# The Changing Hindu Kush Himalayas: Environmental Change and Migration

9

Soumyadeep Banerjee, Richard Black, Dominic Kniveton, and Michael Kollmair

This chapter is focused on the relationship between environmental change and migration in mountain areas, and specifically the Hindu Kush Himalayan region of Asia, which contains the world's highest and most iconic mountains. Mountain populations have long adjusted to living in fragile and marginal environments, and partially as a result, mountains have for many decades been zones of out-migration, as people seek alternative and more reliable livelihoods. At the same time, mountain regions are often seen as particularly vulnerable to climate change, as well as to a range of environmental shocks and hazards. As such, they represent a particularly interesting case study to set alongside the broader regional overviews contained elsewhere in this volume – a special case of how major environmental change could have dramatic migration consequences in the future.

The chapter is organized into three main parts. First, we review available knowledge about climate and other environmental change in the Hindu Kush Himalayan region, based on a range of scientific reports and projections. A key element of this review is uncertainty about the nature of future change, albeit it is clear that temperatures in the region are rising, likely above global averages. Second, we review evidence on migration in the region, including labour migration, internal displacement and flows of refugees. Then, we systematically review evidence from

S. Banerjee (✉)
International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal

University of Sussex, Brighton, UK
e-mail: sbanerjee@icimod.org

R. Black • D. Kniveton
University of Sussex, Brighton, UK

M. Kollmair
Independent consultant, Munich, Germany

E. Piguet and F. Laczko (eds.), *People on the Move in a Changing Climate*, Global Migration Issues 2, DOI 10.1007/978-94-007-6985-4_9,
© Springer Science+Business Media Dordrecht 2014

case studies that link these two phenomena – environmental change and migration – together, including looking specifically at the extent to which migrants remittances help to build resilience against environmental change. Finally, in the conclusion, we examine the nature of causal linkages, and potential patterns of future change.

## What Do We Know About Climate Change in the Himalayas?

Mountains, with their steep relief, high precipitation, and quickly changing climatic patterns, are particularly sensitive to environmental change, with significant influence on human wellbeing (Körner and Ohsawa 2005). There is high confidence that future anthropogenically enduced changes in the climate including enhanced heat waves, glacial retreat, and permafrost degradation are likely to lead to increasing slope instabilities, movements of mass, and glacial lake outburst floods (IPCC 2012). While it is also anticipated that changes in heavy precipitation will affect landslides in some regions (IPCC 2012). Although, the direct impacts of climate change will be most marked at high elevations, they will have a greater impact at lower elevations, the 'cascading' of effects from high to low altitude areas, for example, including increased runoff at high altitude leading to floods and increased sand deposition on agricultural land at lower altitudes (Tse-ring et al. 2010).

However the recent furore over the validity of claims in the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report (AR4) that all glaciers in the Himalayas could disappear by 2035 (Cruz et al. 2007) has highlighted the dearth of data on the environment in mountain regions, and the space that this creates for claims about the future impacts of climate change. In this case, it was claimed that the disappearance of glaciers within 25 years would severely affect the water supplies in the region. While highly likely if glaciers did melt on this timescale, the claim was later retracted when doubts were cast over the evidence base of the claim.

At its core, the Hindu Kush Himalayan (HKH) region – in common with other mountain regions – suffers from a lack of data on the state of the environment. In turn, the cause of this scarcity is primarily due to problems of access. An example of the lack of data on the environment is that available on glacial mass balances. Understanding glacial mass balances is vital for assessing the impact of climate change particularly on water resources in mountain regions and surrounding areas. Yet according to Singh et al. (2011), data on mass balances only exists for roughly 10 out 50,000 glaciers in the HKH region. It should therefore be understood that any scenarios of future climate change in the region are currently built on a poor understanding of baseline conditions and the processes that effect change.

Given uncertainty in terms of unknown future greenhouse gas and aerosol emissions, as well as this lack of data and highly heterogeneous conditions in the region, it is difficult to develop scenarios of climate change. For example at their most detailed, global climate models create climate outputs at a resolution of a 100 km by 100 km. While regional climate models create scenarios at approximately 25 km by 25 km, this is still of limited use in mountainous regions

where climate varies over distances of kilometres. In this sense the climate change scenarios developed for the region should be viewed as speculative and illustrative of only a range of changes that may occur rather than representative of the full range of potential futures. It should be borne in mind when considering future climate scenarios that models vary between each other in the ways in which processes are parameterised so that scenarios developed from only one model may contain systematic biases and thus not be representative of a large field of climate possibilities.

Despite this lack of confidence in forecasting, the Hindu Kush Himalayan region is still widely believed to be likely to be one of the planet's hot spots of future climate change impacts (Maplecroft 2011). As with other mountain environments there exists a fine equilibrium between snow, ice, and water that effects biodiversity and ecosystem services, such as the regulation of water resources. This equilibrium is particularly sensitive to small changes in temperature and precipitation. The subsections below cover expected changes in temperature and precipitation, as well as a range of other potential environmental changes.

## Temperature Change

Mountain regions have experienced above average warming in the twentieth century (IPCC 2007a, b; Nogues-Bravo et al. 2007), although available studies are limited to isolated parts of the HKH region, and may not be representative of elsewhere. The warming rate for a major part of the region is higher than 0.01 ºC per year, ranging from 0.01 to 0.03 ºC per year in the Western and Eastern Himalayas. However, warming is higher in the central Himalayas and the whole of the Tibetan plateau at 0.03–0.07 ºC per year (Shrestha 2009). In turn, progressive warming at higher altitudes is three times greater than the global average (Eriksson et al. 2009; Xu et al. 2009). The warming trend in the three elevation zones – <1,000 masl, 1,000–4,000 masl, and >4,000 masl – over the past one and a half decades has been higher than the global average. This trend is greater at >4,000 masl zone compared to the other zones (Singh et al. 2011).

Looking to the future, IPCC assessment reports attempt to integrate the numerous studies undertaken to create scenarios of future climate change. Largely global in outlook, the last report (AR4) indicated an increased likelihood for a continuation of the current warming in the HKH region with increases in temperature likely to be greater at the higher altitudes and in winter. Spatially, some regional climate modelling work has indicated that the maximum warming (projected to the end of the century) will likely be in the Western Himalayan region (Kulkarni et al. 2011), although this was carried out with a single climate model. By comparison a study using three global climate models suggested that for the Eastern Himalayas the rate of future winter warming up to the 2080s is projected to vary between 3.6 and 5.3 °C, while the increase in summer temperature is projected to vary between 2.8 and 3.8 °C (Tse-ring et al. 2010).

## Changes in Precipitation

In contrast to studies of temperature change, most of the studies of precipitation in the Hindu Kush Himalayan region (Shrestha et al. 2000; Shrestha 2009; Dimri and Dash 2011) report a lack of notable trends. The lack of long-term observations even on spatial scales of a few tens of kilometres forms the major obstacle to assess the long term pattern of precipitation. Regardless of the reports of an increased frequency of heavy rainfall events and that of moderate rainfall events in the region had decreased, the available data is insufficient to support these claims (Singh et al. 2011).

As with many parts of the world, projections of changes in precipitation in the HKH are also highly uncertain with some models indicating increases and others decreases. More recent studies have confirmed this variation in precipitation projections into the future between models, with some projecting 10–20 % increases in precipitation and others a 10–20 % decrease (Immerzeel 2008). However, it should be recognised that many models produce scenarios of increased precipitation and an accelerated hydrological cycle (Singh et al. 2011).

Once again, there are regional variations within the HKH region. For example, winter precipitation averaged across the Eastern Himalayas is likely to increase by 23–35 %, and summer monsoon precipitation by 17–28 % (Tse-ring et al. 2010). This compares to 20–40 % over the entire HKH region at the end of the century (Kulkarni et al. 2011).

Noticeably in terms of water availability, these figures indicate a much greater loss through evapotranspiration due to warmer temperatures than increase in water from the increase in rainfall in the summer period (Singh et al. 2011)

## Changes in Snow Cover and Glaciers

Whilst in many parts of the world, the key determinant of water availability is precipitation, in the HKH region, large volumes of water were stored in the form of ice and snow that are released gradually as water over a long period during the dry seasons (Messerli and Ives 1997; Chettri et al. 2011). The estimated snow cover area in the HKH region for the 2000–2010 period was estimated to be 0.76 million square kilometer (Gurung et al. 2011a, b). During this period, the snow cover of this region was more or less stable, or only decreased slightly (Gurung et al. 2011a).

Notwithstanding the lack of information about glacier mass balances noted above, there is some evidence on glacier retreat. First, about 70 % of the glaciers that have been studied in the Hindu Kush Himalayan region have retreated 15 m per year or less in recent years (Singh et al. 2011). A substantial decrease in the total area of glaciers in Bhutan and Nepal accompanied by fragmentation of glacier was reported by several studies (Bajracharya et al. 2010, 2011; Bajracharya and Shrestha 2011). The rate of retreat for the Gangotri Glacier in the Indian Himalayas over the last three decades is more than three times the rate during the preceding 200 years

(Srivastava 2003). In the last half century, 82.2 % of the glaciers in western China have retreated (Ding et al. 2006; Kang et al. 2010). One exception is the Karakoram, where some high altitude glaciers are advancing (Hewitt 2005). Glacier retreat had also been reported for other parts of the region (Kulkarni et al. 2010; Nie et al. 2010).

However, recent studies (Immerzeel et al. 2010; Bolch et al. 2011) reported that rates of glacial retreat in this region were less than that suggested by the AR4 (Cogley et al. 2010; Miller et al. 2013). The rate of glacier melting in the Himalayas varies across the region. The shrinkage generally decreased from the Himalayas to the continental interior. The eastern Pamir is characterised by the least glacial retreat, area reduction and positive mass balance. The Himalayas, excluding Karakoram, experienced the greatest reduction in glacial length and area and the most negative mass balance (Yao et al. 2012). In the Himalayas, the glaciers are of significance as they are an important source of water for springs and rivers, particularly during the dry season. The contribution of snow to the runoff of major rivers varies between Eastern and Western Himalayas. It is about 10 % for the former and more than 60 % for the latter (Vohra 1981).

## Changes in River Flow

Notwithstanding the uncertainties noted so far, a number of studies have attempted to model the impact of climate change on river flows (see Singh et al. 2011). For example, one of these studies indicated that the mean upstream water supply was likely to decrease between the two time slices 2000–2007 and 2046–2065 by −8.4 % for the Upper Indus, −17.6 % for the Ganges, −19.6 % for the Brahmaputra, and −5.6 % for the Yangtze (Immerzeel et al. 2010). It should be noted that these decreases were less than would be expected from the loss of snow cover and glacial retreat alone, as they were compensated to varying extents by an increase in upstream rainfall depicted in the model runs used (Immerzeel et al. 2010).

## Biodiversity

Mountain systems support about half of the world's biological diversity and nearly half of the world's biodiversity hotspots (Myers et al. 2000; Hassan et al. 2005). Of the world's total acreage of land-based protected areas, some 27.6 % are situated in mountains (Kollmair et al. 2005). With rising temperatures, upward shifts of vegetation belts to higher elevations and northward advances in the geographical ranges of species in the northern hemisphere were expected (Nogues-Bravo et al. 2007). Some mountain species were likely to be losers including large territorial animals, late successional plant species, species with small and restricted populations, and species confined to summits (Körner 2009).

However, these processes should not be regarded as entirely negative – they may also present new opportunities. Because temperatures decrease with altitude, mountain species are in the privileged position of being able to migrate upwards to cooler areas, whereas lowland species usually have no other option than to adapt to higher temperatures, which is much more difficult (Körner 2009). Some of the observed impacts of climate change on biodiversity in Eastern Himalayas were loss and fragmentation of habitat, reduction in forest biodiversity, degradation of wetland and riverine island ecosystems, decline in forage and fodder resources, reduction in agrobiodiversity, increase in forest fires, rise in exotic and invasive species, soil fertility degradation, changes in land use pattern, more growth/biomass production in forests and variable productivity in agriculture (Tse-ring et al. 2010). Thus, mountains could serve as refuges for species that can no longer survive in the lowlands (Singh et al. 2010).

## Natural Hazards and Disasters

Mountains are typically exposed to multiple hazards (Kohler and Maselli 2009). According to Guha-Sapir et al. (2011), hydrological disasters – flood, mass movement and drought – accounted for 48 % of the total annual disasters. Other forms of disasters included storms (23 %), earthquakes and landslides (14 %), epidemics (8 %), extreme temperature events (6 %), wildfires (1 %). In Nepal, the number of floods days and consecutive days of flood events had been on the rise (Shrestha et al. 2003). Continued glacier recession is and will increase the incident of glacial lake outburst floods (GLOFs). Globally in the past century, GLOFs have caused disasters in many regions of the world (Rosenzweig et al. 2007), including the Himalayas (Vuichard and Zimmermann 1987; Xin et al. 2008; Bajracharya and Mool 2009; Osti and Egashira 2009: as all cited in IPCC 2012). Some increasing trends have been observed in the number of GLOF events in the Himalayas, in the latter half of the last century, but these findings suffer from incomplete documentation (Richardson and Reynolds 2000; IPCC 2012). However, currently about 204 glacial lakes have been listed as having the potential to breach in the Himalayan region (Ives et al. 2010).

## The Relationship Between Environmental Change and Human Wellbeing

If current knowledge and data of the HKH environment is insufficient to pinpoint realistic detailed scenarios of future change for the region, by extension it is also beyond current capabilities to create meaningful scenarios of change for the diverse populations of the HKH. Certainly mountain communities are sensitive to changes in ecosystem services and these impacts are likely to be manifest in human wellbeing.

One of the key sensitivities of livelihoods is exposure to stresses and shocks in terms of the availability and changing state of water. It is possible to imagine a likely scenario of continued impacts from hydrospheric change of increased ground instability in permafrost regions; increased rock avalanches and erosion of soils; reduced water supplies and hydropower potential as well as changes in the seasonality of flows in basins supplied by meltwater from snow and ice; reductions in water quality and freshwater species due to the adverse impacts of temperature increases on wetlands, freshwater lakes, and rivers (Singh et al. 2011).

As with much of the globe, the rule of thumb predictions indicate that drought-affected areas are likely to increase in extent with climate change, leading to substantial increases in the need for water for irrigation, while the increased variability in precipitation, increase in precipitation intensity and seasonal shifts in runoff are likely to negatively impact water supply, water quality, and flood risk.

## An Assessment of the Main Migration Flows to and from the Region

As with environmental and climate change, a lack of disaggregated mountain specific migration data and literature for this region remains a major challenge to assess the migration flows to and from the Hindu Kush Himalayan region. The available data and literature are often based on national administrative boundaries, which do not necessarily correspond with the boundaries of ecosystems such as mountains. This section provides an overview of the main migration flows in the region.

### Internal Migration

Evidence suggests that most of the migrants from the Hindu Kush Himalayan region remain within their country of origin. There are, generally, no restrictions on internal migration and fewer resources required for moving within the country of origin compared to that of migrating abroad. A study by the Ministry of Agriculture in Bhutan (2006) reported that 47 % of the sampled rural households had one or more migrants. Most of these rural migrants had moved to an urban area, primarily to those in western Bhutan. Only 6 % of rural migrants had moved to another village (Ministry of Agriculture in Bhutan 2006). Based on the Census of India in 2001, over three-quarters of all migrant workers from the Uttarakhand province of India had moved to other parts of the country, with concentrations in cities like Delhi, Mumbai, Lucknow, Chandigarh and Ambala. Others had moved to urban areas within the province such as Dehradun, Nainital and the district headquarters (Mamgain 2004).

Pakistani cities such as Muzaffarabad, Peshawar, Rawalpindi, Lahore, and Karachi were major destinations of migrants from the mountain areas. Migration from mountain areas of northern Pakistan to nearby urban areas in the plains was a

traditional livelihood strategy among rural households (Nadeem et al. 2009; Schutte and Kreutzmann 2011). According to the Census of Nepal in 2001, around 13.2 % of the total native born population were classified as internal migrants. The rural-to-rural (68.2 %) and rural-to-urban stream (25.5 %) were the major streams of internal migration. The same Census figures showed that 11 % of the internal migrants had moved for employment related reasons (Subedi 2009). The rural areas of Mid- and Far-West Nepal were major areas of net out-migration as the migrants moved to the Kathmandu valley and other urban areas, and lowlands of Terai (Lokshin et al. 2007).

## International Migration

There are several well established international migration streams in the Hindu Kush Himalayan region. In a departure from the general pattern in this region, rural migrant households in Afghanistan were twice as likely to send members abroad rather than to destinations within the country. A study by Ghobadi et al. (2005) found that compared to the 22 % of internal migrants, around 43 % of the Afghan migrants had moved abroad to destinations in Iran, Pakistan, Middle East, Europe and North America.[1] The Afghan migrants, besides being employed in low skilled non-primary sector professions such as transport, construction, services, lifting work, trade, and chemical industries, were also hired in large numbers by landlords in Iran and Pakistan during the summer and autumn seasons to do heavy agricultural work (Olimova 2005; Olimova and Olimov 2007).

The flow of migrant workers from Nepal to the Middle East-, South East-, and East Asia had been widely documented (Kollmair et al. 2006; Shrestha 2008; Adhikari and Hobley 2011). According to the Census of Nepal of 2001, about 3.3 % of the total native population of the country were international migrants; and over two-thirds of these had migrated for employment (Subedi 2009). In spite of the growing popularity of destinations such as Malaysia, Qatar, Saudi Arabia, United Arab Emirates, South Korea, and Kuwait among economically better off Nepalese migrants, India still remained the most important destination for unskilled and marginal population of rural Nepal (Bhattrai 2007; Adhikari and Hobley 2011). Adhikari et al. (2006) estimated that approximately 1.5 million Nepalese had found employment in India. There is a lot of variation between available estimates since there was no way to ascertain the actual number of Nepalese migrants in India because of the open border between the two countries. The India-Nepal Treaty of Friendship of 1950 created an open border between the two countries, allowing visa and passport free entry and access to employment without a work permit. Any citizen of India or Nepal can migrate to the other country and stay for as long as desired (Subedi 1991; Adhikari et al. 2008).

[1]The destination was unknown for 32 % of the migrants (Ghobadi et al. 2005).

The countries around the Persian Gulf have provided unprecedented economic opportunities for migrant workers from mountain regions of Pakistan, where they were predominantly occupied in semi to low skilled professions in transportation, construction, cargo services, brick kilns, chemical enterprises, and oilfields (Olimova and Olimov 2007; Hunzai 2010). Based on data from the Bureau of Emigration and Overseas Employment, Arif (2010) estimated that about a quarter of the international labour migrants originated from the Khyber Pakhtunkhwa province in Northern Pakistan. Given the labour market demand in the Middle East, most Pakistani migrant workers to the region are male (BOE 2005).

Olimova and Olimov (2007) observed a direct relationship between the type of migration and altitudinal profile of the origin communities in Afghanistan and Pakistan. Migrants from mid-altitude regions were seasonal workers with relatively sophisticated professional skills, including a significant number of seasonal employees in trade and commerce. Migration from high-altitude areas was dominated by younger semi-skilled or unskilled individuals, who were usually employed in low skilled occupations in destination that required heavy manual work. Only few were involved in trade and commerce. On an average, there were more female migrant workers from this region than from other regions.

## Internal Displacement

The cases of conflict induced internal displacement have been reported from all across the Hindu Kush Himalayan region. As of 2011, 448,000 people remained internally displaced in Afghanistan because of armed conflict, human rights abuses, and other forms of generalised violence. (UNHCR IDP data 2012 cited in IDMC 2012a). The majority of this displacement has taken place in the southern, south-eastern, eastern and western regions of Afghanistan (IDMC 2012a). In neighbouring Pakistan, some 850,000 people were displaced due to the military operations against the insurgents in Khyber-Pakhtunkhwa and Federally Administered Tribal Areas (FATA) (FDMA 2011 cited in IDMC 2012c). In Nepal, although the signing of the Comprehensive Peace Accord (CPA) between the Government and the Unified Communist Party of Nepal (Maoist) in 2006 ended a decade old conflict, by the end of 2011, about 50,000 people still remained displaced and were unable or unwilling to return to their places of origin (RCHCO 2011 cited in IDMC 2012b). Inter-ethnic violence in various parts of Northeast India such as western Assam, along the border between Assam and Meghalaya, and in Tripura has also displaced scores of people. As of 2011, conservative estimates suggest that more that 76,000 people were still displaced (IDMC 2011).

Presently, there is no coordinated mechanism in the Hindu Kush Himalayan region to collect and compile data on mobility due to natural disasters. The available evidence is based on post-disaster rapid assessments or sporadic case studies. A rapid assessment by IOM in 11 districts of the Khyber-Pakhtunkhwa province of northern Pakistan affected by the 2010 floods found that over 257,000 households

had been temporarily displaced (IOM 2010). The 2005 earthquake in Northern Pakistan resulted in the displacement 2.8–3.5 million people (DFID 2006, ERRA 2005 cited in Yasir 2009). Banerjee et al. (2011) reported permanent as well as temporary displacement in flood affected communities of the Koshi sub-basin of East Nepal, Eastern Brahmaputra sub-basin in Assam province of India, and Upper Indus sub-basin in Chitral district of Pakistan.

### Refugees

For the past three decades, most refugees in the region originated from Afghanistan. At the end of 2009, almost 2.9 million Afghans were still refugees. Almost 96 % of Afghan refugees were based in Pakistan and the Islamic Republic of Iran (UNHCR 2010). Since 2006, security concerns and poor prospects of economic and social improvement had caused a decline in the rate of returns to Afghanistan (Altai Consulting 2009). It is also estimated that around two million Myanmarese refugees are in Thailand (Brees 2008). The exact estimate of Myanmarese refugees in other neighbouring countries – Bangladesh, India, China and Malaysia – is unknown (Brees 2008; Shukla 2008).

Over the years, though, the refugee population in Pakistan had decreased due to voluntary repatriation, registration and resettlement. In 2009, Pakistan was still the country with largest number of refugees, around 1.7 million. Most of these refugees were from neighbouring Afghanistan (UNHCR 2010). India hosted some 110,000–150,000 refugees from the Tibetan Autonomous Region of China, about 75,000 ethnic Chin refugees from Myanmar, around 36,000 Chakma and Hajong refugees from the Chittagong Hill Tracts of Bangladesh, between 15,000 and 30,000 ethnic Nepalese from Bhutan, and over 31,000 Afghans (HRLN 2007; United States Committee on Refugees and Immigrants 2008).

## Case Studies on Links Between Migration and Environmental Change

The multi-causal nature of migration is widely acknowledged (Castles and Miller 1993; Boyle et al. 1998; Foresight: Migration and Global Environmental Change 2011). Indeed, even in the Hindu Kush Himalayan region, where the livelihoods of many households are dependent on ecosystem services, a disruption of lives and livelihoods due to environmental shocks and stresses may not be a sufficient motivation to migrate, as the environmental driver of migration does not function in isolation from non-environmental drivers and intervening obstacles. For this reason, this last part of the chapter considers first environmental drivers of migration in the Hindu Kush Himalayan region, but then turns to other drivers that interact with environmental drivers in the context of climate change.

## Environmental Drivers of Migration

There is a relative lack of specific empirical evidence on the role of environmental drivers of in the Hindu Kush Himalayan region. This sub-section reviews all available empirical evidence from this region. Some of the reviewed case studies (Massey et al. 2007; Shrestha and Bhandari 2007; Banerjee et al. 2011; Bohra-Mishra and Massey 2011) specifically focus on the relationship between environmental change and migration. In other case studies (Ghobadi et al. 2005; IUCN 2005), the effects of environmental variables are mentioned as a passing reference within a wider study.

Drought affected households in Afghanistan are more likely to have migrant members than those unaffected by drought (Ghobadi et al. 2005). During long winters when the valleys are covered with snow, migrations to urban centres in the plains had been a traditional strategy among the lower income rural migrants of northern Pakistan (IUCN 2005). To represent environmental change in Chitwan valley of south-east Nepal, Massey et al. (2007) used variables such as neighbourhood population density, perceptions of changing agricultural productivity, share of neighbourhood land covered by flora, time required to collect fodder, and time required to collect firewood. This study found that environmental change had a greater chance of influencing local (within Chitwan valley) rather than long-distance (outside Chitwan Valley) mobility. The likelihood of moving within the Chitwan valley was greater if a decline in agricultural productivity was perceived, the share of the neighbourhood covered in flora declined, or time required gathering firewood increased. For long distance mobility, only a perceived decline of agricultural productivity was significant but the effect was considerably less powerful (Massey et al. 2007).

Yet in a separate study in the same area, Shrestha and Bhandari (2007) conceptualised the notion of environmental security in terms of changes in time required to collect firewood from forest or common land. The results from Chitwan valley in Nepal showed that increases in environmental insecurity raised the likelihood of labour migration, regardless of destination (Shrestha and Bhandari 2007). This contradictory result from two case studies (Massey et al. 2007; Shrestha and Bhandari 2007) set in the same area – Chitwan valley in Nepal – may be due in part to differences in the definitions of migration adopted by them. Massey et al. (2007) focused on local (i.e. within Chitwan valley) versus long-distance mobility (i.e. outside Chitwan valley). Whereas, Shrestha and Bhandari (2007) considered domestic (i.e. within Nepal) versus international mobility (i.e. outside Nepal) (Bohra-Mishra and Massey 2011).

In order to resolve this contradiction, Bohra-Mishra and Massey (2011) distinguished three streams of migration – within Chitwan, outside Chitwan but within Nepal, and those outside Nepal – in the same database that had been used by the earlier studies. This study identified five environmental indicators: change in time required to collect fodder, change in time required to collect firewood, change in agricultural productivity, change in quality of drinking water, and population density (Bohra-Mishra and Massey 2011). The likelihood of undertaking a local move had a

strong and consistent relationship with neighbourhood density, rise in time required to collect fodder and firewood, and declining agricultural productivity. The effects of environmental drivers were more prevalent on local migration of women than that for men. Environmental deterioration had little influence on migration outside the Chitwan district, either to other districts in Nepal or overseas. However, the likelihood of male migration to other districts of Nepal or international destinations increased with rise in time to collect firewood (Bohra-Mishra and Massey 2011).

A recent study by Banerjee et al. (2011) across the Hindu Kush Himalayan region has assessed patterns of labour migration in rural communities that were exposed to water hazards. The environmental variables used in this study were the type of water hazard (i.e. rapid or slow onset water hazard), natural hazard proneness of livelihoods prior to migration, and impact of water hazard on owned agricultural land. This study found that the likelihood that household members would migrate for work was higher in communities exposed to rapid onset water hazard (i.e. flood and flash flood) than those exposed to slow onset water hazard (i.e. drought). Among the communities exposed to slow onset water hazards, the likelihood of labour migration was higher in communities affected by very severe hazards rather than those affected by less severe ones. In flood or flash flood affected communities, a comparison between the households where agricultural land had been damaged by the hazard to those where it had not been, showed that members of the former were less likely to migrate for work. The likelihood of labour migration from households that depended on natural hazard prone livelihoods (e.g. farming or animal husbandry) in the past was lower when exposed to slow onset water hazards (Banerjee et al. 2011).

## Economic Drivers of Migration

Livelihood opportunities in the rural areas of the Hindu Kush Himalayan region are generally restricted to primary sector occupations. Factors such as market volatility, environmental shocks and stress, land degradation, and lack of basic infrastructure undermined agricultural growth, its labour absorption potential, income generating capacity and role in food security. At the same time, the introduction of modern agricultural technology and natural increase in the rural population has created a surplus of rural labour (Bohle and Adhikari 1998; Liang and Ma 2004; Huo et al. 2006; Olimova and Olimov 2007). There is a growing awareness of prospects beyond the mountains through education, communication, and social networks (Opel 2005; Hoermann et al. 2010). In such circumstances, labour migration has become one of the most important livelihood strategies across this region: Afghanistan (Ghobadi et al. 2005; Opel 2005), Bhutan (Ministry of Finance in Bhutan 2005); China (Liang and Ma 2004; Zhu and He 2010); Nepal (Seddon et al. 2002; Sharma 2008, 2011); and Pakistan (Nadeem et al. 2009; Arif 2010).

Economic opportunities within the Hindu Kush Himalayas also attract migrants from within the region and neighbouring lowlands (Liang and Ma 2004;

Nepal 2007; Brusle 2008). For instance, tourism induced growth in the service sector in Yunnan attracted 'floating migrants' (those without the *hukou* or household registration status) from within the province and elsewhere (Liang and Ma 2004).

## Social Drivers of Migration

Social networks based on familial links or affiliation to a social group have a strong influence on the migration decision and choice of destination. These networks support migration by extending loans, assisting in logistics, arranging jobs and accommodation, and providing emotional support to the migrant or family left behind. The influence of social networks on migration had been documented in Afghanistan (Opel 2005; Ghobadi et al. 2005); Bhutan (Walcott 2009); China (Liang and Ma 2004); India (Mamgain 2004); Nepal (Seddon et al. 2002; Thieme 2006; Sharma 2008); and Pakistan (Nadeem et al. 2009).

Education has emerged as another important social determinant of migration. The lack of adequate education facilities was the most commonly cited reason for leaving rural homes in Bhutan (Ministry of Finance in Bhutan 2005; Ministry of Agriculture in Bhutan 2006). Access to better education facilities for their children was one of the factors considered by the migrants in Ladakh district of India (Goodall 2004) and Far West Nepal (Poertner et al. 2011).

## Demographic Drivers of Migration

The demographic factors such as household composition, age, and gender influence migration process. In Afghanistan, likelihood of migration has been found to be higher in households with more persons of working age (Ghobadi et al. 2005). Banerjee et al. (2011) report that a rise in the number of males in the working age group in a household increased the likelihood of the household to send one of its members to work somewhere else. In Nepal, Massey et al. (2007) reported that both local mobility and long-distance migration was age-selective in nature. The same study found that the likelihood of local mobility and long-distance migration declined with rising age. This effect was more pronounced for local rather than long distance migration.

In Nepal, Shrestha and Bhandari (2007) found that the presence of both men and women was important for international migration but only the availability of men positively contributed to internal migration. Also, households that engaged men in firewood collection were less likely to send members to work somewhere else in Nepal or abroad. In another study from Nepal, Massey et al. (2007) reported that an increase in the time required to gather firewood raised the odds of male migration but had no effect on female migration. Similarly, an increase in the time needed to collect fodder raised the odds of female long-distance mobility but had no effect on the odds of male long-distance mobility.

## Political Drivers of Migration

Some policies, either explicitly or implicitly, seek to control migration, and may have an independent effect on whether people move or not. The Government of India-sponsored Mahatma Gandhi National Rural Employment Guarantee Act provides a legal guarantee for 100 days of wage employment in a financial year to every rural household (Ministry of Rural Development in India 2008). Jain (2010) found that this programme has reduced the need for seasonal migration to some extent in the province of Uttarakhand, mainly among unskilled or less educated persons.

In turn, other policies seek to facilitate migration. The India-Nepal Treaty of Friendship of 1950 created an open border between the two countries, which includes visa and passport-free entry and access to employment without the necessity of a work permit. Citizens of either country can migrate to the other country and stay as long as desired (Subedi 1991; Adhikari et al. 2008). For the poor, even the acquisition of official documents such as a passport is frequently an insurmountable hurdle (Hoermann and Kollmair 2008). The open border permits any national identification documents, such as electoral identity cards or driving license, to gain entry.

In practice, the political drivers of migration go well beyond this. For example, the Hindu Kush Himalayan region has also witnessed conflicts in various forms. These conflicts continue to uproot many across this region, and hinder the return of refugees and internally displaced persons (IDPs), including Tibetan refugees in India and Nepal (Baral 2003; Mahajan et al. 2008); Bhutanese refugees in Nepal (Mazumdar 2005); Afghan refugees in Iran and Pakistan (AREU 2006; UNHCR 2010); Chin refugees from Myanmar in India (Mahajan et al. 2008); and IDP populations in Pakistan (IDMC 2012c). Meanwhile, there are a number of policies which, whilst not specifically targeted at migration, may have an effect on whether it occurs or not – including broader development policies, and policies towards disasters and displacement.

## Intervening Obstacles

With progress in communication, electrification, and transportation networks, marginal mountain communities have become connected to the main market economies of the region (Ediger and Huafang 2006; Massey et al. 2007; Olimova and Olimov 2007). According to Du et al. (2004), the low population density and high transportation costs of rural mountainous regions of China has been a major challenge to the growth of industries in the interior rural areas, which implies that migration may be an important component of the structural change occurring there. Yet the creation of supportive infrastructure, particularly roads and communication facilities, could facilitate out-migration as well as in-migration (Bhandari 2004; Massey et al. 2007). Conversely, the probability of migration has been shown to

be lower among households in Afghanistan that resided in large communities with more irrigated land and services such as markets, public transportation or health facilities (Ghobadi et al. 2005).

Some households may not be able to meet the financial cost of migration. Yet, migration for work may be a necessary livelihood choice for them. If the expected income in destination is higher than the actual income at the place origin, some households borrowed loans to finance the migration (see Opel 2005; Ghobadi et al. 2005; Jain 2010; Nadeem et al. 2009).

## Migrant Remittances: Closing the Circle Between Migration and Environmental Change

In general, the environmental migration discourse has been overtly focused on the impacts of environmental variability and change on migration (Barnett and Webber 2009). In contrast, the feedback from migration in context of adaptation such as the role of financial and social remittances, and the influence of social networks, has received little empirical research attention (Banerjee et al. 2012), including in mountain areas. Thus only two case studies (Suleri and Savage 2006; Banerjee et al. 2011) from the Hindu Kush Himalayan region have explicitly discussed the role of remittances in context of adaptation, though other examples cited in this sub-section have discussed the role of remittances in mountain households but not in context of environmental change. These findings can still be used to illustrate the potential role that migration outcomes can have on adaptation to environmental variability and change.

Financial remittances are a significant source of cash income for many mountain households (Blaikie et al. 2002; Olimova and Olimov 2007; Subedi 2009), and the percentage contribution of remittances to recipient household's income is significant. They often supplement household income from other sources such as agriculture, livestock, wage labour, salary or business (Kreutzmann 1993). Suleri and Savage (2006) reported that 96 % of the studied households in Northern Pakistan claimed that remittances were their primary source of income, and half declared it to be their only source of income. Remittances contributed to recipient household's wellbeing as these were widely used to purchase food, repay loan, afford healthcare and education, buy consumer goods and construct or repair houses across the Hindu Kush Himalayas: Afghanistan (Opel 2005; Ghobadi et al. 2005); Bhutan (Ministry of Agriculture in Bhutan 2006); India (Jain 2010); Nepal (Lokshin et al. 2007; Adhikari and Hobley 2011); and Pakistan (Arif 2010). To a lesser extent they have been invested in farming, business ventures and savings (Ghobadi et al. 2005; Banerjee et al. 2011).

Remittances have also been used to procure food and other basic needs during or in aftermath of a disaster and re-establish livelihoods and rebuild lost assets (Suleri and Savage 2006; Banerjee et al. 2011). In some cases, remittances have been used for disaster preparedness such as strengthening of housing quality or procurement

of boat in flood affected communities and buying irrigation equipment in drought affected settlements (Banerjee et al. 2011). The impacts of remittance are not limited to recipient households. Suleri and Savage (2006) reported in the aftermath of the 2001 earthquake, remittance cash generated demand for goods and services in the local economy.

Besides remittance cash, migrants also bring back social remittances – ideas, behaviours, identities, social capital, knowledge, and skills – from destination to origin communities (Levitt 1998; Bailey 2010). Globally, their role in promoting innovation, entrepreneurship, community and family formation, and political integration has been widely documented (Levitt 1998; Levitt and Lamba-Nieves 2011). However, knowledge gaps still exist in terms of their role in building adaptation to climate change in general, and specifically the role of social remittances in the Hindu Kush Himalayan region.

## Conclusion

Mountain regions are often perceived as particularly vulnerable to climate change, as well as to a range of environmental shocks and hazards. Mountain communities are sensitive to these stressors, and their impacts are likely to be manifest in human wellbeing through effects on local livelihoods and infrastructure. Though there is uncertainty about the nature of future change, it is clear that temperatures in the region are rising, likely above global averages. In addition, there is a dearth of data on the state of environment in Hindu Kush Himalayan region, and the space that this creates for claims about the future impacts of climate change. Nonetheless, despite this lack of confidence in forecasting, the Hindu Kush-Himalayan region is still widely considered as one of the planet's hot spots of future climate change impacts.

Mountain people have long adjusted to living in fragile and marginal environments, and partially as a result, mountains have for many decades been zones of out-migration, as people seek alternative and more reliable livelihoods. There are several well-established internal and international migration streams in the Hindu Kush Himalayan region. Evidence, though sporadic, from across this region indicates that environmental stressors do influence migration decisions but not in isolation from non-environmental drivers and intervening obstacles. The impact of the environment is largely manifest through the other determinants of migration. Remittances have a significant role in the relationship between environmental change and migration, as it contributes to the well being of recipient households in normal time as well as during or in aftermath of a disaster. In the process, it is has a key role in reducing vulnerability and building resilience to environmental stresses and shocks.

At the start of this chapter, we highlighted some of the specificities of mountain areas and particular vulnerability to environmental change and especially environmental shocks and hazards. This, and the extent of downstream effects of changes that occur in mountains make it particularly important for regional policy-makers to work together to address both environmental risks and shocks themselves, and

associated migration flows. Migration is long-established as a consequence of the marginal conditions within many mountain zones, but also represents an important potential form of adaptation to such conditions.

Yet the consequences of migration in terms of adaptation to climate change and environmental shocks, through the role of financial and social remittances, and influence of social networks, have received little empirical research attention in these regions. In this context, Banerjee et al. (2012) have identified a number of knowledge gaps within the wider environmental migration discourse, including the role of migrant remittances in structural and non-structural adaptation measures to reduce household vulnerability to environmental hazards; the circumstances – social, political or economic – that are most propitious for this kind of spending; the extent to which benefits from migration spread beyond migrant households to the wider community; the additional risks for migrants themselves and for family members left behind in origin communities; the sustainability of remittance flows at the household level; and effect of migration on resilience and vulnerability. Future research in the Hindu Kush Himalayan region could usefully focus on any or all of questions.

**Acknowledgement** The authors would like to thank Etienne Piguet (University of Neuchatel), Frank Laczko (IOM), Nand Kishor Agrawal (ICIMOD) and Neera Shrestha Pradhan (ICIMOD) for their insightful feedback at various stages during this research. The authors would also like to thank the anonymous reviewers for their helpful comments. This research was funded by the Ministry of Foreign Affairs (MFA) of the Government of Norway as a part of ICIMOD's Himalayan Climate Change Adaptation Programme (HICAP). This chapter draws upon the DR9 Drivers of Migration in Mountain Regions of the Developing World: A Review, which was submitted to the Foresight: Migration and Global Environment Change project.

## References

Adhikari, J., & Hobley, M. (2011). *Everyone is leaving – Who will sow our fields? The Effects of Migration from Khotang District to the Gulf and Malaysia*. Kathmandu: Swiss Agency for Development and Corporation.

Adhikari, J., Gurung, G., Bhadra, C., Seddon, D., Niraula, B. P., Gurung, P., & Gurung, K. (2006). *Nepali women and foreign labour migration*. Kathmandu: UNIFEM and Nepal Institute for Development Studies.

Adhikari, K., Suwal, B., & Sharma, M. (2008). *Foreign labour migration and remittance in Nepal: Policy, institution and services*. Washington, DC: International Food Policy Research Institute.

Altai Consulting. (2009). *Study on cross border population movements between Afghanistan and Pakistan. Report commissioned by the Office of the United Nations High Commissioner for Refugees*. Kabul: Altai Consulting.

AREU. (2006). *Afghans in Karachi: Migration. Settlement and social networks* (Case studies series). Kabul: Afghanistan Research and Evaluation Unit (AREU).

Arif, G. M. (2010). *Economic and social impacts of remittances on households: The case of Pakistani migrants working in Saudi Arabia*. Geneva: International Organisation for Migration.

Bailey, A. J. (2010). Population geographies, gender, and the migration-development nexus. *Progress in Human Geography, 34*(3), 375–386.

Bajracharya, S. R., & Mool, P. (2009). Glaciers, glacial lakes and glacial lake outburst floods in the Mount Everest region, Nepal. *Annals of Glaciology, 50*(53), 81–86.

Bajracharya, S. R., & Shrestha, B. (2011). *The status of glaciers in the Hindu Kush-Himalayan region*. Kathmandu: International Centre for Integrated Mountain Development.

Bajracharya, S. R., Maharjan, S. B., & Shrestha, F. (2010). *Glaciers shrinking in Nepal Himalaya*. www.intechopen.com/articles/show/title/glaciers-shrinking-in-nepal-himalaya. Accessed 12 Mar 2012.

Bajracharya, S. R., Maharjan, S. B., & Shrestha, F. (2011). Glaciers shrinking in Nepal Himalaya. In J. Blanco & H. Kheradmand (Eds.), *Climate change: Geophysical foundations and ecological effects* (pp. 445–458). Rijeka: InTech.

Banerjee, S., Gerlitz, J. Y., & Hoermann, B. (2011). *Labour migration as a response strategy to water hazards in the Hindu Kush-Himalayas*. Kathmandu: International Centre for Integrated Mountain Development.

Banerjee, S., Black, R., & Kniveton, D. (2012). *Migration as an effective mode of adaptation to climate change*. Policy paper for the European Commission. Brussels: European Commission.

Baral, L. (2003). Nepal: Forced migration, challenges and prospects. *Nepali Journal of Contemporary Studies, III*(1), 51–66.

Barnett, J., & Webber, M. (2009). *Accommodating migration to promote adaptation to climate change*. Policy brief prepared for the Secretariat of the Swedish Commission on Climate Change and Development and the World Bank World Development Report 2010 Team. Retrieved from http://www.ccdcommission.org/Filer/documents/Accommodating%20Migration.pdf

Bhandari, P. (2004). Relative deprivation and migration in an agricultural setting of Nepal. *Population and Environment, 25*(5), 475–499.

Bhattrai, R. (2007). *Open borders, closed citizenships: Nepali labor migrants in Delhi*. Paper prepared for Conference on International migration, multi-local livelihoods and human security: Perspectives from Europe, Asia and Africa, Institute of Social Studies, 30–31 August 2007, The Netherlands.

Blaikie, P. M., Cameron, J., & Seddon, D. (2002). Understanding 20 years of change in west-central Nepal: Continuity and change in lives and ideas. *World Development, 30*, 1255–1270.

BOE. (2005). *International migration statistics*. Islamabad: Government of Pakistan, Bureau of Emigration and Overseas Employment. www.beoe.gov.pk. Accessed 16 Sept 2009.

Bohle, H. G., & Adhikari, J. (1998). Rural livelihoods at risk: How Nepalese farmers cope with food insecurity. *Mountain Research and Development, 18*, 321–332.

Bohra-Mishra, P., & Massey, D. S. (2011). Environmental degradation and out-migration: New evidence from Nepal. In E. Piguet, A. Pécoud, & P. de Guchteneire (Eds.), *Migration and climate change* (pp. 74–101). Cambridge: Cambridge University Press.

Bolch, T., Pieczonka, T., & Benn, D. I. (2011). Multi-decadal mass loss of glaciers in the Everest area (Nepal Himalaya) derived from stereo imagery. *The Cryosphere, 5*, 349–358.

Boyle, P., Halfracree, K., & Robinson, V. (1998). *Exploring contemporary migration*. Harlow: Pearson Education.

Brees, I. (2008). Forced displacement of Burmese people. *Forced Migration Review, 30*, 4–5.

Brusle, T. (2008). Choosing a destination and work. *Mountain Research and Development, 28*(3), 240–247.

Castles, S., & Miller, M. J. (1993). *The age of migration: International population movements in the modern world*. Basingstoke: Macmillan.

Chettri, N., Sharma, E., Shrestha, A. B., Zhoali, Y., Hua, Q., & Bajracharya, B. (2011). Real world protection for the 'third pole' and its people. In F. Huettmann (Ed.), *Protection of three poles* (pp. 113–133). Tokyo: Springer.

Cogley, J. G., Kargel, J. S., Kaser, G., & van der Veen, C. J. (2010). Tracking the source of glacier misinformation. *Science, 327*(5965), 522.

Cruz, R. V., Harasawa, H., Lal, M., Wu, S., Anokhin, Y., Punsalmaa, B., Honda, Y., Jafari, M., Li, C., & Huu Ninh, N. (2007). Asia. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, & C. E. Hanson (Eds.), *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change* (pp. 469–506). Cambridge: Cambridge University Press.

Department for International Development (DFID). (2006). *South Asia earthquake* (Situation Report No. 44). Available at: http://www.reliefweb.int/rw/RWFiles2005.nsf/FilesByRWDocUNIDFileName/HMYT-6HRLDP-dfid-southasia-02nov.pdf/$File/dfid-southasia-02nov.pdf. Accessed 12 Feb 2012.

Dimri, A. P., & Dash, S. K. (2011). Wintertime climate trends in the western Himalayas. *Climate Change*. doi:10.1007/A10584-011-0201-y.

Ding, Y., Liu, S., Li, J., & Shangguan, D. (2006). The retreat of glaciers in response to recent climate warming in western China. *Annals of Glaciology, 43*(1), 97–105.

Du, Y., Park, A., & Wang, S. (2004). *Is migration helping China's poor?* Paper prepared for the Conference on Poverty, Inequality, Labour Market and Welfare Reform in China. Canberra: Australia National University.

Ediger, L., & Huafang, C. (2006). Upland China in transition. *Mountain Research and Development, 26*(3), 220–226.

Eriksson, M., Jianchu, X., Shrestha, A. B., Vaidya, R. A., Nepal, S., & Sandstrom, K. (2009). *The changing Himalayas: Impact of climate change on water resources and livelihoods in the greater Himalayas*. Kathmandu: ICIMOD.

Foresight: Migration and Global Environmental Change. (2011). *Final project report*. London: The Government Office for Science.

Ghobadi, N., Koettl, J., & Vakis, R. (2005). *Moving out of poverty: Migration insights from Rural Afghanistan* (Working Paper Series). Kabul: Afghanistan Research and Evaluation Unit (AREU).

Goodall, S. (2004). Rural-to-urban migration and urbanization in Leh, Ladakh: A case study of three nomadic pastoral communities. *Mountain Research and Development, 24*(3), 220–227.

Guha-Sapir, D., Vos, F., Below, R., & Ponserre, S. (2011). *Annual disaster statistical review 2010: The numbers and trends*. Brussels: CRED.

Gurung, D. R., Giriraj, A., Aung, K. S., Shrestha, B., & Kulkarni, A. V. (2011a). *Snow-cover mapping and monitoring in the Hindu Kush-Himalayas*. Nepal: ICIMOD.

Gurung, D. R., Kulkarni, A. V., Giriraj, A., Aung, K. S., Shrestha, B., & Srinivasan, J. (2011b). Change in seasonal snow cover in Hindu Kush–Himalayan Region. *The Cryosphere Discuss, 5*(2), 755–777.

Hassan, R., Scholes, R., & Ash, N. (Eds.). (2005). *Ecosystems and human well-being: Current state and trends* (Findings of the Condition and Trends Working Group of the Millennium Ecosystem Assessment, Vol. 1). Washington, DC: Island Press.

Hewitt, K. (2005). The Karakoram anomaly? Glacier expansion and the 'elevation effect', Karakoram Himalaya. *Mountain Research and Development, 25*(4), 332–340.

Hoermann, B., & Kollmair, M. (2008). *Labour migration and remittances in the Hindu Kush-Himalayan region*. Kathmandu: ICIMOD.

Hoermann, B., Banerjee, S., & Kollmair, M. (2010). *Labour migration for development in the western Hindu Kush-Himalayas*. Kathmandu: ICIMOD.

HRLN. (2007). *Report of refugee populations in India*. New Delhi: Human Rights Law Network.

Hunzai, K. (2010). *Labour migration and remittances in the mountains of Pakistan*. Kathmandu: ICIMOD.

Huo, W., Deng, G., Wang, P., & Yang, X. (2006). The pull of inter-provincial migration of rural labor force and its influence on policy making. *Ecological Economy, 2*, 25–31.

IDMC. (2011). *North-East India: People displaced by ethnic violence "forgotten"* (Press Release). Geneva: Internal Displacement Monitoring Centre.

IDMC. (2012a). *Afghanistan: Durable solutions far from reach amid escalating conflict*. Geneva: Internal Displacement Monitoring Centre.

IDMC. (2012b). *Nepal: Unresolved property issues and IDP policy hiatus undermine search for durable solutions*. Geneva: Internal Displacement Monitoring Centre.

IDMC. (2012c). *Pakistan: Displacement caused by conflict and natural disasters, achievements and challenges*. Geneva: Internal Displacement Monitoring Centre.

Immerzeel, W. (2008). Historical trends in future predictions of climate variability in the Brahmaputra basin. *International Journal of Climatology, 28*(2), 243–254.

Immerzeel, W. W., van Beek, L. P. H., & Bierkens, M. F. P. (2010). Climate change will affect the Asian water towers. *Science, 328*(5984), 1382–1385.

IOM. (2010). *IOM appeal in support of Pakistan Initial floods emergency response plan*. Geneva: International Organisation for Migration.

IPCC. (2007a). *Fourth assessment report*. Geneva: Intergovernmental Panel on Climate Change Secretariat.

IPCC. (2007b). *Climate change 2007: Summary for policymakers.* Fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

IPCC. (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change*. Cambridge/New York: Cambridge University Press. 582 pp.

IUCN. (2005). *Project proposal on baseline study regarding the socio-economic condition including socio-economic survey of 10 selected villages in Shishi valley of Chitral with special focus on chilghoza pine and its contribution to livelihoods; situation of disadvantaged groups including women and their involvement in Chilghoza business; mapping of resource base (conditions and practices)*. Islamabad: IUCN.

Ives, J. D., Shrestha, R. B., & Mool, P. K. (2010). *Formation of glacial lakes in the Hindu Kush-Himalayas and GLOF risk assessment*. Kathmandu: ICIMOD.

Jain, A. (2010). *Labour migration and remittances in Uttarakhand*. Kathmandu: International Centre for Integrated Mountain Development.

Kang, S., You, Q., Flügel, W., Pepin, N., Yan, Y., Xu, Y., & Huang, J. (2010). Review of climate and cryospheric change in the Tibetan Plateau. *Environmental Research Letters*, *5*(1). doi:10.1088/1748-9326/5/1/015101.

Kohler, T., & Maselli, D. (Eds.). (2009). *Mountains and climate change – From understanding to action*. Berne: Geographica Bernensia and Swiss Agency for Development and Cooperation.

Kollmair, M., Gurung, G. S., Hurni, K., & Maselli, D. (2005). Mountains: Special places to be protected? An analysis of worldwide nature conservation efforts in mountains. *International Journal of Biodiversity Science and Management, 1*, 181–189.

Kollmair, M., Manandhar, S., Subedi, B., & Thieme, S. (2006). New figures for old stories: Migration and remittances in Nepal. *Migration Letters, 3*(2), 151–160.

Körner, C. (2009). Conservation of mountain biodiversity in the context of climate change. In: *Proceedings of the international mountain biodiversity conference*, Kathmandu, 16–18 November 2008. Kathmandu: ICIMOD.

Körner, C., & Ohsawa, M. (2005). Mountain systems. Chapter 24. In R. Hasser, R. Scholes, & N. Ash (Eds.), *Millennium ecosystem assessment, 2005. Current state and trends: Findings of the condition and trends working group* (Ecosystems and human well-being, Vol. 1). Washington, DC: Island Press.

Kreutzmann, H. (1993). Challenge and response in the Karakoram: Socioeconomic transformation in Hunza, Northern Areas, Pakistan. *Mountain Research and Development, 13*(1), 19–39.

Kulkarni, A. V., Rathore, B. P., & Singh, S. K. (2010). Distribution of seasonal snow cover in central and western Himalaya. *Annals of Glaciology, 51*(54), 123–128.

Kulkarni, A., Patwardhan, S., Kumar, K. K., Ashok, K., & Krishnan, R. (2011, August 18–19). *Projected climate change over Hindukush-Himalayan region using high Resolution Regional Climate Model PRECIS.* Paper presented at the Authors' Workshop for the Regional Report on Climate Change in the Hindu Kush–Himalayas: The State of Current Knowledge. Kathmandu: ICIMOD.

Levitt, P. (1998). Social remittances: Migration-driven local-level forms of cultural diffusion. *International Migration Review, 32*(4), 926–948.

Levitt, P., & Lamba-Nieves, D. (2011). Social remittances revisited. *Journal of Ethnic and Migration Studies, 37*(1), 1–22.

Liang, Z., & Ma, Z. (2004). China's floating population: New evidence from the 2000 census. *Population and Development Review, 30*(3), 467–488.

Lokshin, M., Bontch-Osmolovski, M., & Glinskaya, E. (2007). *Work-related migration and poverty in Nepal* (World Bank Policy Research Working Paper 4231). Washington, DC: World Bank.

Mahajan, D., Sharma, D., Vivekanandan, J., & Talwar, S. (2008). *Climate change induced migration and its security implications in India's neighbourhood* (Project Report No. 2008RS10). New Delhi: TERI.

Mamgain, R. P. (2004). *Employment, migration and livelihoods in the hill economy of Uttaranchal*. PhD thesis submitted to Jawaharlal Nehru University, Centre for the Study of Regional Development, School of Social Sciences. New Delhi: Jawaharlal Nehru University.

Maplecroft. (2011). *Climate change risk atlas 2011*. http://maplecroft.com/search/?q=climate+change+vulnerability+ranking. Accessed 10 July 2012.

Massey, D., Axinn, W., & Ghimire, D. (2007). *Environmental change and out-migration: Evidence from Nepal* (Population Studies Center Research Report 07-615). Ann Arbor: Population Studies Center.

Mazumdar, A. (2005). Bhutan's military action against Indian insurgents. *Asian Survey, 45*(4), 566–580.

Messerli, B., & Ives, J. D. (Eds.). (1997). *Mountains of the world: A global priority*. London: The Parthenon Publication Group.

Miller, J., Rees, G., Warnaars, T., Young, G., Collins, D., & Shrestha, A. (2013). What is the evidence for glacial shrinkage across the Himalayas? CEE Review 10–008. Collaboration for Environmental Evidence.

Ministry of Agriculture. (2006). *Rural-urban migration in Bhutan*. Thimphu: Royal Government of Bhutan.

Ministry of Finance. (2005). *Bhutan National Human Development Report 2005*. Thimphu: Royal Government of Bhutan.

Ministry of Rural Development. (2008). *The National Rural Employment Guarantee Act 2005 (NREGA)*. Operational guidelines (3rd ed.). New Delhi: Ministry of Rural Development.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature, 403*, 853–858.

Nadeem, S., Elahi, I., Hadi, A., & Uddin, I. (2009). *Traditional knowledge and local institutions support adaptation to water-induced hazards in Chitral, Pakistan*. Kathmandu: International Centre for Integrated Mountain Development.

Nepal, S. (2007). Tourism and rural settlements: Nepal's Annapurna region. *Annals of Tourism Research, 34*(4), 855–875.

Nie, Y., Zhang, Y., Liu, L., & Zhang, J. (2010). Glacial change in the vicinity of Mt. Qomolangmc (Everest), central high Himalayas since 1976. *Journal of Geographical Sciences, 20*(5), 667–686.

Nogues-Bravo, D., Araujo, M. B., Erra, M. P., & Martinez-Rica, J. P. (2007). Exposure of global mountain systems to climate warming during the 21st century. *Global Environmental Change, 17*, 420–428.

Olimova, S. (2005). *Impact of external migration on development of mountainous regions: Tajikistan, Kyrgyzstan, Afghanistan, and Pakistan*. Paper prepared for the International Workshop on Strategies for Development and Food Security in Mountainous Areas of Central Asia, 6–10 June 2005, Dushanbe, Tajikistan.

Olimova, S., & Olimov, M. (2007). Labor migration from mountainous areas in the Central Asian Region: Good or evil? *Mountain Research and Development, 27*(2), 104–108.

Opel, A. (2005). *Bound for the city: A study of Rural to Urban labour migration in Afghanistan* (Working Paper Series). Kabul: Afghanistan Research and Evaluation Unit (AREU).

Osti, R., & Egashira, S. (2009). Hydrodynamic characteristics of the Tam Pokhari glacial lake outburst flood in the Mt. Everest region, Nepal. *Hydrological Processes, 23*(20), 2943–2955.

Poertner, E., Junginger, M., & Müller-Böker, U. (2011). Migration in far west Nepal: Intergenerational linkages between internal and international migration of rural-to-urban migrants. *Critical Asian Studies, 43*(1), 23–47.

Richardson, S. D., & Reynolds, J. M. (2000). An overview of glacial hazards in the Himalayas. *Quaternary International, 65*, 31–47.

Rosenzweig, C., Casassa, G., Karoly, D. J., Imeson, A., Liu, C., Menzel, A., Rawlins, S., Root, T. L., Seguin, B., & Tryjanowski, P. (2007). Assessment of observed changes and responses in natural and managed systems. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. Van Der Linden, & C. E. Hanson (Eds.), *Climate change 2007. Impacts, adaptation and vulnerability. Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change* (pp. 79–131). Cambridge: Cambridge University Press.

Schutte, S., & Kreutzmann, H. (2011). Linking relief and development in Pakistan-administered Kashmir. *Mountain Research and Development, 31*(1), 5–15.

Seddon, D., Gurung, G., & Adhikari, J. (2002). Foreign labour migration and the remittance economy of Nepal. *Himalayan Research Bulletin, XVIII*(2), 3–10.

Sharma, J. R. (2008). Practices of male labor migration from the hills of Nepal to India in development discourses: Which pathology? *Gender, Technology and Development, 12*, 303–323.

Sharma, J. R. (2011). *The impact of environmental change on labour migration from Nepal to the Gulf States*. Foresight case study. London: The Government Office for Science.

Shrestha, B. (2008). Contribution of foreign employment to Nepalese Economy. *Economic Review, Occasional Paper, 20*, 1–15. Kathmandu: Nepal Rastra Bank.

Shrestha, A. B. (2009). Climate change in the Hindu Kush-Himalayas and its impacts on water and hazards. *APMN (Asia Pacific Mountain Network) Bulletin, 9*, 1–5.

Shrestha, S. S., & Bhandari, P. (2007). Environmental security and labor migration in Nepal. *Population and Environment, 29*, 25–38.

Shrestha, A. B., Wake, C. P., Dibb, J. E., & Mayewski, P. A. (2000). Precipitation fluctuations in the Nepal Himalaya and its vicinity and relationship with some large scale climatological parameters. *International Journal of Climatology, 20*(3), 317–327.

Shrestha, K. L., Shrestha, M. L., Shakya, N. M., Ghimire, M. L., & Sapkota, B. K. (2003). Climate change and water resources of Nepal. In A. Muhammed & F. J. Hansen (Eds.), *Climate change and water resources in South Asia: Proceedings of year end workshop, Kathmandu, Nepal, 7–9 January 2003, Kathmandu, Nepal*. Islamabad: Asianics Agro Development International.

Shukla, K. (2008). The international community's responsibility to protect. *Forced Migration Review, 30*, 7–9.

Singh, S. P., Singh, V., & Skutsch, M. (2010). Rapid warming in the Himalayas: Ecosystem responses and development options. *Climate Change and Development, 2*, 1–13.

Singh, S. P., Bassignana-Khadka, I., Karky, B. S., & Sharma, E. (2011). *Climate change in the Hindu Kush Himalayas: The state of current knowledge*. Kathmandu: ICIMOD.

Srivastava, D. (2003). Recession of Gangotri glacier. In D. Srivastava, K. R. Gupta, & S. Mukerji (Eds.), *Proceedings of a workshop on Gangotri glacier, Lucknow, 26–28 March 2003* (Special Publication No. 80). New Delhi: Geological Survey of India.

Subedi, B. (1991). International migration in Nepal: Towards an analytical framework. *Contribution to Nepalese Studies, 18*(1), 83–102.

Subedi, M. K. (2009). *The impact of labor migration and remittances on household income and welfare in Nepal*. Paper prepared for Pacific Conference for Development Economics, March 14, 2009, San Francisco State University.

Suleri, A. Q., & Savage, K. (2006). *Remittances in crises: A case study from Pakistan* (An Humanitarian Policy Group Background Paper). London: Overseas Development Institute.

Thieme, S. (2006). *Social networks and migration: Far west Nepalese labour migrants in Delhi*. Muenster: LIT Publishing House.

Tse-ring, K., Sharma, E., Chettri, N., & Shrestha, A. (2010). *Climate change vulnerability of mountain ecosystems in the Eastern Himalayas: Climate change impact and vulnerability in the Eastern Himalayas – Synthesis report*. Kathmandu: ICIMOD.

UNHCR. (2010). *Statistical yearbook 2009: Trends in displacement, protection and solutions*. Geneva: United Nations High Commissioner for Refugees.

United States Committee for Refugees and Immigrants. (2008). *World Refugee Survey 2008 – India*. Available at: http://www.unhcr.org/refworld/docid/485f50d82.html. Accessed 19 Apr 2012.

Vohra, C. P. (1981). Himalayan glaciers. In J. S. Lal & A. D. Moddie (Eds.), *The Himalaya: Aspect of change* (pp. 138–151). New Delhi: Oxford University Press.

Vuichard, D., & Zimmermann, M. (1987). The 1985 catastrophic drainage of a moraine-dammed lake, Khumbu Himal, Nepal: Cause and consequences. *Mountain Research and Development, 7*(2), 91–110.

Walcott, S. (2009). Urbanization in Bhutan. *Geographical Review, 99*(1), 81–93.

Xin, W., Shiyin, L., Wanqin, G., & Junli, X. (2008). Assessment and simulation of glacier lake outburst floods for Longbasaba and Pida Lakes, China. *Mountain Research and Development, 28*(3), 310–317.

Xu, J., Grumbine, R. E., Shrestha, A., Eriksson, M., Yang, X., Wang, Y. U. N., & Wilkes, A. (2009). The melting Himalayas: Cascading effects of climate change on water, biodiversity, and livelihoods. *Conservation Biodiversity, 23*(3), 520–530.

Yao, T., Thompson, L., Yang, W., Yu, W., Gao, Y., Guo, X., Yang, X., Duan, K., Zhao, H., Xu, B., Pu, J., Lu1, A., Xiang, Y., Kattel, D. B., & Joswiak, D. (2012). Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings. *NClimate* 1580. www.nature.com/natureclimatechange. Accessed 20 July 2012.

Yasir, A. (2009). *The political economy of disaster vulnerability: A case study of Pakistan earthquake 2005*. London: London School of Economics & Political Science.

Zhu, H., & He, S. (2010). Land pressure and adaptation in the mountainous region of northern China: An empirical analysis of 21 small watersheds. *Journal of Geographical Science, 20*(6), 913–922.