Chapter 8
Mitigating Climatic and Human Induced Disaster Risks Through Ecosystem Resilience: Harmonizing Built and Natural Environments in the HKH Region

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Abstract The Hindu Kush Himalayan (HKH) region is environmentally stressed, economically under-developed and highly prone to climate change impacts and natural hazards. The region is affected by increasing frequency and intensity of flash flood and river-line flood which are among the most devastating types of hazard as they occur rapidly with little lead time for warning, and transport tremendous amounts of water and debris at high velocity.

The HKH region, which is a fragile geology, is now facing increasing and intense pressure of the built environment in the process of inevitable and unstoppable economic development. It is increasingly evident that development processes create a built environment that interacts with nature and, therefore, with natural hazards. When development pursuits ignore this reality and fail to create a harmony between built-in and natural environment systems, they become responsible for turning natural hazards into disasters. Natural environmental systems can decrease or increase climate induced disasters depending on how development policies and practices treat the environment. There is a need for an ecologically compatible and socially acceptable framework of site-specific developmental models to ensure future risk reduction. In this backdrop, this chapter discusses the issues of environmental risk management and ecosystem adaptation with their inter-linkages with disaster risk reduction in the Hindu Kush Himalayan mountain region.

Keywords Built environment • Disasters • Ecosystem • Environment • Resilience

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8.1 Introduction

The altitude of the mountains is defined as High (2,438–3,658 m), Very High (3,658–5,487 m), and Extremely High (5,500 m). Mountain regions occupy approximately one fifth of the earth's land surface and cover 54 % of Asia's land mass. High altitude mountain ranges create diverse ecosystems, sanctuaries for plants, animal species and shelter for 10 % of world's population. Mountains are the sources of 80 % of the Earth's surface water, important not only for mountain communities but also for billions of people living in the plains (MEA 2005). Therefore, the changes in the mountain ecology affect not only the mountain communities, but also 90 % of world population living in 75 % the earth's low land surface (Eckholm 1975).

Mountain forests contribute close to 75 % of forest revenue in the United States, 30 % of total foreign exchange revenue in the Laos and protect valuable properties valued at 3–4 billion dollars every year in Switzerland. The rich bio diversity of the mountains is a source of many valuable livelihoods products such as wood, fruits, herbs, mushrooms, etc. With such multi-functionality, mountains serve not only as a source of ecological and food security of billions of people, but also act as buffer against natural hazards. Most importantly, mountains are critical to the water cycle. Mountains trap moisture from air masses, which gets precipitated in the form of snow, which melts in spring and summer, flows to the plains and become a life line for agriculture and industrial activities. Mountains are very sensitive to environmental change and are a barometer for climate change. A change in temperature can disrupt a mountain system in the form of glaciers melting, soil erosion, landslides, rock fall, floods and avalanches.

The Hindu Kush Himalayan (HKH) mountain is the youngest, environmentally stressed and economically underdeveloped region. The HKH mountains are a direct support of water and livelihoods security of over 1.3 billion people through ten river basins (Bandyopadhyay 2009). In addition, "the HKH mountains represent a significant barrier to atmosphere circulation and exert a strong influence on the spatial distribution of precipitation over the Asian continent" (Bandyopadhyay 2009).

About 95 % population of the total population in the HKH region depends on agriculture and forest resources but the forest cover is decreasing 0.36 km^2 per year and the agricultural production decreasing due climate change and several natural disasters (Rawat et al. 2011a). Over one billion People living in this fragile ecosystem are subject to the increasing frequency and intensity of disasters such as flash flood and river-line flood, earth quakes, landslides and debris flow. Neo-tectonic activities in HKH region along the several active thrusts and faults responsible for earthquake disasters whereas climate change and land use degradation accelerating the water-induced disasters such as flash flood, river-line flood, erosion, wet mass movement during monsoon period and drought in non-monsoon period as drying up of natural water springs and streams (Rawat et al. 2011b).

Out of total annual disasters in HKH region countries, 14 % are earthquake and landslide disasters, 48 % are hydrological disasters (i.e., 36 % flood, 9 % mass

movement, 3 % drought) whereas 38 % are other types of disasters such as storm (23 %), wildfire (1 %), extreme temperature (6 %), epidemic (8 %). Further, climate change is contributing to the hazard events with the growth rate of 6 % each year. Human casualties increasing with the rate of 9 % each year whereas affected people and infrastructural loss increasing with that rate of, respectively, 6 and 4 % each year (Nibanupudi and Rawat 2012).

8.2 Climate Change, Natural Hazards and Disasters in the HKH Region

The adverse impacts of climate change combined with massive ecological degradation are accelerating the frequency and intensity of disasters in the HKH region, besides disconnecting people from their traditional and cultural roots of sustainability. It is increasingly evident that development interacts with nature and, therefore, with natural hazards. When development pursuits ignore this reality, they contribute to turning natural hazards in to disasters. Environment can prevent or accelerate climate induced disasters depending on how the development policies and practices treat the environment. Further, environmental protection and disaster risk management requires trans-boundary efforts as the HKH mountain region is shared by multiple countries and disaster impacts cut across boundaries.

The most common type of disaster in the region is flooding. The increasing frequency of floods in the HKH region cause greater and longer-lasting damage to infrastructure and livelihoods in the region. Although, early warning could save many lives, floods still cause great loss to livelihoods and public infrastructure, destroy crops, erode river banks and disrupt irrigation channels. The HKH region countries have particularly been affected by deadly disasters in the last couple of years. While, some of these countries have responded to local and global pressures for disaster mitigation, the actual efforts remained inadequate compared to the scale of disaster risk the region is faced with. The recent Indus floods in Pakistan that affected over twenty million people raise a serious question on the adequacy of resources, capacities and effectiveness of disaster management plans and policies in reducing disaster losses. It is expected that existing risk patterns in the region will continue to intensify, especially in the Hindu Kush and Himalayan region in view of climate change, urbanization, economic globalization, poverty and environmental degradation.

The flash flood and river-line flood occur rapidly with little lead time for warning, and transport tremendous amounts of water and debris at high velocity. Flash floods and river-line floods affect thousands of people in the HKH region every year by taking lives, homes, and livelihoods along with expensive infrastructure. There are several different causes of flash flood and river-line flood in HKH region such as intense rainfall (IRF); glacial lake outburst (GLO), landslide dam outburst (LDO), rapid snow melt (RSM) and failure of dams and other hydraulic

structures (Jonkman 2005; Rawat et al. 2011c). But intense rainfall (IRF) is very frequent cause for flash flood and river-line flood in the Himalayan which play a key role for flash flood and river-line flood.

Uttarakhand State in Indian Himalayan is known to face disastrous impacts of climatic hazard events like floods and landslides. Table 8.1 lists major floods and landslides in Uttarakhand during 1978–2009. Flash flood of 2013 in Uttarakhand was termed as 'Himalayan Tsunami' due to series of flood events in the month of June 2013 causing havoc resulting in huge death toll, thousands people stranded for weeks, severe damage to ecosystems, infrastructure, resources and thereby posing lasting challenge to livelihood sustainability of local people. There is increased recognition of the linkages between climate change and disasters. The Intergovernmental Panel on Climate Change (IPCC 2007) concluded that the frequency and severity of hot and cold extremes and heavy precipitation events is increasing and this trend will continue. According to a number of studies and reports, the climate change seems to impact on the frequency and intensity of hydro meteorological disasters. Due to limited data availability covering the past three decades, it is statistically difficult to quantify and isolate the exact impact of climate change. However, there is some evidence of linkages between physical changes, atmospheric, terrestrial and oceanic, and the weather processes that lead to disaster caused by natural hazards

Table 8.1 Flood and landslide disasters in Uttarakhand during 1978–2009

Year	Disaster	Impact
1978	Bhagirathi flash floods	Devastating impact on Uttarakhand including on agriculture, livestock, infrastructure, property and loss of life
1980	Gyansu Nala landslide	Claimed 24 lives and destroyed several houses
1991	Utharkasi earthquake	653 people and 1,300 livestock died, 6,000 people injured and massive infrastructure damage
1998	Malpa landslide	Devastating impact on Uttarakhand including on agriculture, livestock, infrastructure, property and loss of life
2001	Phata landslide	Devastating impact on Uttarakhand including on agriculture, livestock, infrastructure, property and loss of life
2003	Landslide triggered by cloudburst in Varunwat hills, Uttarkashi	Destroyed a 4 story hotel and damaged several buildings, roads and other infrastructure. Economic damage to the tune of 50 million dollars
2009	Landslide disaster in Kuity village on Beringa-Munsiyari road, Pithoragarh district	Wiped out two villages, namely Jhakhla abd Lah, claiming 43 lives

According to the IPCC report of 2007, In the Indian sub-continent over the last 100 years, the air temperature has increased by an estimated 0.3–0.6 °C—and by 2,100 the temperature may increase further by 3.5–5.5 °C (IPCC 2007). This will affect high-altitude glacial environments, which are very sensitive to temperature changes. A number of disaster events were reported in 2010 alone that reflect the impacts of climate change in high altitudes. A cloud burst incident destroyed an entire village in Almora district of India in 2010, while a similar incident killed hundreds and displaced thousands in the Ladakh district of India. There were more than ten major incidences of similar nature were recorded in the Himalayan regions of Uttarakhand, Himachal Pradesh and Jammu & Kashmir states of India in 2010. Studies by ICIMOD (2007), SAARC (2008) and others have shown that in recent decades the Himalayan glaciers have been melting at unprecedented rates. The devastating Uttarakhand flood of 2013 (Box 8.1), caused by 20 in. rain with in a span of 4 days was a grin reminder of the intensity of risks that Himalayan communities are faced with in the times of climate change.

Box 8.1. Uttarakhand Floods, 2013: A Classic Case of Environmental Catastrophe

Photo: Hari Krishna Nibanupudi

Uttarakhand, a Himalayan mountain state of India was hit by extreme rains, landslides, debris flow and flash floods in June 2013. Hundreds lost lives and thousands of pilgrims and tourists were stranded in the high mountains.

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Heavy rainfall has wreaked havoc on the region because of the fragile nature of the Himalayan range and poor soil stability in its steep slopes. But it is man-made factors that have compounded the scale of the disaster. Unabated expansion of hydro-power projects and construction of roads to accommodate ever-increasing tourism, especially religious tourism, are also major causes for the unprecedented scale of devastation, say experts. Huge expansion of roads and transport is bringing the mountains in Uttarakhand down say local people. Data with the Uttarakhand State Transport Department confirms this. In 2005–2006, 83,000-odd vehicles were registered in the state. The figure rose to nearly 180,000 in 2012–2013. Out of this, proportion of cars, jeeps and taxis, which are the most preferred means of transport for tourists landing in the state, increased the most. In 2005–2006, 4,000 such vehicles were registered, which jumped to 40,000 in 2012–2013. It is an established fact that there is a straight co-relation between tourism increase and higher incidence of landslides.
Source: Singh 2013

8.3 Conflict Between Built and Natural Environments

Relationship between climate change, built environment and disasters are multi-faceted, and therefore need to be understood through an interdisciplinary lens. Key dimensions are the following:

- Climate change is known to increase abruptness of extreme events, and therefore, causes increased intensity and frequency of hazards, with uncertainties in prediction.
- Impact of climate change on ecosystems, water bodies and landscapes accelerate changes in land-use and increase environmental and geographical vulnerability to natural hazards.
- Impact of climate change and environmental degradation on livelihood and natural resources, health and occupations, affects people's capacities and economy making them more vulnerable. These conditions coupled with human aspirations lead them locate to hazardous locations and occupations with unsafe infrastructure.
- Conflict between natural environment and built environment especially in the sites of religious tourism or ecotourism in Himalayan regions is intensified due to increased demand pressure of tourism industry.
- Lack of adequate consideration of upstream-downstream relations of land-water-forests-system stability (not only water-system in isolation) in disaster risk assessment and developmental planning makes entire infrastructure and economic development unsafe and vulnerable.

- Increased hazards and increased vulnerability, both are responsible for more complex and devastating disaster incidences like Uttarakhand flood 2013.

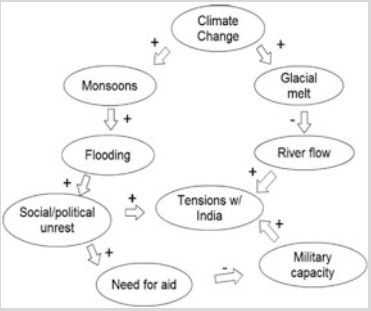
The natural environment of the HKH mountain region is in turmoil due to extensive degradation of land and forest resources, change of climate, drying up of river flows, etc. For many centuries, remoteness, absence of road infrastructure and development neglect ensued sustenance of rich ecological diversity in the Himalayas. However, advent of engineering technology, clearance of natural resources in the plains, brought the development focus of the Governments and private sector on to the natural resources wealth of the mountains. Rapid development of roads and other infrastructure in many parts of the mountains meant, greater interaction between mountain communities and plains. This interaction has substantially affected the Himalayan mountain communities, who for very long, lived a life of self reliance, sustainability and in harmony with natural environment.

The development processes, instead of building on the local knowledge of sustainability, eroded it and replaced it with a culture of over exploitation of natural resources for consumptive life styles. Further, the new perspective on high altitude Himalayas as strategic locations for national defense contributed to increasing troops movement in the Himalayas and rapid expansion of road infrastructure that has been contributing to ecological disturbance in the mountains (Box 8.2). In the Himalayas, a long history of forest degradation to give way to human built environment is a primary cause for massive changes in the ecological and water security. In the last few decades, massive forest degradation has taken place in the Himalayas in the process of expanding human habitations, construction of dams, tourism infrastructure, etc. "The forest degradation further led to many environmental degradation processes like soil erosion, slope failure, depletion of soil fertility, scarcity of fuel wood and fodder, increased over land flows, decreased ground water recharge and loss of biological diversity. Further, siltation of river beds in the low lands arise of forest cover degradation in the Himalayas" (Ramakrishnan et al. 1994).

Box 8.2. Human Conflicts and Environmental Suffering

River ecology's struggle with relentless built environment push by humans in Tibet

Photo by Hari Krishna Nibanupudi



Robins (2011)

In the last six decades, there has been a mass damming and surface communication development for future troops movement in Tibet that disturbed the ecology of many rivers flowing from the Tibetan plateau. Recent severe floods in Pakistan, China and Bangladesh has been attributed to the damming of rivers on the plateau. Further, the destruction of the Tibetan forests has resulted in soil erosion leading to deposits of silt which in turn leads to the rise of the river beds. The consequence of this, together with the damming projects, has been massive flooding and landslides downstream. The frequent flooding that devastates Bangladesh has also been directly associated with the deforestation of Tibet.

The six decades of wide-spread environmental destruction: massive deforestation, overgrazing, uncontrolled mining, nuclear waste dumping, soil erosion leading to landslides and the destruction of many species of birds and animals. The recent flooding of the Indus valley, especially severe in Pakistan, is a direct consequence of both over-damming of the rivers and the deforestation on the Tibetan plateau. Prior to these ambitious infrastructure development, the people in Tibetan Himalayas lived in harmony with the natural environment. This nature friendly way of life disappeared with the coming of a materialistic ideology.

Source: Dowenes 2012

After an unpleasant separation of India and Pakistan by then British empire In 1947, the two separated countries went to war three times. Two of these wars were fought in the Himalayan region of Kashmir. In addition to these full fledged wars, India and Pakistan have been fighting a low intensity war for several decades for a number of political reasons. The continued state of war in Kashmir on both sides of the border has brought life to a stand still many parts of this Himalayan region.

The life in most parts of Kashmir is controlled by the huge presence of defense personnel of the two countries, their needs, their way of living and mammoth military infrastructure, creating a huge disconnect between people and their eco system based living. Further, as the above casual diagram explains, militarized mountains triggered by simmering conflicts coupled with the new challenge of climate change and concerns over water security are affecting many aspects of environment and quality of human lives.

As a result of extraordinary military infrastructure, massive deforestation, depletion of water resources coupled with climate change impacts, there has been a rise in average temperature, receded permanent snow fall, soil erosion resulting in for frequent flash floods now seen in the state of Jammu and Kashmir. Major lakes and rivers in Kashmir harbour serious diseases due to serious environment pollution.

Source: Robins 2011

The conservation of biological diversity is defined as the management of human interaction with the variety of life forms and ecosystems so as to maximise the benefits, they provide today and maintain their potential needs for future generation's needs and aspiration. For this, the hydrology and water management plays a crucial role as we have to deal with ecosystems in changing moisture and temperature conditions on the ground depending on altitude and location (latitude, longitude and distance from ocean—the source and the snow and ice fields—the sink) (Khoshoo 1996), The concurrent changes in topography, altitude, precipitation, temperature, and soil conditions contributed to diversity of bioclimatic settings, which is increasingly altered with increasing anthropogenic and technological interventions of expanding built environments into natural systems. This leads to loss of mountain people's livelihood primarily dependent on ecosystem services, making them socio-economically vulnerable and advance their dependencies to commercial avenues requiring more and more built-environment infrastructure, for example, tourism, industry, etc.

The natural phenomena like landslides, GLOFs are accelerating due to human interference with nature. Humans and human built structures have caused the disturbance in the regime of nature and nature in turn has caused damaging effects to the human and human structures. Ecological disturbances and natural hazards are created and accelerated by the following processes in the HKH region (Fig. 8.1).

Hazards Caused by Natural Environmental Processes Snow, glacial lakes and earth quakes. Earthquakes trigger GLOF due to fall of glacial avalanches.

Hazards Caused by Geological Conditions Steep valley and topography. In steep valleys, monsoon and snow melt of water are continuously cutting the floor of the river beds. When cutting is deep and geological structures are favourable, rock slides occur which block the rivers temporarily and cause disasters in the downstream after the burst.

Hazards Caused by Hydro-Climatic Processes Distribution of water resources, melting of glacial lakes, flooding of river valleys, undercutting of banks and flooding of distant plains.

Hazards Caused by Human Factor In the high altitude mountains, overgrazing by animals causes removal of forest cover, which takes several years to grow, this in turn causes soil erosion, which might have taken several 100 years to form under the low temperature conditions. The contribution of sediment load is much more in high altitudes due to mass human waste compared to soil erosion. Further, the high altitude mountains experience frequent and intense hazards like avalanches, GLOFs, etc. However, their interaction with human civilization is rather limited as there can be no human settlements above 4,000 m altitude in the mountains. They can however, impact the people down-stream in the mid hills and plains by creating GLOFs. Huge rocks carried by glacial lake out burst floods create temporary damming in the rivers and subsequently infuse sudden burst of flooding.

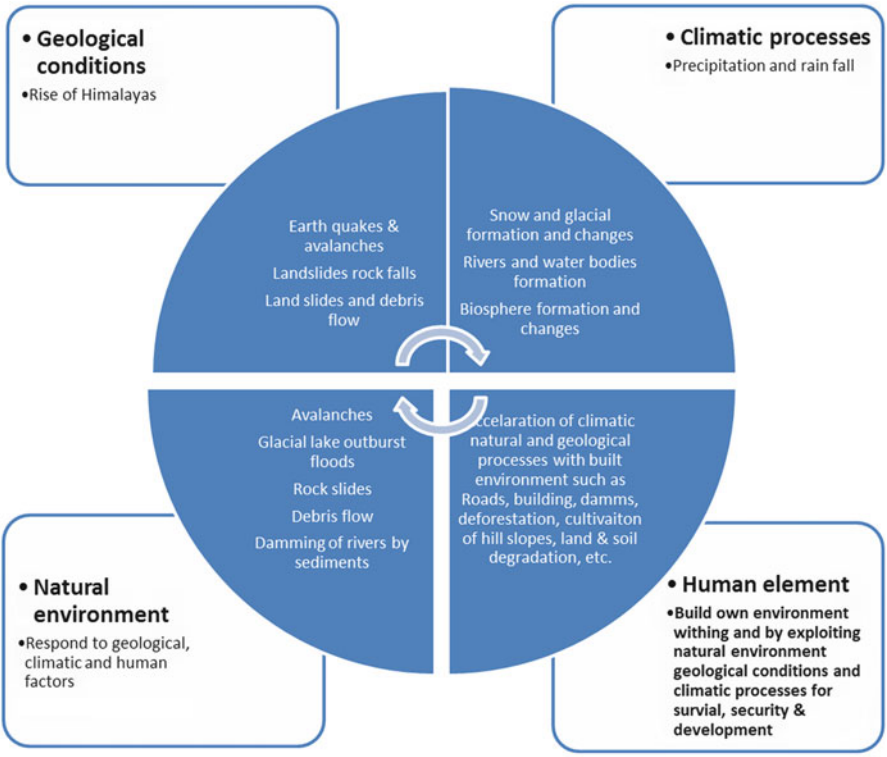


Fig. 8.1 Natural hazards in the HKH region are created and accelerated by conflict between built in and the natural environments

The recent example of such phenomena was Seti river floods in 2012, in Pokhara., Nepal that killed over 70 people and displaced hundreds of families apart from destroying infrastructure built on the river bank. Several experts who made tireless efforts to understand the cause of these floods came to a reasonable analysis in 2014, that; "It began weeks before the flood with a series of rock falls that sent debris tumbling into the Seti River, backing water up in the extremely deep and narrow gorge. The last of these landslides occurred just a week or so before the flood. The situation grew dire on May 5, 2012, when an unusually powerful ice avalanche and rock fall tumbled down a vertical cliff on a ridge just south of Annapurna IV. As the force of the avalanche and winds poured into the gorge, it overwhelmed the natural dam created by the earlier rockslides. The dam burst and sent a surge of pent up water and avalanche debris rushing downstream" (Earth Observatory 2014).

The cultivated areas in the mid hill valleys frequently face flooding due to GLOFs burst of temporary dams created along river way because of landslides or rock slides in the upstream. Landslides are mostly caused by erosion of rive banks, tectonic activities, and they carry loads of sediments and rocks to rivers in the plains

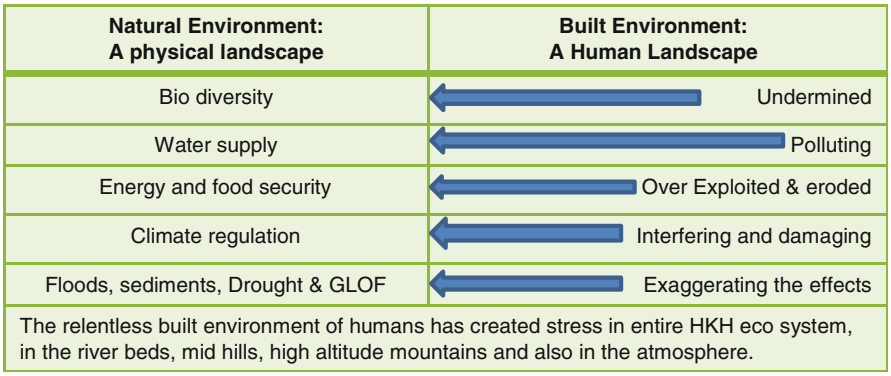


Fig. 8.2 Built environment causing obstructions to natural environmental processes and invite disasters

that destroy fertile lands and human habitations. The plains under the influence of ten major rivers that flow from the HKH mountains are most inhabited with over a billion population today whose exposure to floods has increased in recent years. For instance, the annual flooding in Koshi, Brahmaputra, Yellow and Indus rivers have been killing thousands ad displacing millions of people.

The human element in the HKH ecosystem has increased its interference with the other three systems in recent years. Human interventions transformed the water and forest based eco system of mountains in to mono-culture plantations, agricultural fields, grazing lands and concrete structures in large parts with impact on fresh water resources and pristine bio diversity. While human civilization has always depended on rivers for irrigation, on forests for fuel wood and housing, its interference with the geological and climatic systems increased with the industrial revolution and explosion of technology and urbanization. The relentless expansion of built environment of humans has created stress in entire HKH ecosystem, in the river beds, mid hills, high altitude mountains and also in the atmosphere (Fig. 8.2).

Increasing and uncontrolled mining in the river beds that causes slide in the bottom part of the mountains to fill the gaps caused by mining, massive construction of concrete buildings in the river beds has affected the percolation of surface water to the ground. This cause immediate run off in the form of flash floods. Similarly, soil is being polluted by chemical fertilizers, while air is polluted with pesticides and harmful gasses emanating from industries. Further, unsustainable use of wood for fire and housing beyond the rate of regeneration in the mountains has created crisis of water, increase in forest fires and created deep ecological disturbances in the HKH mountains. As the third assessment report of the Inter Governmental Panel on Climate Change (IPCC) concludes, global warming observed over the last 50 years was due to human activities. The IPCC report further elaborates that, human emissions of carbon dioxide are due to fossil fuel burning, deforestation, land use change, etc, (IPCC 2001).

With environmental degradation resulting in limited livelihood opportunities, the communities may be forced to further over-exploit the local environment making it even more vulnerable. In mountain areas with little access to financial services, communities often have savings in the form of livestock, which may be lost in the event of a disaster. Reducing the risks of disasters require widespread and sustained commitment across a wide range of activities. And since many of the hazards will intensify because of climate change, it is also vital to approach these issues on a broad front, integrating disasters and climate change policies with socio-economic policies aimed at reducing poverty and inequities (ESCAP 2010).

8.4 Environmental and Social Considerations: Harmonizing Built and Natural Environments for DRR

As discussed in previous sections, climate Change coupled with environmental degradation in the HKH region causing deforestation, high monsoon runoff, flash floods, river-line floods, soil erosion and landslide etc. whereas non-monsoon hydrological hazards comprises of decreasing under ground water table, drying up of natural water springs and decreasing trends of streams discharge due to deforestation during monsoon period. Rawat et al. (2011d) suggested that during last two decades climate change and land use degradation reduced the protective vegetal cover. As a result the significant proportion of rainfall goes waste as flood water without replenishing the groundwater reserve. Consequentially 24 % natural springs have gone dry, and 28 % springs have become seasonal during last two decades period (1990–2010) in HKH region, resulting in drought hazard in non-monsoon period which poses a serious threat to rural socio-economy and livelihood because these rain fed springs and streams are major sources for dirking water and agricultural irrigation in HKH region.

On the other hand, during monsoon period land-use degradation is accelerating flash flood, river line flood, soil erosion and landslide. These hydrological hazards cause great loss to life and property and poses serious threat to the process of development with far-reaching economic and social consequences, not only in the mountains, but also in adjoining ecosystems in plains (Ives 1989; Rawat 2011). A robust and healthy ecosystem serves as an absorber of natural shocks by mitigating the intensity of natural hazards and reduces people's exposure to hazards. The outcomes report of Rio + 20 also calls for disaster risk reduction to continue to be addressed in the context of sustainable development and placed within the post-2015 development agenda. It also calls for increased coordination among national, regional and international levels for a robust response to environmental emergencies and improved forecasting and early warning systems and their integration into development policy (United Nations 2012a).

This philosophy also finds resonance in the UN Systems task team's report to UN Secretary general on the post 2015 UN development agenda, titled "Realizing

the future we want for all", which says "Promoting environmental sustainability, including sustainable, integrated natural resource management, with the full participation of local organizations, can build resilience at all levels of society and realize multiple benefits. Ecosystem-based approaches to adaptation can provide a win-win opportunity for reducing vulnerabilities, as part of national adaptation strategies" (United Nations 2012b). Bangkok Declaration on DRR in Asia and Pacific, adaptation in sixth Asian Ministerial Conference on DRR held during June 2014 recognises the role of ecosystem based DRR and integrating livelihood resilience and natural resource management as a holistic approach to disaster resilient communities especially in coastal and mountain areas.

The impacts of unsustainable development are particularly apparent in the HKH region. In the last five decades, Himalayan region experienced massive land use change that was driven by political, socio-economic, demographic and technical factors and compounded by the impact of climate change. These changes directly affect biodiversity and the ability of biological systems to support human needs. They also increase the vulnerability of ecosystems and people to climatic, economic or socio-political perturbations and are the primary cause for soil, water and land degradation. Further, climate change with its negative impacts on mountain environment is increasing disaster risks and affecting community resilience. This drives us to the recognition that disaster risk reduction approaches should recognize and seeks to exploit specific programmatic synergies with sustainable livelihoods, ecological sustainability, climate change adaptation and natural resource management.

The impact of ecosystem change is not limited to people living in this region, it can also affect people who live far away, even on another continent. The findings of the Millennium Ecosystem Assessment (2005) show that mountain ecosystems and its inhabitants are among the most vulnerable in global environmental change including climate change. Ecosystem services have already been affected by the way human activities have changed mountain habitats. Current trends in population growth and consumption patterns suggest that competition for these diminishing resources and services will become more intense, and will frequently require trade-offs between alternative ecosystem goods and services among stakeholders at different scales (MEA 2005). Therefore, it is essential to understand the complicated interactions between human activities, climate change and ecosystems in mountain settings in order to develop mitigation and adaptation measures that are appropriate, applicable, accessible and affordable for mountain regions.

Conclusion

The global sustainable development and human well being to a large extent depend directly or indirectly, on resources and services from mountains. However, while mountain ecosystems are under immense stress due to unsustainable demand of growing world economy, the mountain

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communities are deprived of the development gains of the world. The critical question is how to sustainably harness the multi-functionality of mountain region with a fair share of benefits going to the mountain communities and How can mountain people be compensated for the services they provide to downstream users?

There are no easy answers to this question. A combination of urgent efforts are required to protect fragile mountains from the impacts of climate change and to reduce disaster risks in the mountain regions. These efforts may include, proper drainage management to control shallow debris and bio engineering, using appropriate forms of vegetation to stabilise vulnerable surface areas, ensuring disaster preparedness in the mountain habitations and settlements, setting up early warning systems and improving information flow and providing access to mitigation and relief measures. Further, there is an urgent need for strengthening built in resilience and ecosystem resilience by each country in the region in addition to trans-boundary and regional cooperation among mountain countries in the areas of data sharing, flood and seismic catastrophe management, periodic digital hazard mapping, monitoring and modeling for accurate understanding and forecasting of disasters to save thousands of lives across the nations. Such cooperation efforts are especially crucial for countries in the Himalayan Hindu Kush region, where each country in the region should develop a mountain specific disaster management action plan with active involvement of communities in the mountain region. Some of countries like Nepal, India, China have envisaged relating provisions in their national policies and laws. India's National Action Plan on Climate Change envisages eight missions with a dedicated National Mission for Sustaining the Himalayan Ecosystem. The National Environment Policy of India (2006) envisages for following in relation to mountain ecosystems, and proposes to:

- Adopt appropriate land-use planning and watershed management practices for sustainable development of mountain ecosystem.
- Adopt "best practice" norms for infrastructure construction in mountain regions to avoid or minimize damage to sensitive ecosystems and despoiling of landscapes.
- Encourage cultivation of traditional varieties of crops and horticulture by promotion of organic farming, enabling farmers to realize a price premium.
- Promote sustainable tourism through adoption of "best practice" norms of eco-friendly and responsible tourism, creation of appropriate facilities and access to ecological resources, and multi-stakeholder partnerships to enable local communities to gain livelihoods, while leveraging financial, technical, and managerial capacities of investors.

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- Take measures to regulate tourist inflows into mountain regions to ensure that these remain within the carrying capacity of the mountain ecology.
- Consider unique mountain scapes as entities with "Incomparable Values", in developing strategies for their protection.

The indisputable fact that ecological destruction is increasing risk of disasters, that affect most of the HKH population, highlights the obvious relation between the two areas of work. Disaster risk management is largely pursued by most organizations and governments in the region in the independent domains of communities, institutions, water and engineering with short term goals, objectives and funding cycles. It is high time that, disaster risk management programs and practices adapt a comprehensive approach of working from source to the end, upstream to downstream and combine risk and vulnerability reduction with eco system strengthening. Ecosystem strengthening essentially would mean enabling the different components in the system work in harmony. The most destructive component in this ecosystem is the human systems if it doesn't reduce those actions and pursuits which create imbalance in the ecosystem causing natural abnormalities and extremes. Unless these damages to the ecosystem are repaired and normal function of ecosystem is restored, the efforts and fight for mitigating natural hazards and enhancing adaptive capacities will not be able to provide long term safety and sustainability to our lives and livelihoods.

Most of the natural hazards in the HKH region are trans-boundary in nature. Environmental degradation - geological, hydro-meteorological, climatic or anthropogenic factors, in one country cause hazards transcend the political boundaries and affect communities in the neighboring countries too. The South Asian earthquake of October 2005 damaged life and property over large areas of Pakistan and India. Koshi floods devastate parts of Nepal and India every monsoon, while Ganges floods maroon hundreds of villages in India and Bangladesh. Similarly, Indus river floods affect Afghanistan and Pakistan and Brahmaputra floods affect China and India. Therefore, regional cooperation among countries of the HKH region is very crucial for disaster risk reduction, especially in the areas of data sharing, flood and seismic catastrophe management, periodic digital hazard mapping, monitoring and modelling for accurate understanding and forecasting of disasters to save thousands of lives across the nations. Further, countries in the Himalayan Hindu Kush region should develop a joint disaster management action plan with active involvement of communities in the mountain region. Further, a HKH regional treaty on ecosystem approach to climate and disaster resilience is the need of the time for sustaining and ensuring consistency in regional cooperation for environmental sustainability and disaster risk reduction.

8.5 Way Forward: Need for Harmonizing the Interface Between Built and Natural Environments

The discussion with evidences and examples in previous sections establishes that fact unprecedented and unsustainable interference of built environment has eroded the strength and resilience of natural environment in the mountain environment. Reversal of the damage caused by built environment to nature and preventing future damages by changing built environment practices are some crucial and urgent steps needed to reduce the negative impacts of climate change and intensity of devastating natural hazards. Given the fragility of Hindu Kush Himalayan mountains and their vulnerability to rapidly advancing effects of climate change, the governments in the region should put in urgent and effective measures to harmonize the development processes so that built environment aligns with the natural environment, instead of destabilizing it. In this context, the mountain development processes need to be pursued, keeping in harmony with environment (Box 8.3) and must be locally relevant.

Box 8.3. Key Principles for Sustainable Development in the Himalayan Mountain Regions (Narain (2013)

- The Himalayan states must build a viable and sustainable forest-based economy (forests for development, and value ecosystem services so that protection is valued).
- The strategy for water development must balance the opportunity for energy and threat to livelihood, particularly in the age of changing climate and hydrology.
- The need for energy in remote villages must be secured first, before export to regions outside.
- Promote local organic agriculture and its produce as speciality, high value premium produce of a fragile ecology.
- Use ecosystem-based tourism for development but with safeguards and local benefits, and
- Build policies for sustainable urbanisation in the mountains.

The recently held Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) called on to the United Nations to building coherence between the post-2015 framework for disaster risk reduction and the concurrent processes on the Sustainable Development Goals and climate change arrangements. The declaration also appealed to the national Governments in the region to encourage disaster risk assessment in development policies and programs; promote, as appropriate, sustainable development strategies that enhance our ability to manage natural resources sustainably and reduce disaster risk (AMCDRR 2014). Emphasizing on such coherent linkage between environment, development and disaster risk

reduction, PEDRR (Partnership in Environment and Disaster Risk Reduction) recommends that the post 2015 HFA (Hyogo Framework for Action) should promote, integration of eco-system-based approaches by member states as an integrated solution to disaster risk reduction expansion of environmental impact assessments of projects with DRR perspective, use of local environmental knowledge and community led eco system based approaches to DRR in order to ensure reduction of environmental risks without compromising on development goals (PEDRR 2014).

In line with above regional and global advocacy messages for eco system based disaster risk reduction, this chapter makes following specific suggestions for policy and practice, especially for the consumption of post 2015 HFA and sustainable development goals from mountain perspective:

- Mountains are the water towers of the world and hotspots for hydro power development. Given the fragility and relative high poverty in mountain regions, policies must be promoted to balance conservation and development to reduce environmental risks.
- Mountain perspectives should be adequately and effectively integrated in disaster risk reduction guidelines and policies so as to support adaptive capacities of the mountain communities and strengthen their resilience.
- Mountain are not only the major sources of water, energy and other ecosystem services to half of the humanity, but also provide invaluable health, spiritual and recreation services. Therefore, it is important to ensure fair share benefits go to mountain communities and their social and economic vulnerabilities are reduced.
- The mountain women are the guardians of the mountain environment and harbingers of the eco system services. Therefore, it is important to build women's resilience through capacity, access to resources and their role in decision making.

At global level and in the international agenda, there seems significant awakening and recognitions for DRR in mountain regions as critical aspect of sustainable development. However, there are still serious challenges on the ground, especially when it comes to translating international agreements into plans, programs and local actions. Landscape based planning as key to sustainable local development that takes care of upstream-downstream relations while working out strategies of adaptation to climatic changes and social aspirations, is need of the time. Therefore, significant focus on developing and promoting locally relevant models of development with mainstreamed preventive disaster mitigation and preparedness is must. There is also need to learn from past mistakes, success stories and local experiences of dealing with such risks arising from conflicts of built environment with natural ones by developing knowledge sharing platforms, compilation of good practices and case studies which would also feed substantially to effective policies, planning and capacity building efforts.

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