

Climate Change Impact and Vulnerability  
in the Eastern Himalayas – Technical Report 6

ICIMOD

FOR MOUNTAINS AND PEOPLE

# Potential Threats from Climate Change to Human Wellbeing in the Eastern Himalayan Region

MacArthur  
Foundation

# Preface

Mountains are among the most fragile environments on Earth. They are also rich repositories of biodiversity and water and providers of ecosystem goods and services on which downstream communities (both regional and global) rely. Mountains are home to some of the world's most threatened and endemic species, as well as to some of the poorest people, who are dependent on the biological resources. Realising the importance of mountains as ecosystems of crucial significance, the Convention on Biological Diversity specifically developed a Programme of Work on Mountain Biodiversity in 2004 aimed at reducing the loss of mountain biological diversity at global, regional, and national levels by 2010. Despite these activities, mountains are still facing enormous pressure from various drivers of global change, including climate change. Under the influence of climate change, mountains are likely to experience wide ranging effects on the environment, natural resources including biodiversity, and socioeconomic conditions.

Little is known in detail about the vulnerability of mountain ecosystems to climate change. Intuitively it seems plausible that these regions, where small changes in temperature can turn ice and snow to water, and where extreme slopes lead to rapid changes in climatic zones over small distances, will show marked impacts in terms of biodiversity, water availability, agriculture, and hazards, and that this will have an impact on general human well being. But the nature of the mountains, fragile and poorly accessible landscapes with sparsely scattered settlements and poor infrastructure, means that research and assessment are least just where they are needed most. And this is truest of all for the Hindu Kush-Himalayas, with the highest mountains in the world, situated in developing and least developed countries with few resources for meeting the challenges of developing the detailed scientific knowledge needed to assess the current situation and likely impacts of climate change.

The International Centre for Integrated Mountain Development (ICIMOD) undertook a series of research activities together with partners in the Eastern Himalayas from 2007 to 2008 to provide a preliminary assessment of the impacts and vulnerability of this region to climate change. Activities included rapid surveys at country level, thematic workshops, interaction with stakeholders at national and regional levels, and development of technical papers by individual experts in collaboration with institutions that synthesised the available information on the region. A summary of the findings of the rapid assessment was published in 2009, and is being followed with a series of publication comprising the main vulnerability synthesis report and technical papers on the thematic topics climate change projections, biodiversity, wetlands, water resources, hazards, and human wellbeing (this publication).

Clearly much more, and more precise, information will be needed to corroborate the present findings. Nevertheless, this series of publications highlights the vulnerability of the Eastern Himalayan ecosystems to climate change as a result of their ecological fragility and economic marginality. It is hoped that it will both inform conservation policy at national and regional levels, and stimulate the coordinated research that is urgently needed.

Andreas Schild, PhD  
Director General, ICIMOD

# Potential Threats from Climate Change to Human Wellbeing in the Eastern Himalayan Region

Fang Jing – Institute of Health and Development Studies, Kunming Medical University, Kunming, China  
Brigitte Leduc – ICIMOD, Kathmandu, Nepal

## Contents

Introduction	1
The Current Status of Human Wellbeing in the Eastern Himalayas	3
The Observed and Possible Threats of Climate Change to Human Wellbeing in the Eastern Himalayas	11
Conclusion	14
Bibliography	14
Acronyms and Abbreviations	17
Acknowledgements	18

## Introduction

The Eastern Himalayas contain one of the 34 global hotspots for biodiversity. The region is characterised by diversified landscapes and climates; a rich variety of animals and plant species; and a multitude of different ethnic groups with diverse cultures and political and socioeconomic systems. The historical and prevailing interactions of all of these components create complex ecosystems. As an integral part of an ecosystem, human beings rely heavily on natural resources and ecosystem services for their livelihoods and wellbeing. The complicated interactions between human beings and other components of the ecosystem greatly affect and determine human status and the biodiversity of the ecosystem.

In the last decade, climate change has been recognised increasingly as an important factor affecting and continuing to affect profoundly various aspects of our planet; and it puts an additional variable into the pre-existing complicated interactions among different components of ecosystems: it also poses new threats to human wellbeing.

Climate change directly affects human wellbeing through extreme weather events and indirectly through its effects

on ecosystems. The impacts of climate change on human wellbeing have not been well documented so far, however, particularly in the Himalayan region where data are particularly scarce; and, hence, it is essential to generate knowledge to understand how climate change is affecting people's lives.

The Eastern Himalayas cover a geographic area that crosses five countries – Bhutan, China, India, Myanmar, and Nepal – with different political and socioeconomic systems as well as diverse cultures and ethnic groups. Data on human wellbeing in this region are scarce and scattered and this limits analysis.

Using the framework of human wellbeing adopted by the Millennium Ecosystem Assessment (MEA), this paper summarises the current status of human wellbeing in the Eastern Himalayas and analyses the potential impact on it of climate change. The first section introduces the review framework and methodology; data on various aspects of human wellbeing are presented in the second section of the report; and the third section summarises the outcomes of stakeholders' consultation workshops and concludes with a recapitulation of the findings and discussion of the information gaps.

## Review framework and methodology

This paper reflects on the potential threats of climate change to human wellbeing. It is based on the assumptions that 1) climate change is already happening in the Eastern Himalayas; 2) it affects the ecosystems of the region; and 3) there are probably negative impacts on people.

### Key concepts

The concept of human wellbeing is complex and multidimensional. The Millennium Ecosystem Assessment (MEA) provides an interesting framework for looking at the interactions between ecosystem services and human wellbeing (Figure 1).

The MEA defines an **ecosystem** as “a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit” (MEA 2005a).

Ecosystems provide a wide range of **services** essential to human wellbeing such as food, water, and other resources to support livelihoods. Therefore, a healthy

ecosystem contributes to the comfort, safety, and health of human beings.

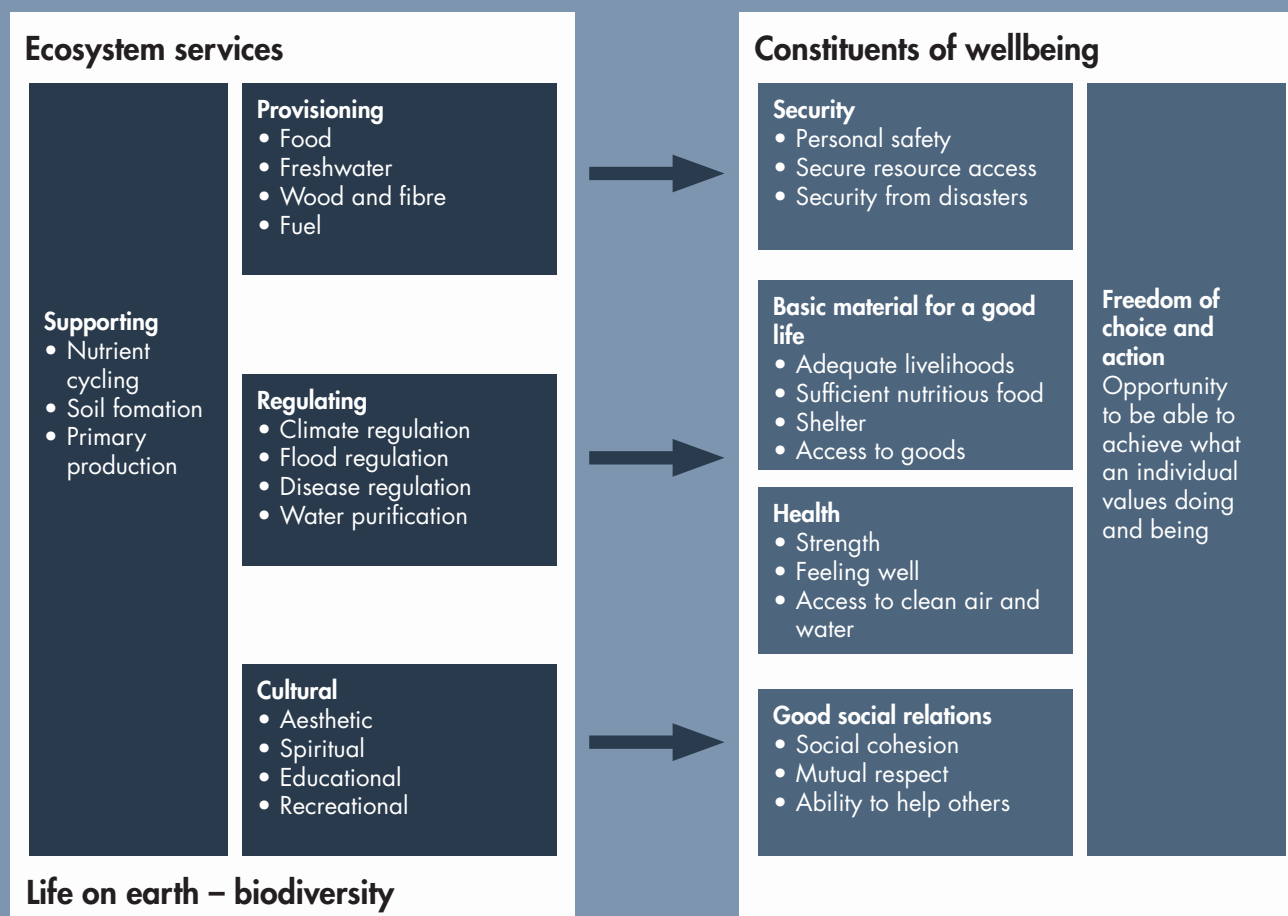
**Human wellbeing** as defined by the MEA includes basic materials for a good life: freedom and choice; health; good social relations; and security.

### Climate change and human wellbeing

Mountain ecosystems are clearly affected by climate change: it is considered to have been a moderate but increasing driver of ecosystem change in mountain areas over the last century (MEA 2005b). Many studies indicate that the temperature is rising in the Himalayas at a rate greater than the global average. On average, air temperature in the Himalayas has risen by 0.06 centigrade per year since the 1970s (WHO 2006) compared to a global average of 0.74% over the last 100 years (IPCC 2007).

Increased temperatures, changes in rainfall and snowfall, extended periods of drought, increased risks, and occurrence of floods and flash floods are among the climate changes observed in the Eastern Himalayas. Climate change is affecting the availability of water

Figure 1: Relationships between ecosystem services and human wellbeing (adapted from MEA 2005b)



resources, and biodiversity and ecosystems, hence challenging people's livelihoods, health, security, and wellbeing. Not all people are equally equipped to face these challenges. Rural populations, notably the ones highly dependent on land-based resources for their livelihoods, are likely to be the most negatively affected by changes in ecosystems caused by climate change.

In this paper, the emphasis is on the elements of human wellbeing that may be sensitive to climate change such as materials for a good life, health, and security (MEA 2005a). Materials for a good life usually mean access to food, water, energy, shelter, and income. Security is related to the safety of people and their belongings during natural hazards, conflicts, and major socioeconomic changes; and not only the safety of actual possessions but also secure access to essential resources and services. Materials for a good life, health, and security could all be considered as drivers of human wellbeing.

### Methodology

To examine the status of human wellbeing in the Eastern Himalayas, a set of indicators were used; for example, human development, socioeconomic and poverty status, livelihood and food security, the existence of basic infrastructure, health, and security in the context of five countries in the Eastern Himalayas – Bhutan, China (Yunnan, Tibet Autonomous Region, and Sichuan), India (North East), Myanmar, and Nepal.

The information for the analysis of potential threats from climate-change impacts on human wellbeing in the Eastern Himalayas was collected through a literature review and through discussions at three stakeholder workshops. The resources included the following.

- Published academic papers, research reports, working papers and reports, and statistics published by government websites, research institutions, and development organisations were part of the literature review. It is worth noting that statistical data on the same issue in the same time period from different sources are often inconsistent, such as the ones related to population or the figures on gross domestic product (GDP). This reflects the issue of data reliability. In these cases, we used the data having most authority.
- Three stakeholder workshops were held in 2007 and 2008, where resource persons from Bhutan, China, India, and Nepal shared the state of knowledge about threats from climate change to human wellbeing. The results of these discussions are

incorporated in this paper. It is important to mention, however, that there is little or no scientific data, and climate change impacts and linkages on human wellbeing are new areas so that few social scientists in the region are involved in research on these issues. As a result, the information shared during the workshop seemed to be based more on participants' perceptions than on scientific evidence.

## The Current Status of Human Wellbeing in the Eastern Himalayas

### Human wellbeing and the human development index

Using a combination of comprehensive indicators such as the gross domestic product (GDP), literacy rate, and life expectancy and income, the Human Development Index (HDI) provides information that can be used to assess human wellbeing. In 2007/08 the HDI was 0.534 in Nepal, 0.586 in Myanmar, 0.579 in Bhutan, 0.619 in India, and 0.777 in China, ranking the countries 142nd, 138th, 133rd, 128th, and 81st in the world, respectively.

There is no Human Development Index (HDI) available for the Eastern Himalaya region as such, although in recent years the HDIs of some individual provinces or states within one country have become available following the generation of disaggregated HDI data in China and India.

- The HDI of Yunnan Province in 2003 was 0.657 and in the Tibet Autonomous Region (TAR) 0.586; both were lower than the average HDI for China overall which was 0.746 (UNDP China 2005).
- In India, the HDI in the state of Assam in 2001 was 0.386 while the whole nation in the same year had an HDI of 0.470 (Gol 2001). The HDI in Nagaland in 2004 was 0.623, (UNDP website in 2005) and it was 0.515 in Arunachal Pradesh in 2005 (Government of Arunachal Pradesh 2005).

A slow rate of human development translates into increased vulnerability to the negative impacts of climate change and shocks caused by other factors. It also affects the capacity of the government and the population to adapt to the effects of climate change.

### Demography, socioeconomics and poverty

The demographic, socioeconomic, and poverty situations in a country provide information which helps us reflect on 'materials for a good life', the basic aspect of human wellbeing. The rapid rate of population growth affects

land use and the exploitation of natural resources. Food security is greatly challenged by a weakened ecosystem. There is also still a very low level of industrialisation in most areas of the Eastern Himalayas, thus limiting the creation of livelihood options and access to incomes that would reduce people's vulnerability. Furthermore, conflicts and marginalisation increase people's vulnerability and their capacity to respond to socioeconomic and environmental changes.

### Rapid population growth

The rapid population growth in some countries of the Eastern Himalayas places additional stress on the scarce natural resources and fragile ecosystems of the mountain environment. Population growth rates in this region are relatively high: 2.5% in Bhutan (Alam and Tshering 2004); 2.3% in Nepal (Nepal Poverty Report 2005); and 6.86/1,000 in Yunnan Province of China in 2006, which is greater than the population growth rate in many other provinces in China. North East India also experienced rapid population growth from 4.27 million inhabitants in 1901 to 10.26 million in 1951, 31.55 million in 1991, and 39 million in 2001.

### A region stricken by poverty

Despite the fact that poverty is a multidimensional concept and there are various indicators to measure it, economic and income indicators such as GDP and per capita income are still the most commonly used. The states, provinces, or nations located in the Eastern Himalayas all have a lower GDP and per capita income and a greater proportion of poor people than other parts of India. This implies that the Eastern Himalayas are areas of poverty in general according to GDP and per capita income.

- Both Nepal and Bhutan are among the lower rungs of the 49 least-developed countries (LDCs) in the world (Huq et al. 2003).
- Although extreme poverty is relatively rare in Bhutan and few suffer from hunger or homelessness, 32% of the population were still living under the national poverty line in 2003 (UNDP Bhutan 2006).
- Nepal was ranked as 13th from the bottom of a list of 90 developing countries and 38% of the population falls below the one dollar a day poverty line (UNDP 2001). The agricultural sector produced 41% of the GDP and employed more than 80% of the population (Gill et al. 2003).
- Myanmar's GDP per capita is US\$904 and the country is ranked 167th in terms of GDP (compared to its HDI ranking of 138).

- The GDPs of the Tibet Autonomous Region (TAR) and Yunnan Province were at the bottom among 31 provinces and/or municipalities in China in 2005 with TAR being in the 31st position and Yunnan in the 24th position: in terms of per capita income TAR ranked 27th and Yunnan 31st (Xinhua News Agency 2007).
- North East India contains eight states — Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura — which together cover a total area of 262,179 sq.km and have a total population of 39 million (GoI 2001). The overall growth rates of this region have been low over recent years and the poverty level remains high. The region's agricultural sector has been declining, and diversification into services and manufacturing has been inadequate (World Bank 2007). An assessment carried out by the Centre for Monitoring India's Economy (CMIE) index of relative development of infrastructure (1966/67–1992/93) shows that, with the exception of Assam (ranked 13), the remaining seven states in this region rank below 15 among the 25 states of India.

### Underdeveloped industrialisation and slow economic growth

Industrialisation is generally underdeveloped in the Eastern Himalayan region. This not only affects economic development but also the development of infrastructure such as roads and communication facilities.

- In 2000-2001, the gross output from industries in rupees per capita was 466 in Meghalaya and 485 in Nagaland, compared to 9,111 for the whole of India (Nandy et al. 2006).
- In Nepal the failure to add value to the agricultural sector has meant lost opportunities and slow development. Many are jobless and thousands of young people join the empty job market each year.
- The sluggish growth rates of states in northeastern India (see previous section), lack of industrialisation, and poor development in the agricultural sector have led to a general decline throughout the region; and, in turn, this has rendered these areas more vulnerable to any changes in climate and at greater risk from natural disasters since, within a context of poverty, coping mechanisms remain poor also.

### Social discrimination and vulnerability

Discrimination and social exclusion based on caste, ethnicity, and gender may all contribute to vulnerability and hamper adaptation to socioeconomic changes and

environmental stress such as climate change. Moreover, the livelihood options of poor and marginalised groups in the Eastern Himalayas, which are mainly dependent on agriculture and forest products, are limited and place people at more risk from climate change impacts.

- In Nepal, 90% of the 'dalits' (so-called low castes) were living below the poverty line in 2001 with an average per capita income of only US\$40 per year (compared with an average of US\$210 per year for the whole country, with 45% of the total population living below the poverty line). The 'dalits' own less than 1% of the total farmland in Nepal collectively and are among the poorest populations in the world (Human Rights Watch 2001).
- Despite the absence of discrimination in Chinese policies related to land ownership or employment, women are still more vulnerable to poverty than men. While men are engaged increasingly in off-farm labour, the feminisation of agriculture in China, and notably in Sichuan, can be linked to the feminisation of poverty according to a study carried out by the UK Department for International Development (DFID) (Du and Kanji 2003). Feminisation of agriculture affects not only women's drudgery, but also their health, incomes, and mobility: it also has implications for child labour and girls' education.
- Indigenous peoples are disproportionately represented among the poor but their needs are rarely addressed through poverty reduction programmes (ICIMOD 2007).
- Several ethnic groups are living in the mountainous borders which are among the most deprived areas in Myanmar (UNDP Myanmar 2005).

### Political instability and conflict

Social unrest and political conflict affect people's security, slow down economic development, and affect the supply of daily goods: the way the governments respond to conflicts greatly affects human wellbeing. There are several conflicts in the region that place extra stress on people's capacity to adapt.

- Basic services, such as communication and health services, already insufficient in most of rural Nepal, were even more difficult to access during the 10-year period of armed conflict. Transportation was regularly disrupted and affected the supply of fuel, food, and medicine. Much of the infrastructure was damaged and the service delivery system, such as the village development committee offices and police posts, was interrupted (Shakya 2009).

- In Myanmar the difficult political situation has caused the displacement of over 350,000 people (UNHCR 2009). Limited external assistance and deterioration of trade are among the causes of poverty – directly challenging food security, education delivery, and delivery of health services (UNDP Myanmar 2005).
- Insurgencies in northeastern India have hampered the economic and industrial development of the region and affected the development of its states (CNES 2010).

### Increase in migration

Out-country labour migration to the Gulf countries and South East Asia and internal migration from rural to urban areas and mountains to plains have intensified in the last decades. This represents a coping mechanism to environmental stresses which is increasing, resulting in reduction of farm productivity and increased food insecurity. In the mountains and hills of the Eastern Himalayas, outmigration is gendered: men are leaving to work abroad while women and children are staying back and taking over the work usually carried out by men.

- High unemployment and underemployment rates cause a significant number of Nepalese to migrate in search of employment within and outside the country. In 2001 in Nepal, 1,727,350 people migrated internally (inter-regional migration). The number of people absent for more than six months from their place of origin in Nepal and living in foreign countries was 762,181 or 3.4% of the total population (CBS 2002; cited by UNESCAP 2003).
- In China young people are moving west to east and interior provinces, such as Sichuan, Hunan, and Guangxi, are losing people to Guangdong (Migration News 2001).

### Livelihood and food security

Security is a basic component of human wellbeing, and this includes different aspects of security such as biodiversity, water, food, public health, and disaster mitigation. This section will focus on food security. Food security is affected greatly by variations in climate and environmental changes. This is particularly the case in the eastern Himalayan region where the population is dependent on agriculture and livestock.

Hydrological variability caused by climate change will greatly affect the livelihoods of people in the region. It is estimated that for low-income countries, major natural disasters can cost an average of five per cent of the GDP. The cost of climate change in India and South East

Asia could be as high as a 9-13% loss in GDP by 2100 compared with a world without climate change. Up to an additional 165,000 to 250,000 children could die each year in South Asia and sub-Saharan Africa by 2100 due to income losses alone (Stern 2006).

### Threat to food security in China

Although China has made significant progress in poverty reduction and eradication of hunger, it is projected that by 2050 China's grain output could fall by as much as 10% unless crop varieties adapt to new temperature and water regimes. By the latter half of the century, production of wheat and rice could drop by as much as 37% (Koday 2007). This poses new threats to food security in China. Tibet and Yunnan are relatively poor provinces economically which makes them more vulnerable to possible declines in food production as a result of climate change.

### Food deficit in Nepal

Food security is a chronic problem in Nepal, particularly among hill and mountain populations and indigenous groups (the latter account for 37.2% of the total population) (Nepal Poverty Report 2005). In 1996, 51% of households in Nepal felt that their food intake was less than adequate, 47% of households stated that their food intake was just adequate, and just two per cent of households reported it was more than adequate. The percentage of households reporting food inadequacy was higher in rural and hill areas than in urban and Terai areas (HMG/N1996). Although there have been improvements in the last decade, the nation is still facing the threat of food insecurity. Most of the districts in Nepal are classified as food-deficit and Nepal as a whole does not produce enough food for its population (Table 1).

Recent data on food security have not as yet been recorded because of the conflict which commenced in 1996. It is believed, however, that long-term male migration led to a reduction in food production and the conflict disrupted the food supply and /or distribution and livelihoods (Gill et al. 2003). All these factors have exacerbated food insecurity in Nepal.

### Decrease of crop yields in India

It has been estimated that crop yields in India will decrease in spite of the impact of CO<sub>2</sub> fertilisation. This may exacerbate the pre-existing under-nourishment that affects more than half the adults in this region. One projection claims that climate change will affect the biodiversity of forests in India and, thus, will affect the livelihoods of local communities which depend mostly on forests. It does not project, however, what specific impact this will have (Ravindranath et al. 2006).

A large proportion of the land in northeastern India is flood prone: the flood-prone area was estimated to be 3.6 million hectares (World Bank 2006). It has been projected that floods will increase in the coming decades due to increasing snowmelt from the Himalayas. By 2050, however, the average runoff in the Brahmaputra river will decline by 14%.

### Vulnerability to food shortages in Bhutan

In Bhutan only around 16% of the land is cultivable and this severely constrains agricultural production and also exposes the nation to the risk of food insecurity (Alam and Tshering 2004). Vulnerability to food shortages is a more pressing contemporary issue for Bhutan than the other dimensions of food security such as access, availability, and use (Alam and Tshering 2004).

### Maintaining food security in Myanmar

Maintaining food security in Myanmar is difficult. In Myanmar in 2001 the average household was spending 72% of its budget on food (Central Statistical Organization, Statistical Yearbook 2002 cited by UNDP Myanmar, 2005). Three-quarters of the population of Myanmar live in rural areas where the challenges of poverty are more acute. Besides the difficult agricultural conditions – particularly in the highlands – two-thirds of the farmers possess less than the 2 ha (5 acres) of land necessary to maintain a basic subsistence level. In 1997, two-thirds of the households were not consuming the basic, daily recommended calories and only 56% were consuming enough protein (National Nutrition Centre 1997 cited by UNDP Myanmar 2005).

Table 1: **Cereal production-consumption balance by ecological division in Nepal (mid 1990s)**

	Production ('000 MT)	Consumption ('000 MT)	Surplus/deficit	
			'000 tonnes	Proportionate
Mountains	163	290	-128	79.0% deficit
Hills	1,340	1,831	-491	36.6% deficit
Terai	1,895	1,761	134	7.1% surplus
Nepal	3,398	3,883	-485	14.3% deficit

Source: Gill et al. (2003)



## Human health

Human health is an essential component of human wellbeing and is highly susceptible to climate change. It is agreed that climate change will affect the incidence and distribution of vector-borne diseases, water-borne diseases, and health problems caused by extreme weather events. Climate change can also affect human health indirectly through a number of pathways; for example, its impact on food production and supply will exacerbate the existing, pervasive malnutrition in this region.

### Increase in vector-borne diseases

Malaria is a typical vector-borne disease which could spread with increased temperatures even to the Himalayan region. Malaria may have a prolonged transmission window and penetrate elevations above 1,800 metres (WHO 2007). The prevalence of malaria in Bhutan, Yunnan and Tibet in China, and Nepal, showed a declining trend over past decades, which is attributed to various control programmes and advances made in diagnosis and treatment. Since 2001, however, the incidence of malaria in China has increased (Li 2007). The increasingly warmer weather will make it more difficult to control and eradicate malaria and prevention will cost more. For example, from 2001-2003 malaria in Yunnan Province affected 9,267 people (21 deaths) in 2001; 12,218 people (33 deaths) in 2002; and 15,431 people (43 deaths) in 2003 (Statistic from the National Institute for Parasitic Disease).

Projection using modelling shows that climate change will open up northeastern India to the spread of malaria and maintain the endemic status of malaria in the state of Assam. The projection of the impact of climate change on forests also shows that the forests in northeastern India will become wetter, which will make them conducive to sustaining the malaria vector.

In Myanmar, malaria and other arthropod-borne viral fevers, and viral hemorrhagic fevers, were among the leading causes of morbidity in 2007 and responsible for 5.5 and 3.1% of deaths respectively (WHO 2009).

Both Nepal and Bhutan have witnessed increasing instances of dengue hemorrhagic fever and both countries have reported cases of malaria at higher altitudes than previously (WHO 2006). Nevertheless, it is not clear whether the infection was contracted locally or imported. Dengue was not reported in Bhutan until July 2004 and is now endemic during the monsoon period (WHO 2006).

In China, dengue fever cases rose 165% in 2005 but there were no fatalities.

Greater risks of kalaazar and Japanese encephalitis are highlighted by Nepalese national communications (Kelkar and Bhadwal 2007).

### Increase in water-borne diseases

Water-borne diseases are still common in the region and are the major killers of children under five years. The prevalence of this group of diseases is closely related to the presence or absence of safe drinking water supplies and sanitation: the latter is in general underdeveloped.

- By the end of 2006, the proportion of homes in rural China receiving tap water was 61% and the proportion having hygienic toilets 55% (Ministry of Health of China 2007). The two indicators in Yunnan in the same year were close to the rural average with 61% for tap water and 51% for hygienic toilets (Statistics from the Yunnan Statistical Bureau). In 2004, only 29% of the total population in Tibet AR had access to safe drinking water, and then mostly the urban population (95% had access), although it was planned that by the end of 2020, 85% of the population would have access (Xinhua News Agency 2005).
- In Tibet AR diarrhoea is the second highest cause of infant mortality and the first cause of death among children under the age of five (INWCCW 2003).
- Tuberculosis (TB), hepatitis B, dysentery, gonorrhoea, and hepatitis A are the five most common infectious deceases in China, accounting for 85% of the total reported cases of infectious diseases (www.chinaview.cn 18 February 2005).
- Hepatitis, dysentery, and TB were the major infectious diseases of patients in four hospitals in Linze District of Tibet AR (Liu et al. 2006).
- There are various old and new infectious, vector-borne, and zoonotic diseases in Tibet AR and it is not clear how climate change will affect the distribution and spread of these diseases and thus influence human wellbeing. For instance, there is a high prevalence of echinococcosis in Tibetan populations (Li Taiyong et al. 2005) and in 2005 in August Tibet reported an avian flu outbreak in poultry ([http://id\\_cntre.apic.org/apic/influenzaavianflue/news/aug112005tibet.html](http://id_cntre.apic.org/apic/influenzaavianflue/news/aug112005tibet.html)).
- The supply of treated water in Nepal is extremely inadequate even in Kathmandu and the sewage system is underdeveloped and almost non-existent in rural areas. Tap water and sanitation coverage

in Nepal is only 60 and 40% respectively (personal communication at the regional stakeholder workshop, 2008); the population with improved water resources was 81%; and only 27% of the population has adequate sanitation facilities (UNDP 2001). Many water sources are contaminated by human and animal faeces like E coli (14% of the water samples tested found this bacterium) which cause a high prevalence and frequent outbreaks of diarrhoea and other water-borne diseases. In addition, 15% of Nepal's wells are contaminated by arsenic. ([www.unicef.org/infobycountry/nepal\\_nepal\\_background.html](http://www.unicef.org/infobycountry/nepal_nepal_background.html)).

- Diarrhoea and gastroenteritis of presumed infectious origin represented 6.2% of the causes of morbidity in Myanmar in 2007 (WHO 2009).
- Health systems are deficient in most areas of the Eastern Himalayas due to lack of resources and supplies. This increases the vulnerability of the population of this region to the adverse impacts of climate change (Ravindranath et al. 2009).

#### HIV: an additional pressure

Apart from climate-sensitive diseases, such as vector-borne and water-borne diseases, other pre-existing health issues add extra pressure to the already over-stretched health systems. Human immunodeficiency virus and acquired immunodeficiency syndrome (HIV/AIDS) may not have a direct link to climate change, but can increase the vulnerability of populations and undermine their capacity to adapt to climate change.

- The northeastern states of India have nearly 25% of the HIV seropositive population detected in India. (Sarkar et al. 1992). Manipur and Nagaland are classified as high-prevalence states for HIV, and intravenous drug use is an important route of transmission (Devine et al. 2007).
- Yunnan also has a high prevalence of HIV in China, the main transmission route is intravenous drug use.
- Myanmar has the third highest prevalence rate in Asia and AIDs causes about 20,000 deaths every year. In 2003, an estimated 340,000 people were living with HIV/AIDS (ICG 2004 cited by UNDP Myanmar 2005).

#### Prevailing malnutrition

Malnutrition is a common health problem in this region: malnutrition is a health outcome in itself, but it also lowers natural resistance to infectious diseases by weakening the immune system.

- More than 50,000 children die in Nepal each year with malnutrition as the underlying cause for more than 60% of these deaths; half of the children in Nepal are underweight; and three-quarters of pregnant women are anaemic ([www.unicef.org/infobycountry/nepal\\_nepal\\_background.html](http://www.unicef.org/infobycountry/nepal_nepal_background.html)).
- In 2006, undernourishment was still significant in Nepal, with one in two Nepalese children under five stunted (short for their age), 13% wasted (thin for their height), and 35% underweight (Pradhan et al. 2007, pp 47,48). Also, 24% of Nepalese women age 15-49 were malnourished (below the cut-off point of 18.5 for the body mass index (BMI) (Pradhan et al. 2007, p 69).
- The situation is similar in northeastern India. The incidence of anaemia among the tribal people was 59.8% in 2006; in Arunachal Pradesh it was 53.8%; and in Tripura it was 57.5% (De et al. 2006).
- One survey in Tibet of 1,655 children under three years of age found that 39% of the children surveyed were under the normal WHO standards for height, 23.5% for weight, and 5.6% for thinness. The malnutrition rates were higher in rural than in urban areas and higher among nomads than among farmers (Xie Hong et al. 2002). Another survey in Tibet AR of 1,257 children under six years of age found that prevalence of vitamin A deficiency was 5.4% in urban, 4.7% in pastoral, 11% in agricultural, and 12.3% in semi-pastoral areas (Me Jie et al. 2003).
- A survey of three to six-year old children In Yunnan Province found growth retardation among 20%; low weight among 14.4%; and thinness among 3.2%. When the data were disaggregated in terms of urban and rural areas, retardation of growth among the urban population was 9.1% and among the rural population 32.8%; low weight among the urban population was 37.7% and among the rural population 22.4 %; and thinness among the urban population was 2.7% and among the rural population 3.7% (Li Yuping et al, 2006). A survey carried out in 2006 in Nanhua county, Yunnan, found that the malnutrition rate among rural students was 34% and the over-nutrition rate 4%. For urban students malnutrition was 37.6% and over-nutrition 7.5%. The main reason for urban malnutrition was bad eating habits and unbalanced diets, whereas for rural students it was lack of meat and milk and poor food hygiene.
- The malnutrition rate is also very high in Myanmar where almost one quarter of all infants are born underweight and one out of every three children under five years' old is moderately or severely malnourished (UNICEF 2003, cited by UNDP Myanmar 2005).

## Low life expectancy and high infant and maternal mortality rates

Maternal mortality rate (MMR), infant mortality rate (IMR), and life expectancy are commonly used to measure the health of any population. These indicators not only show the health status of the population but also reflect its general socioeconomic status. People in the countries or states and provinces in this region generally have higher MMRs and IMRs, and shorter life expectancies, than their counterparts outside the eastern Himalayan region.

- For example, in 2001 the MMR for the whole of China, was 48.44/100,000 and the IMR 16.95/1,000 live births, whereas the MMRs in Yunnan and Tibet Autonomous Region were 78.15 and 327.27/100,000 live births, respectively (GoC 2001). Life expectancy at birth in 2000 in Tibet was 64.37 (total), 62.52 (male), and 66.15 (female), and in Yunnan 65.49 (total), 64.24 (male), and 66.89 (female) (Ministry of Health China 2007) – all less than the over 70 years' life expectancy for the population of China as a whole. The population health index formulated by Chinese scientists has 27 indicators that show that the lowest ranked area is that of Tibet AR while the highest ranked is that of Beijing. Yunnan and Tibet are among five regions whose population health indices are below 25 (Tibet's is only 10.4).
- Nepal, Bhutan, and the states in northeastern India also have high maternal mortality rates, infant mortality rates, and shorter life expectancies.
- One hundred and thirty thousand children under five years' old die every year in Myanmar as a result of pneumonia, diarrhoea, malaria, and neonatal causes. The maternal mortality rate is also high with an average of 360 deaths per 100,000 (UNICEF 2001 cited by UNDP Myanmar 2005).

## Vulnerability to natural disasters

Climate-induced disasters such as droughts, floods, and landslides are frequent in this region. They have significant negative impacts on human wellbeing through loss of life and property, injury, disease epidemics, and so forth. In Bhutan, people, their lives, property, and livelihoods are under increasing threat from glacial lake outburst floods (GLOFs). Both Bhutan and Nepal are especially vulnerable to hydrological variability because hydropower is one of the main sources of income in Bhutan and the main source of electricity in Nepal.

## Strategies for adapting to and mitigating the impacts of climate change

Guided and promoted by international organisations, such as the United Nations Framework Convention on Climate Change (UNFCCC), all the countries in this region have developed national-level strategies to respond to climate change. It is difficult, nevertheless, to assess to what extent these strategies have been implemented, particularly in the eastern Himalayan region.

Bhutan identified six areas – all crucial for human wellbeing – that are most vulnerable to climate change: forests and biodiversity (it has 70% forest coverage and is part of the Himalayan hotspot); agriculture (employing 80% of the population and contributing 33% of the GDP); water resources (it has 30,000 MW of potential power generation); human health (water-borne and vector-borne diseases are increasing); and glacial lake outburst floods (GLOFs) and other natural disasters (floods, flash floods, and landslides) (Alam and Tshering 2004). In Bhutan, glacial lake outburst floods (GLOFs) are a major concern. There are 2,674 glacial lakes and 562 glaciers in Bhutan, of which 24 are considered to be potentially dangerous. A major glacial lake outburst flood is projected to occur by 2010. In addition, major flash floods and/or landslides occurred in 2000, 2003, and 2004 and damaged villages and hydropower projects (WHO 2005).

Bhutan also identified a number of options and measures to be taken in response to climate change in its initial national communication to UNFCCC. These measures are as follows.

- Promoting community involvement and awareness about using water resources more sustainably
- Improving land-use planning to promote afforestation in degraded water catchment areas
- Developing varieties of crops and livestock with greater resilience and for use on limited arable land and in extreme temperature events
- Promoting community-based forest management and afforestation projects which lead to conservation of land, water resources, and nature
- Making the forests productive and sustainable and conserving the human living environment as well as contributing to the prevention of global warming (Alam and Tshering 2004).

China released its National Strategy for Adaptation to Climate Change in June 2007. To achieve the goal of responding to climate change impacts, the strategy proposes "...to make significant achievements in controlling greenhouse gas emissions; to enhance the capability of continuous adaptation to climate change; to promote climate change related science, technology and R&D to a new level; to raise public awareness on climate change; and to further strengthen the institutions and mechanisms on climate change."

India issued its National Action Plan on Climate Change on 30th of July 2008. A key principle of the action plan is the protection of "...the poor and vulnerable sections of society through an inclusive and sustainable development strategy, sensitive to climate change."

The plan proposes interventions to enhance the country's capacity to adapt to climate change, notably by promoting energy efficiency and sustainable habitats; sustaining the Himalayan ecosystem; developing sustainable agriculture; and building on strategic knowledge about climate change (Government of India 2008).

## Findings from the stakeholders' consultation workshops

### Changes observed

In the Nepal stakeholders' workshop, the participants mentioned changes in cropping patterns in which cereals had been replaced by cash crops such as ginger, cardamom, and vegetables and increased migration as a new livelihood option in the mountains. It was not clear, however, whether the adoption of such activities was caused by climate changes or market opportunities.

The participants at the workshop held in Shillong felt there was a critical lack of data about livelihoods in this region, thus little was known about the vulnerability of farmers to climate change. Climate change was noticeable, however: erratic weather had been observed such as delayed monsoons and droughts – causing crop failure; reduced or delayed snowfall – affecting winter crops; excessive rainfall within short periods which caused floods; and unexpected hailstorms that damaged crops. This climate variability affected crops: premature blooming and early harvesting occurred while, in some cases, delays in crop maturation were experienced. Crop productivity had also changed. For example, the productivity of oranges in some traditional orange-

growing areas had decreased whereas at higher altitudes it had increased. This brought about changes in cropping patterns.

Farming at higher altitude where it used to be too cold to grow anything has now become possible: the downside is that it increases the risk of deforestation.

Participants also mentioned pest and crop diseases and the decreasing availability of medical plants. Outmigration was common and it might cause labour shortages along with reduction in agricultural productivity and loss of local knowledge. Inflows of migrants were also mentioned as a result of development of new activities.

### Some positive impacts

The positive impact that climate change could bring about included longer tourism seasons due to delayed monsoons and warm weather in December.

The changes observed in Bhutan included the fact that some fodder species, such as white clover, a nutritive fodder for yaks, had migrated upwards from valley bottoms to higher altitudes. Since this species provides good fodder for yaks even in winter; herders seemed appreciative of the situation because they now have shorter periods of transhumance, which could lead to changes in migration patterns. On the other hand, erratic rainfall has caused livestock losses due to sudden natural calamities, such as floods and landslides, en route.

In Tibet AR warmer winters had led to a reduction in livestock losses caused by heavy snowfall and cold, and this was welcomed by herders. Notwithstanding, the spread of poisonous grass was causing the death of livestock and it was not clear whether the growth of this poisonous grass was linked to climate change or not.

These observations reveal that climate change may directly affect the lives of nomads who may not need to migrate or who can migrate for shorter periods than before because the winters are becoming warmer. It may also indirectly affect migration patterns of nomads by changing the distribution of plant species, especially fodder species. Will herders' migratory systems dwindle or disappear due to climate change? These observations also revealed that many issues that link ecosystems with human wellbeing need to be studied: for example, how the growth of certain species in niche habitats affects the livelihoods of local people.

### Some negative impacts

In the hill region of Nepal, the local varieties of potato and rice are declining; however, the reasons for this need to be studied. In Nepal a new crop disease in maize has emerged in the last three years; 'grey leaf spot' is becoming rampant in the high hills. What impact climate change could have had on the intensity of the outbreak of this crop disease is yet to be understood.

Earlier flowering of bamboo has been observed in both China and India. This early flowering can lead to the destruction of crops and cause famine. When the bamboo flowers (usually every 50-60 years), the plant dies and the rats living on the wood stock come out of their habitat niche, start feeding on agricultural crops, and then famine follows. Flowering of bamboo is occurring faster than before: could it be due to climate change? The life cycle of certain perennials can be shortened due to warming.

In northeastern India, the population of 'mahseer' – a kind of high-altitude fish, which is very sensitive to even the slightest change in water temperature – seems to be decreasing. This fish may serve as a biological indicator for climate change.

Increases in water-borne diseases and malaria at higher altitudes than previously have been identified by the participants at both workshops in Nepal and India as health issues potentially related to climate change.

### Some unknown changes

The general consensus among the participants of the Nepal stakeholders' workshop was that people do notice changes in their environment but they ignore the causes of these changes. Apart from climate change, many other factors, such as markets, advances in technology, and population growth also play a role in the changes. Thus, there is an urgent need for research into the interaction of socioeconomic changes with the climate and environment and into mountain people's capacity to adapt to multidimensional changes.

The participants at the Shillong workshop also felt that information about the observed and possible impacts of climate change on livelihoods in the region was scarce and, in some cases, even contradictory and that the current information base was far from adequate for understanding the vulnerability of people to climate change.

### Potential factors that will increase vulnerability

Land-use transformation and outmigration of youth and men are identified as potential threats that will affect agricultural and livestock productivity and, thus, food security. It will cause the loss of local knowledge regarding farm practices and the use of natural resources that is usually passed down from generation to generation also. For example, in the Namdapha area of northeastern India, 200 traditional rice species used to be cultivated: in recent years the knowledge has eroded and only 13 are produced today.

### People's adaptations

Facing these changes, people have started to adapt. For example, in Bhutan, people noticed that mules are more resistant than horses to Eupatorium species, thus they raised more mules. Similarly, they are raising goats because goats are more immune to some of the new highland fodder species that seem to be toxic to yak and other livestock. No household is allowed to keep more than four goats, however, in order to protect the grassland. This policy may need to be changed in the context of climate change.

There are many good varieties of crops that require little moisture and which are resistant to droughts; and these could be useful during water stress: one example is the 'mansuli' variety of rice. Similarly, growing off-season vegetables in the hill districts of Nepal is adding new dimensions to the integrated farming systems and this kind of adaptation might be needed in Bhutan.

## The Observed and Possible Threats of Climate Change to Human Wellbeing in the Eastern Himalayas

Rising temperatures and erratic weather patterns have been observed in the last few decades in the Eastern Himalayan region and this trend is likely to continue. Although scientific research is scarce, there is evidence that climate change is affecting the wellbeing of the population in the Eastern Himalayas. By analysing the current status of the population in the region, their vulnerability, and their capacity to respond to socioeconomic and environmental stress, it is possible to make some projections about how these populations will be affected by climate change in the near future.

**Water stresses** – such as floods and droughts – are likely to increase in this region in the next decades due to the rapid melting of glaciers and warmer temperatures.

This will have significant impacts on people's wellbeing through a number of pathways. Agricultural production may fall or even fail due to lack of water or changes in rainfall patterns. This will reduce food supplies and exacerbate the existing widespread undernourishment in this region. A reduction in hydropower generation will lead to decreases in the financial revenues of governments in Nepal and Bhutan and hinder investments in infrastructure and social services such as education and health care.

We do not have firm evidence yet on the impact of climate change on health in the region. Nevertheless, given the underdeveloped water and sanitation systems in the Eastern Himalayan region, diarrhoea and other water-borne diseases are very likely to increase. New threats to the control of vector-borne diseases have already emerged; for example, the malaria outbreaks that have taken place even in poor mountain areas in the recent past.

Climate change also poses new threats to ecosystems through the interactions of human beings and ecosystems. When food is inadequate and income is also limited, poor people will turn to the increasing use of uncultivated and wild food from the forests. Added to the rapid population growth rates in this region, this will put an additional strain on the ecosystems.

Gender inequalities will likely become worse with climate change. Workloads and responsibilities, such as collecting water, fuel, and food, will grow and become more time consuming in the light of increasing scarcity of resources (Stern 2007); and the burdens of this will be shouldered disproportionately by women. The situation will become worse when large numbers of males migrate out in search of economic opportunities.

In the face of reduced resources, such as water and food, social conflicts and unrest may arise or become exacerbated among nations, communities, or tribes. Nepal has experienced political unrest in the last decade: climate change can aggravate the political unrest by triggering new crises such as food shortages and disease outbreaks.

### The current status of human wellbeing in the context of threats from climate change

The MEA defines human wellbeing as materials for a good life, freedom and choice, good health, good social relations, and security. By looking into the various indicators used to measure human wellbeing, one cannot

be optimistic about the status of human wellbeing in the eastern Himalayan region.

- First, the poverty level is high and over a third of the population still lives below the poverty line. Economic poverty greatly constrains freedom and the choices that people can make and it hinders investment in education and health care.
- Second, infrastructure, such as roads, transportation, electricity and water supplies, education and health care services, communication, and irrigation, is underdeveloped and this is an obstacle to rapid and effective delivery and distribution of information and other goods.
- Third, the majority of the population relies on subsistence farming and forest products for their livelihoods and these are highly susceptible to climate variability and availability of water.
- Fourth, the major health indicators, such as maternal mortality rate, infant mortality rate, and life expectancy at birth, are worse than in other places within the same country.
- Fifth, pre-existing problems, such as lack of access to safe drinking water and sanitation; weak health systems; monopoly of the economy and income; the high prevalence of water-borne diseases and undernourishment; frequent disasters such as flash floods and landslides; and huge inequalities and social exclusion based on wealth, religion, gender, and caste, weaken the status of human wellbeing in the region.

All of these factors make the eastern Himalayan region more vulnerable to climate change than other areas. Smit and Pilifosova (2001) correctly indicate that countries with limited economic resources, low levels of technology, poor information, and inequitable empowerment and access to resources have little capacity to adapt and are vulnerable to climate change: these are the features of the Eastern Himalayas.

### Research gaps and priorities

Despite various projections based on different models and the changes observed in the physical environment, we still do not have adequate scientific evidence about the impacts of climate change on different aspects of human wellbeing; and this is due to a lack of long-term systematic monitoring, documentation, and empirical research. In all countries of the Eastern Himalayas, there are some studies on the impact of climate change on glaciers, rangelands, and other ecosystems, but most of these studies are based on projection rather than on empirical observation and documentation. Besides,

the results of these limited studies have not yet been translated into policy or plans for adaptation. There is a disconnection between the two domains. This also indicates that there is a need for research into how climate-change policy is implemented on the ground.

Little research is available on the impact of climate change on human health in the region. As pointed out by the participants at the Shillong consultation workshop, in northeastern India, except for shifting cultivators, little is known about the livelihoods of local people let alone the impact of climate change. Little research on livelihoods has been carried out in this region. Research into links between changes in the ecosystem and local livelihoods is also badly needed. There is an urgent need for cross-sector, cross-boundary, and transdisciplinary research on climate change and its impacts on human wellbeing. The results of such research would facilitate development of mitigation and adaptation strategies. Some work on climate change promoted by the World Health Organization (WHO 2005, 2006, 2007, 2009) and the Intergovernmental Panel on Climate Change (IPCC 2007) is underway, and some research by climatologists and meteorologists on temperature and precipitation are available in all countries of this region, but little research has been carried out into the impact of climate change on human health; into how climate change interacts with other factors, such as poverty and migration; and what implications this interaction will have for both the ecosystem and human wellbeing.

There is a huge gap in knowledge and the current understanding of climate change and its impact in this region is inadequate in terms of developing good adaptation strategies. Thus, research is needed to understand how climate change affects each aspect of human wellbeing: there are also new challenges in studying the impact of climate change.

For example, to study the relationship between climate change and human health, long-term data on climate and health that span decades and which have been collected on the same spatial, geographic and ecological scales are essential. Such data are often not available in this region; and, even if some data can be found, collection has been on an administrative management scale, which makes them less meaningful for the purposes of research. Furthermore, these limited data are often not accessible because there is lack of cooperation and coordination between different sectors, departments, and nations.

This suggests that we need to rebuild or redesign existing information systems in order to respond to climate change

effectively, and we also need the close cooperation of different sectors, nations, and disciplines in order to study and monitor the impacts of climate change on human wellbeing. In addition, the status of human wellbeing is the consequence of complex interactions among many factors. Climate change is just one of the factors and it interacts with many other physical and socioeconomic variables such as economic dynamics, migration, and poverty: and all of these form a complicated network affecting human wellbeing. This makes it hard to 'isolate' the impact of climate change on human wellbeing from the effects of other parameters. To meet this challenge, we need collaboration and coordination between different sectors and disciplines in a transdisciplinary manner to design new methods and to carry out high quality research.

Most of the available research focuses overwhelmingly on the adverse impacts of climate change. Little attention has been paid to how people adapt to the changing environment and use new opportunities that occur. This was, in fact, revealed by the participants at the stakeholder workshops. Climate change does not occur in a single day; rather it is a process that lasts for decades and centuries. During the process, people reactively and autonomously adapt to the changes continually. This adaptation has not been well documented and understood. Current knowledge about adaptation and adaptive capacities is insufficient for planning adaptation options, measures, and policies of governments (Smit and Pilifosova 2001). In the Eastern Himalayas, climate change may cause intensified interactions between ecosystems and human beings given the fact that the majority of the population relies on natural resources for their livelihoods. It is not very clear how these intensified interactions will affect the ecosystem or human beings. Research at community level is crucially important in order to document and understand how people adapt to the changing environment and how these adaptive strategies in turn affect the ecosystems.

For the success of biodiversity conservation in the context of climate change, it is essential to include the human dimension. To reduce vulnerability and to enhance the human capacity to adapt to climate change requires a careful balance and trade-off between conservation and development. This is particularly true in the Eastern Himalayas where both ecosystems and human beings are vulnerable to climate change. Improving understanding of how communities interact with biodiversity and what traditional and modern institutions govern this interaction will help to arrive at a satisfactory balance and enable us to negotiate better solutions.

A healthy population is a good indicator of its capacity to adapt to climate change. Establishing or strengthening surveillance systems for infectious diseases, strengthening the health sector by training professionals to understand the threats posed by climate change to human health, and carrying out research to fill the knowledge gaps and reduce uncertainties are all important adaptation measures.

## Conclusion

Findings from a review of the literature and existing data indicate that the current status of human wellbeing in the Eastern Himalayas is one of vulnerability to climate change: the region is poorly adaptive to climate change due to factors such as high levels of poverty, underdeveloped infrastructure, rapid population growth, and heavy reliance on sectors that are susceptible to climate change such as subsistence farming and hydropower. Threats brought about by climate change in this region include water stress and scarcity; food insecurity; water-borne and food-borne diseases; and disasters such as GLOFs, landslides, floods, and droughts. Despite general knowledge about the impact of climate change on human wellbeing, there is little robust scientific evidence that can directly attribute changes in human wellbeing to climate change. Knowledge gaps about how climate change has affected various dimensions of human wellbeing are substantial and uncertainties are great. In addition, the majority of the existing research is projection-based and focuses on the negative and adverse impacts with little attention being paid to understanding how people in different settings have adapted to the changing environment or have used the new opportunities provided by the changing environment for better livelihoods.

Empirical research is lacking. Compared to other regions, research into the different aspects of human wellbeing, such as human health per se, is far from sufficient, let alone research into the impacts of climate change on health. The interaction between human wellbeing and ecosystems has become more intense in the context of population growth, technology advances, commercialisation, and globalisation. This will have profound impacts on biodiversity and sustainable development. In other words, biodiversity conservation cannot be successful without taking into account human wellbeing. A good balance and trade-off between conservation and development is a crucial requirement. This will necessitate interdisciplinary and cross-sector research to bring all factors together and to negotiate an equitable solution.

## Bibliography

- Alam, M; Tshering, D (2004) *Adverse impacts of climate change on development of Bhutan: Integrating adaptation into policies and activities*, CLACC Working paper No 2. Dhaka: Bangladesh Centre for Advanced Studies
- Cheng Guowei; Cheng Zhangwei (2003) *China Tropic Medicine* 3(1): 70-71
- CNES (2010) *The impact of insurgency activities in Northeast India on socio-economic development and its solution thereof*. Guwahati: Centre for North East Studies and Policy Research. [www.cnes.org/nycu/539.html](http://www.cnes.org/nycu/539.html) (accessed 13 February 2010)
- Dang Shao Nong; Yan Hong; Wang Xue Liang; et al. (2002) 'Analysis on nutritional status of children below three years old in Tibet.' *Chinese Journal of Public Health* 7. [http://en.cnki.com.cn/Article\\_en/CJFDTOTAL-ZGGW200207031.htm](http://en.cnki.com.cn/Article_en/CJFDTOTAL-ZGGW200207031.htm)
- De, M; Halder, A; Podder, S; Sen, R; Chakrabarty, S; Sengupta, B; Chakraborty, T (2006) 'Anemia and hemoglobinopathies in tribal populations of Eastern and North-eastern India.' *Hematology* 11(5): 371-373
- Devine, A; Kermode, M; Chandra, P; Herrman, H (2007) 'A participatory intervention to improve the mental health of widows of injecting drug users in north-east India as a strategy for HIV prevention.' *BMC International Health and Human Rights* 7(1): 3
- Du Jie; Kanji, N (2003) *Gender equality and poverty reduction in China: issues for development policy and practice*. Beijing: DFID
- Du Jun (2001) 'Change of temperature in Tibetan Plateau from 1961 to 2000.' *Acta Geographica Sinica* 56(6): 682-690
- EarthTrends (2003) *Economic indicators – Nepal*. Washington DC: World Resources Institute. [earthtrends.wri.org/pdf\\_library/country\\_profiles/eco\\_cou\\_524.pdf](http://earthtrends.wri.org/pdf_library/country_profiles/eco_cou_524.pdf) (accessed 31 March 2010)
- Frackiewicz, A (2008) *Ecosystem services, human well-being and quality of life*. [http://openlandscapes.zalf.de/OpenLandscapesWiki\\_Glossaries/Session%20E%20-%20Ecosystem%20services,%20human%20well-being%20and%20quality%20of%20life.aspx](http://openlandscapes.zalf.de/OpenLandscapesWiki_Glossaries/Session%20E%20-%20Ecosystem%20services,%20human%20well-being%20and%20quality%20of%20life.aspx) (accessed 30 March 2010)
- Gill, GJ; Farrington, J; Anderson, E; Luttrell, C; Conway, T; Saxena, NC; Slater, R (2003) *Food security and the Millennium Development Goal on hunger in Asia*, Annex 7: Food security in Nepal. London: Overseas Development Institute. [www.odi.org.uk/publications/working\\_papers/wp231/wp231-references.pdf](http://www.odi.org.uk/publications/working_papers/wp231/wp231-references.pdf) (accessed 30 March 2010)
- GoC (2001) *The annual national health statistics materials*, p433. Beijing: Ministry of Health, Government of China
- GoC (2007) *Chinese health statistical digest*. Beijing: Ministry of Health, Government of China
- Gol (2001) 'State of human development: Concept, methodology and core indices. In *National human development report 2001*. New Delhi: Government of India, Planning Commission. <http://planningcommission.nic.in/reports/genrep/nhdrep/nhdreportf.htm> (accessed 10 March 2010)
- Gol (2008) *National action plan on climate change*. New Delhi: Government of India. [http://pmindia.nic.in/climate\\_change.htm](http://pmindia.nic.in/climate_change.htm) (accessed 29 March 2010)
- Government of Arunachal Pradesh (2005) *Arunachal Pradesh human development report 2005*. Itanagar: Government of Arunachal Pradesh



- Government of Nagaland (2004) *The Nagaland state human development report 2004*. Nagaland: Government of Nagaland, Department of Planning and Coordination
- HMGN (1996) *Nepal living standards survey report*. Kathmandu: Government of Nepal, Central Bureau of Statistics
- Human Rights Watch (2001) *Caste discrimination: A global concern*. A report by Human Rights Watch for the United Nations World Conference against Racism, Racial Discrimination, Xenophobia and Related Intolerance, September 2001, Durban, South Africa
- Huq, S; Rahman, A; Konate, M; Sokona, Y; Reid, H (2003) *Mainstreaming adaptation to climate change in least development countries (LDCs)*. London: International Institute for Environment and Development
- ICIMOD (2007) *First international decade of the world's indigenous people in Asia, 1995-2004*, Assessment synthesis report. Kathmandu: ICIMOD
- IPCC (2007) *Climate change 2007: The physical science basis*, summary for policymakers. Geneva: IPCC
- JICA (2001) *UNDP Human development report 2001*, cited in country profile study on poverty Nepal, March 2003 by Japan International Cooperation Agency Planning and Evaluation Department. Kathmandu: JICA
- Jun Qi; Linsheng Yang ; Wuyi Wang (2007) 'Environmental degradation and health risks in Beijing, China.' *Archives of Environmental and Occupational Health* 62(1): 33-37
- KC, BK (2004) 'Migration, poverty and development in Nepal.' *Asia Pacific Migration Journal* 13(2): 205
- Kelkar, U; Bhadwal, S (2007) 'South Asian regional study on climate change impacts and adaptation: implications for human development.' In *UNDP Human Development Report 2007/2008*, Occasional paper. New York: UNDP
- Khoday, K (2007) 'Climate change and the right to development: Himalayan glacial melting and the future of development on the Tibet Plateau. In *UNDP Human Development Report 2007/2008*, Occasional paper. New York: UNDP
- Li Hua-Xian; Yang Yuan-Chuan, Jiang Hua (2005) 'Malaria epidemic and outbreak situation in Yunnan Province in 2003.' *Parasites and Infectious Diseases* 3(4): 152-156
- Li Huazhong (2007) *China malaria situation and strategy*. A workshop on malaria held at the National Institute for Parasitic Diseases, China CDC
- Li Tiaoying; Qiu Jiamin; Yang Wen; Craig, PS; Chen Xingwang; Xiao Ning; Ito, A; Giraudoux, P; Mamuti Wulamu; Yu Wen; Schantz, PM (2005) 'Echinococcosis in Tibetan populations, western Sichuan Province, China.' *Emerging Infectious Disease* 11: 1866-1873
- Li Yuping, Liu Gintao, Li Yuan et al (2006) *Maternal and Child Health Care of China*, Issue 17
- Liu, J. et al (2006) *Tibet Science and Technology*, Issue 3, 2006
- Me Je, Lin Liangming, Ma Guanfu (2003) *Chinese Journal of Preventive Medicine*. Issue 6
- MEA (Millennium Ecosystem Assessment) (2005a) *Ecosystems and human well-being: A framework for assessment*. Washington DC: Island Press
- MEA (Millennium Ecosystem Assessment) (2005b) *Ecosystems and human well-being: Synthesis*. Washington DC: Island Press
- Migration News (2001) 'China: migrants, Nepal.' *Migration News* 8(1). [http://migration.ucdavis.edu/mn/more.php?id=2287\\_0\\_3\\_0](http://migration.ucdavis.edu/mn/more.php?id=2287_0_3_0) (accessed 25 march 2010)
- Nandy, SN; Dhyani, PP; Samal, PK (2006) 'Resource information database of the Indian Himalaya.' *ENVIS Monograph 3*: 53-56, and Almora: GB Pant Institute of Himalayan Environment and Development. <http://gbpihed.nic.in/envis/HTML/monograph3/development.html> (accessed 10 March 2010)
- NDP Nepal (2004) 'Human development and empowerment in Nepal today.' In *Nepal human development report 2004*, pp17-29. Kathmandu: UNDP
- NDRC (2007) China's national climate change program. Beijing: National Development and Reform Commission. [www.china.org.cn/english/environment/213624.htm](http://www.china.org.cn/english/environment/213624.htm) (accessed 4 June 2007)
- Northwest Hydraulics Consultants (2006) *River flooding and erosion in Northeast India: Exploratory consideration of key issues*, Background paper No 4. New Delhi: Government of India, Ministry of Development of North Eastern Region/Washington, DC: World Bank
- NWCCW (2003) *The monitoring and assessment report of the China children development guidelines in 1990s*. Beijing: The National Working Committee on Children and Women under the State Council
- Pradhan, A; Pant, PD; Govindasamy, P (2007) *Trends in demographic and reproductive health indicators in Nepal further analysis of the 1996, 2001, and 2006 Demographic and health surveys data*, DHS trend report No 5. Calverton: Macro International
- Ravindranath, NH; Joshi, NV; Sukumar, R; Saxena, A (2006) 'Impact of climate change on forests in India.' *Current Science* 90(3): 354-361
- Sarkar SK; Sarkar K; Ponda, S; et al. (1992) *Rapid spread of HIV among injecting drug users of North-Eastern India: A new risk group of transmission in India*. Abstract ThC 1554, 8th International AIDS Conference 19-24 July 1992, Amsterdam, Netherlands. <http://www.aegis.com/conferences/iac/1992/ThC1554.html>
- Sathaye, J; Shukla, PR; Ravindranath, NH (2006) 'Climate change, sustainable development and India: Global and national concerns.' *Current Science*, 90(3): 314-325
- Shakya, A (2009) *Social impact of armed conflict in Nepal: Cause and impact*. [www.internal-displacement.org/.../Social+Impact+of+Armed+Conflict+in+Nepal+by+Anjana+Shakya.pdf](http://www.internal-displacement.org/.../Social+Impact+of+Armed+Conflict+in+Nepal+by+Anjana+Shakya.pdf) (accessed 11 February 2010)
- Sharma, HN; Kar, BK (1997) 'Pattern of population growth in North-East India.' In Ahmad, A; Noin, D; Sharma, HN (eds) *Demographic transition: The Third World scenario*, pp 73-93. Jaipur: Rawat Publications
- Smit, B; Pilifosova, O (2001) 'Adaptation to climate change in the context of sustainable development and equity.' In McCarthy, JJ; Canzianni, OF; Leary, NA; Dokken, DJ; White, KS (eds) *Climate change 2001: Impacts, adaptation, and vulnerability*. Contribution of Working Group II to the Third Assessment Report of the IPCC. Cambridge: Cambridge University Press. <http://www.ipcc.ch/ipccreports/tar/wg2/pdf/wg2TARchap18.pdf> (accessed 11 March 2010)

- Stern, N (2007) *The economics of climate change: The Stern review. Part II: The impacts of climate change on growth and development*. Cambridge: Cambridge University Press
- UNDP (2001) *Human development report 2001*. New York: UNDP
- UNDP (2008) *Fighting Climate change: Human solidarity in a divided world, Human development report 2007/2008*. New York: UNDP
- UNDP Bhutan (2006) *Bhutan common country assessment 2006*. Thimphu: United Nations System in Bhutan
- UNDP China (2005) *Development with equity, China human development report 2005*. Beijing: UNDP, China Country Office
- UNDP India (2005) *The Nagaland state human development report 2004*. Nagaland launches its first state human development report. Nagaland: UNDP
- UNDP Myanmar (2005) *Strategic framework for the UN Agencies in Myanmar*. Yangon: United Nations Agencies in Myanmar
- UNESCAP (Economic and Social Commission for Asia and the Pacific) (2003) *Migration, poverty and development in Nepal*. Ad hoc expert group meeting on Migration and Development, 27-29 August 2003, Bangkok, Thailand.
- UNHCR Myanmar (2009) *Statistical snapshot*. Yangon: UNHCR Myanmar. [www.unhcr.org/pages/49e4877d6.html](http://www.unhcr.org/pages/49e4877d6.html) (accessed 29 March 2010)
- Wang Wuyi (2008) *Environmental degradation and health risks in Beijing, China*. Beijing: Chinese Academy of Sciences, The Institute of Geographic Sciences and Natural Resources Research
- WHO (2005) *Human health impacts from climate variability and climate change in the Hindu Kush-Himalaya region: A report of an Interregional workshop*, Mukteshwar, India, October 2005.
- WHO (2006) Climate change and health implications for SEAR countries: Bhutan takes action to mitigate impact. *WHO Newsletter of the Regional Office for South-East Asia* August 2007: 13-14
- WHO (2007) *County report India*. Workshop on Climate Change and Health in South East and East Asian countries, 2-5 July 2007, Kuala Lumpur, Malaysia
- WHO (2009) *Health in Myanmar 2009*. [www.whomyanmar.org/EN/Section6\\_168.htm](http://www.whomyanmar.org/EN/Section6_168.htm) (accessed 13 march 2010)
- World Bank (2006) *River flooding and erosion in northeast India*, Background paper No 4, prepared by Northwest Hydraulics Consultants (NHC), Edmonton, Alberta, Canada, for the World Bank
- World Bank (2007) *Development and growth in Northeast India: The natural resources, water and environment nexus*. Washington, DC: World Bank

# Acronyms and Abbreviations

CMIE	centre for monitoring India's economy
DFID	UK Department for International Development
GDP	gross domestic product
GLOF	glacial lake outburst flood
HDI	human development index
ICIMOD	International Centre for Integrated Mountain Development
IMR	infant mortality rate
LDC	least developed countries
MEA	Millennium Ecosystem Assessment
MMR	Maternal mortality rate
RMC	regional member country
Tibet AR	Tibetan Autonomous Region of China
UNFCCC	United Nations Framework Convention on Climate Change





## Acknowledgements

ICIMOD expresses its sincere thanks and gratitude to its regional member countries for their extended support during this study. ICIMOD acknowledges the MacArthur Foundation for supporting the initiative by funding the project, and GTZ for co-financing through ECES programme funding. The Centre especially acknowledges the support of all the experts and researchers who have contributed to the technical papers and helped to strengthen understanding of the potential impact of climate change on biodiversity and other natural resources in the Eastern Himalayas. ICIMOD is also grateful for the assistance provided by various government agencies, partners from the RMCs, NGOs, and INGOs, all of whom contributed to developing this valuable information about the Eastern Himalayas.

The assessment team comprised Birendra Bajracharya, Nakul Chettri, Mats Eriksson, Fang Jing, Brigitte Leduc, Pradeep Mool, Bandana Shakya, Eklabya Sharma, Rita Sharma, Rajendra Shilpakar, Arun Shrestha, Rajesh Thapa, and Karma Tsering.

Technical contributions were received from Dhruvad Choudhury, Joy Dasgupta, Anupa Lamichhane, Krishna P. Oli, Manisha Sharma, Kabir Uddin (all ICIMOD); SK Barik (North Eastern Hill University, Shillong, India); LP Devkota (Tribhuvan University, Nepal); Karpo Dukpa (Ministry of Agriculture, Policy and Planning Division, Bhutan); AP Gajurel (Tribhuvan University, Nepal); Brij Gopal (National Institute of Ecology, New Delhi, India); AK Gosain (Indian Institute of Technology, New Delhi, India); Sandhya Rao (Integrated Natural Resource Management Consultants, New Delhi, India); Janita Gurung (Nepal); D Pathak (Tribhuvan University, Nepal); Kamal Raj Rai (Namsaling Community Development Center, Ilam, Nepal); and Nitesh Shrestha (Nepal)

Particular thanks are due to Karma Tsering, Rita Sharma and Joy Dasgupta who collaborated in the production of the white paper on which this publication is based.

### Series editor

Eklabya Sharma

### Production team

Greta Rana (Consultant editor)

A Beatrice Murray (Senior editor)

Dharma R. Maharjan (Layout and design)

Asha Kaji Thaku (Editorial assistant)

**Printed by** Hill Side Press (P) Ltd., Kathmandu, Nepal

## Publication details

**Published by International Centre for Integrated Mountain Development**  
GPO Box 3226, Kathmandu, Nepal

Copyright © 2010 ICIMOD  
All rights reserved, published 2010

**ISBN** 978 92 9115 156 1 (electronic)

**LCCN** 2010-319010

This publication may be reproduced in whole or in part and in any form for educational or non-profit purposes without special permission from the copyright holder, provided acknowledgement of the source is made. ICIMOD would appreciate receiving a copy of any publication that uses this publication as a source. No use of this publication may be made for resale or for any other commercial purpose whatsoever without prior permission in writing from ICIMOD.

The views and interpretations in this publication are those of the author(s). They are not attributable to ICIMOD and do not imply the expression of any opinion concerning the legal status of any country, territory, city or area of its authorities, or concerning the delimitation of its frontiers or boundaries, or the endorsement of any product.

This publication is available in electronic form at [www.books.icimod.org](http://www.books.icimod.org).

**Citation:** Fang Jing; Leduc, B (2010) *Potential threats from climate change to human wellbeing in the Eastern Himalayan region*; Climate change impact and vulnerability in the Eastern Himalayas: Technical report 6. Kathmandu: ICIMOD

## About ICIMOD

The International Centre for Integrated Mountain Development, ICIMOD, is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush-Himalayas – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalisation and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.



## About MacArthur Foundation

The MacArthur Foundation supports creative people and effective institutions committed to building a more just, verdant, and peaceful world. In addition to selecting the MacArthur Fellows, the Foundation works to defend human rights, advance global conservation and security, make cities better places, and understand how technology is affecting children and society.



© ICIMOD 2010

**International Centre for Integrated Mountain Development**

GPO Box 3226, Kathmandu, Khumaltar, Lalitpur, Nepal

**Tel** +977-1-5003222 **email** [info@icimod.org](mailto:info@icimod.org) [www.icimod.org](http://www.icimod.org)