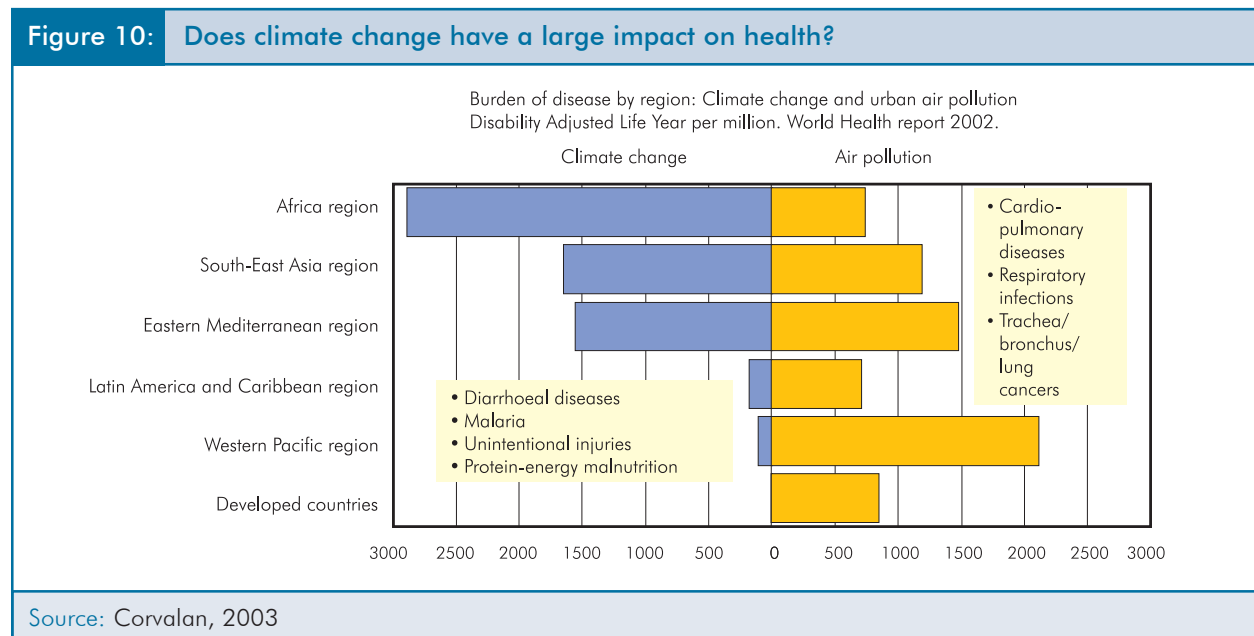
Reducing emissions of greenhouse gases will reduce emissions of other air pollutants that have negative health effects, resulting in co-benefits to health of mitigation.



## 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



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.

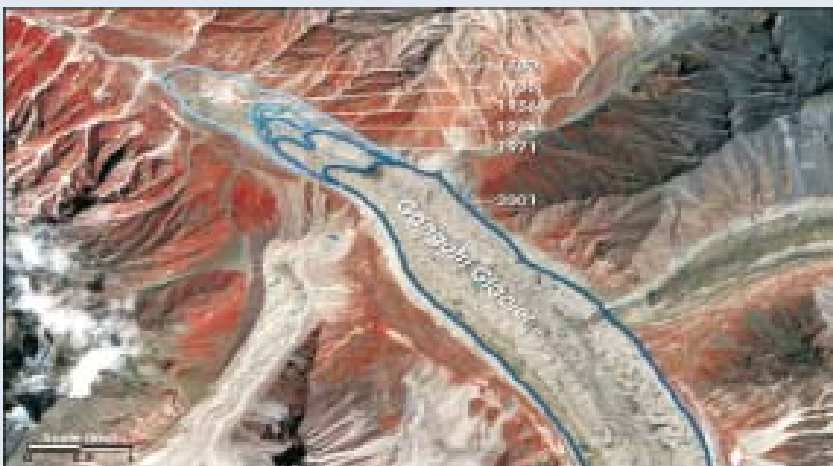
Climate change will exacerbate current environmental problems and these factors could negatively affect the quality of life and the potential for economic growth. These effects would be felt in both mountain regions

#### 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](http://www.raonline.ch/pages/story/bt/btbg_glacier02a.html#lunana)) A glacial 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 policies 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 country; 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°C 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 subtropics 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 3<sup>rd</sup> replenishment (2002-2005) and there is agreement for a 4<sup>th</sup> 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?