Pt. Govind Ballabh Pant Memorial Lecture : XXI

DAVID MOLDEN

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G.B. Pant Institute of Himalayan Environment and Development
(An autonomous Institute of Ministry of Environment, Forest & Climate Change, Govt. of India)
Kosi-Katarmal, Almora - 263 643, Uttarakhand (India)

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Director General of the International Center for Integrated Mountain Development (ICIMOD) ●Worked as Acting Director General, Deputy Director General and Theme Leader for the International Water Management Institute (IWMI) ●Led the acclaimed Comprehensive Assessment of Water Management in Agriculture, involving over one thousand researchers and practitioners from hundreds of institutes to answer the question how can water be developed and managed to reduce poverty and support ecosystems ●Contributed to concepts of water scarcity, water productivity, water accounting ●Ability to integrate social, technical and environmental aspects of natural resources management, and promotes interdisciplinary and cross-cultural teamwork ● Communicates key messages to broad audiences with several keynote speeches, media interviews and opinion pieces ●Work experience across Asia and Africa

EDUCATION

1983 - 87	Ph.D. Colorado State University (Civil Engineering with specialties in water resources)
1980 - 82	M.Sc. Colorado State University (Civil Engineering in groundwater hydrology)
1973 - 77	B.Sc. University of Denver

AWARDS AND AFFILIATIONS

- CGIAR Outstanding Scientist, 2009
- PAWEES (International Society of Paddy and Water Environment Engineering) International Award, 2009, in recognition of distinguished achievements and excellent contributions.
- IWMI won the Stockholm Water Prize (2012) and the International Water Resources Association Crystal Drop Award (2011) for work during my period at the Institute
- IWMI Outstanding Researcher, 2006
- IWMI Outstanding Partnership for the Comprehensive Assessment, 2006
- Editor in Chief for Mountain Research and Development; Editorial Panels for International Journal for Water Resources Development; Irrigation and Drainage Systems, and Paddy; Water and Environment; Hydro Nepal
- Board of Directors – International Center for Biosaline Agriculture (ICBA), Management Advisory Committee – South Asian Network of Development and Environmental Economists (SANDEE)
- Graduate student advisor for students from many countries.

EXPERIENCE

- Present – Director General, International Center for Integrated Mountain Development (ICIMOD)
- 1996 -11: IWMI, Sri Lanka. DDG, Research; Acting DG (June – Oct 2007); Theme Leader
- 2001 - 07: Leader, Comprehensive Assessment of Water Management in Agriculture program.
- 1995 - 96: Egypt: Chief of Party for Strategic Research Project of USAID/Egypt Ministry of Public Works
- 1991 -95:Nepal: Chief of Party for Irrigation Management Project
- 1989 - 91: Egypt, USA and India: consulting for Computer Assisted Development, Inc.
- 1982 - 87: Research Associate, Colorado State University, in USA and Botswana.
- 1977 - 79: Lesotho: Peace Corps Volunteer.

PUBLICATIONS

Contributed to the publication of over 200 pieces of works in books, refereed journals, research report series, the media, project reports and educational material, including more than 75 peer reviewed scientific articles.

Climate Plus Change: Actions for Adaptation and Transformation for the Hindu Kush-Himalayan Region

I would like to thank the Governing Body of the G.B. Pant Institute of Himalayan Environment and Development, and the Director Dr. P. P. Dhyani, for providing me with this opportunity to share my thoughts with you today – the128th birth anniversary of Pandit G.B. Pant, one of the greatest leaders from the Himalayas, and so aptly called Mountain Man. ICIMOD and the G.B. Pant Institute have a long and fruitful history of collaboration (see Box). Our mutual concern for this mountain region, sharing of our knowledge and learning, and efforts to support the people of the mountains in developing satisfying livelihoods and maintaining their mountain heritage, have brought us together in many productive and challenging activities. This adds to the pleasure of sharing with you today some thoughts on the implications of climate change for the people of the mountains, a focus of the work of both our institutions over many years.

The Hindu Kush Himalayan (HKH) mountains provide a range of services to people in Asia, including water, food, energy, and biodiversity. About 1.3 billion people living downstream of these mountains benefit from HKH water that serves vast irrigated areas in ten major river basins. The food produced from this water contributes to the food security of more than one-third of humanity. The mountains are home to treasured biodiversity, and include four of the world's 34 global biodiversity hotspots. Mountain ecosystems have nourished diverse cultures over millennia, and resilient mountain communities have found ways to survive and thrive in these remote, fragile, and harsh environments.

Yet in today's world, mountains and mountain people face unprecedented pressures. The HKH mountain systems are highly vulnerable to climate change. There is an increasing number of disasters, brought about both by more hazards and by the way that people interact with the environment. Mountain societies are undergoing unprecedented transformations. Migration and urbanization are rapidly changing the face of rural mountain areas. Globalization and modernization reach to even the most remote communities, and the aspirations of young people are very different to those of their grandparents. Mountain people have to contend with climate change as well as other socio-ecological changes, many of them brought from the outside world. The effects of this change will reach far beyond the mountains to the distant and heavily populated plains, and have repercussions for the global community. Given these immense pressures, is it possible to adapt, and transform to maintain vibrant mountain communities who will maintain a healthy mountain environment?

ICIMOD-GBPIHED Collaboration

ICIMOD engages in strategic and programmatic cooperation in India. ICIMOD's focal ministry for all strategic and policy matters is the Ministry of Environment, Forest and Climate Change, and the Secretary of this Ministry represents India on ICIMOD's Board of Governors.

ICIMOD's nodal agency for coordination of programmatic partnership is the G.B. Pant Institute of Himalayan Environment and Development (GBPIHED). The ICIMOD-GBPIHED partnership has flourished since the historic Manali (Himachal Pradesh) workshop held in the early 1990s, where delegations from the two institutions developed a working framework, and ICIMOD has had a Memorandum of Understanding with GBPIHED on programmatic cooperation in India since 2008. ICIMOD has many programmes in India related to adaptation to change, transboundary landscape management, river basin management, cryosphere and atmosphere, and the Himalayan University Consortium. GBPIHED is coordinating the Indian participation and activities in an extensive transboundary landscape programme, particularly in the Kailash Sacred Landscape (China-India-Nepal), Kangchenjunga Landscape (Bhutan-India-Nepal), and HI-LIFE Landscape (China-India-Myanmar). There are 26 professionals from India among ICIMOD's staff, a number of them former GBPIHED staff, which helps to increase the bond between the two institutions. ICIMOD's partnership with GBPIHED, with a similar vision and mission, has been immensely fruitful, and we are confident that it will strengthen further in the years to come.

Let us draw inspiration from the visionary Pandit Govind Ballabh Pant, freedom fighter and Satyagrahi with Mahatma Gandhi, who stood for truth, and ultimately used the truth to mobilize people for change. Science is an important means of searching for truth, and we should bring science to bear on the pressing issues of climate and change. This memorial lecture will explore the impacts of climate and other changes as they affect us in the Himalayan region, and suggest actions that need to be taken.

The Hindu Kush Himalayan Region – Diversity and Challenges

The Hindu Kush-Himalayan region extends for 3,500 km from Myanmar in the east to Afghanistan in the west over an area of 4.3 million sq. km (Figure 1). It covers all or part of eight countries with widely varying geographical terrain, ecosystems, and human and community attributes, and contains the headwaters of ten large Asian river systems (the Amu Darya, Indus, Tarim, Ganges, Brahmaputra, Irrawaddy, Salween, Mekong, Yangtze, and Yellow). Close to one-fifth of the area is covered by snow, with around 60,000 km2 of glaciers and 6,000 km3 of ice reserves (Bajracharya and Shrestha 2011). The rich natural resources – water, forests, rangelands, soils, biodiversity – provide livelihoods to the 210 million people who live in the region and goods and services to 1.3 billion people living downstream, as well as regulating the regional and global climate and hydrological regimes (Table 1).

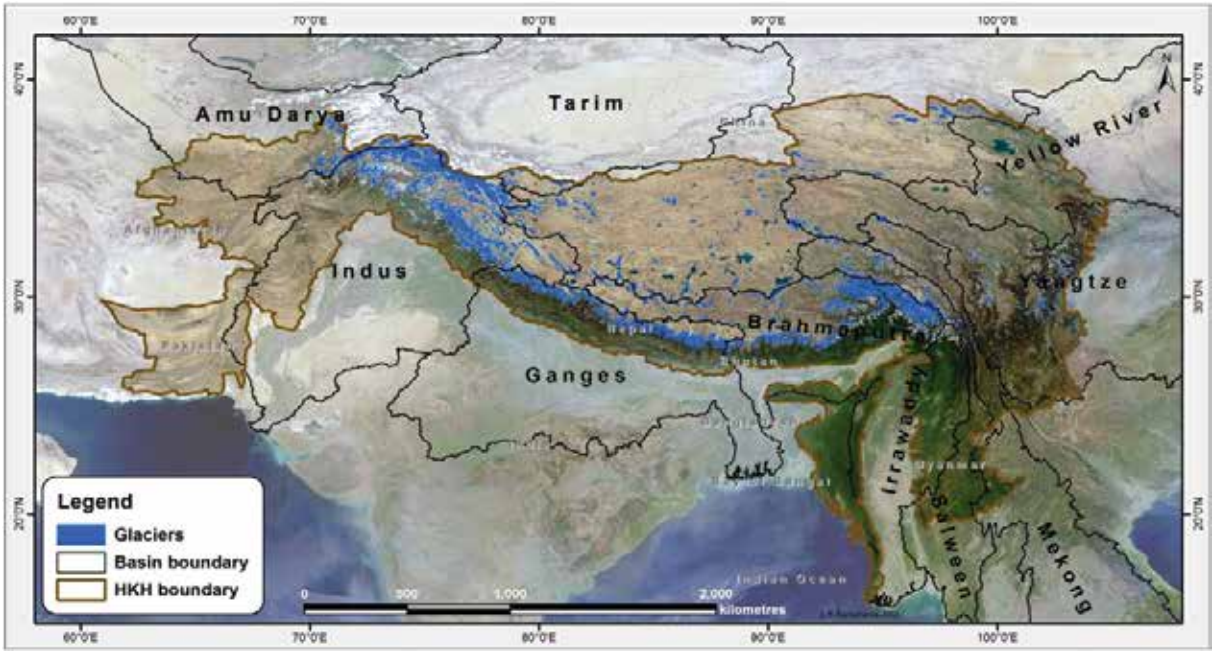

Figure 1: The HKH Region showing glaciers and the major river basins.

Table 1: The HKH region – geographical area, population, glacier coverage, major land-use, and protected area of countries within the HKH

Country	Total area within HKH[a]		Population in 2007	Glacier area[b]	Forest	Grassland, shrubland, and similar	Agricultural land[c]	Protected area[d]	
	km^2	%	million	km^2	km^2		km^2	km^2	%
Afghanistan	391,560	61	28.48	2,677	2,179	235,935	94,577	2,461	<1
Bangladesh	15,543	11	1.33	-	4,920	7,912	2,723	632	4
Bhutan	39,837	100	0.71	680	28,739	3,994	2,897	12,681	32
China	2,395,105	26	29.48	29,529	228,699	1,388,496	688,294	1,522,172	64
India	404,701	13	72.36	12,296	140,097	137,806	99,886	62,417	15
Myanmar	323,646	49	11.01	24	143,588	112,488	63,747	23,967	7
Nepal	147,163	100	27.80	4,213	41,942	26,929	68,777	24,972	17
Pakistan	479,039	55	39.36	10,994	5,541	354,044	84,644	18,721	4
Total	~4,190,000		210.53	57,736	595,705	2,267,600	1,105,546	1,668,023	40

[a]approximate area; % total country area

[b] approximate area

[c]includes irrigated and rainfed cropland and mosaic cropland/vegetation

[d] % of HKH area protected

Sources: Bajracharya et al. (2010), Bajracharya and Shrestha (2011), Chettri et al. (2008), Singh et al. (2011),Globcover 2009 Version 2.3 from European Space Agency

Elevation zones in the HKH extend from tropical (<500 m asl) to alpine ice-snow (>6000 m asl). With its varied landscapes, soils, and climatic conditions, the region has developed a rich and remarkable biodiversity (Pei 1995; Brooks et al. 2006); it includes all or part of four global biodiversity hotspots (Mittermeier et al. 2004) with a rich variety of gene pools and species, ecosystems, and endemic species of global importance (Brooks et al. 2006).

The HKH region has enormous socioeconomic and cultural diversity with many ethnic groups and more than 600different languages (Turin 2007).The rugged terrain and harsh climate are a challenge to survival; communities practise a variety of traditional livelihoods with diverse farming techniques designed to maintain the integrity of the resources and minimize risk.

In recent years, rapid population growth, urbanization, migration (especially men's out migration), economic development, and climate change have begun to pose new challenges to traditional livelihood strategies and coping mechanisms. Increasing demands on ecosystem goods and services are putting pressure on the natural resources, and recent decades have seen extensive changes in land use as well as degradation of forest, rangelands, and wetlands. Environmental degradation has been identified as a major threat to the functioning of the HKH ecosystems and flow of ecosystem services (Chettri et al. 2010; ICIMOD and RSPN 2014; ICIMOD and MoFSC 2014). Biodiversity is also facing challenges of species loss and extinction resulting from habitat degradation and fragmentation of the landscape (Myers et al. 2000; Ives et al. 2004; Pandit et al. 2007).Adapting to and mitigating the effects of environmental change and sustaining ecosystem services in the context of an increasing human population is a major challenge in the HKH as elsewhere (Molden et al. 2014; Xu J et al. 2009).

Evidence for Climate Change

Studies show consistent trends in overall warming in the HKH region over the past 100 years (Du et al. 2004; IPCC 2007), with indications that temperatures are rising at higher rates in higher altitude areas. Model-based projections indicate that the warming will continue for the foreseeable future (Shrestha and Devkota 2010).

Although there are no clear trends in annual precipitation, there is some indication of increased variability within and between years, and in many areas a greater proportion of total precipitation appears to be falling as rain rather than snow. Changes in the pattern of the monsoon, with later onset, later end, and changes in intensity, are also thought to be linked to climate change. Climate change is expected to lead to an increase in extreme events, and several studies indicate that this is already happening with more heat waves, heavy and very heavy rainfall events, droughts, and cyclones across South Asia (Goswami et al. 2006; Sivakumar and Stefanski 2011).

With rising temperatures, the areas covered by permafrost and glaciers are decreasing across most of the region, except for the Karakorum, with average annual loss in glacier area in the greater Himalayas estimated at 0.4–0.5% per annum since the 1950s (Miller et al. 2013). Decadal change studies showed a decrease in Bhutan's glacial area by 23% and Nepal by 24% over the last 30 years (Bajracharya et al. 2014a,b). Future projections indicate continued loss in glacier mass through the 21st century. A recent modelling study showed that a large part of the glaciated area in the Everest region could sustain mass loss by the end of this century (Shea et al. 2015).

Changes in moisture inputs in the form of snow and rainfall, and temporary storage in the form of glaciers, ice, permafrost, snow, groundwater, and wetlands, are likely to have a profound effect on the flow regimes of the major rivers. There is a large variation in the contribution of glacier and snow melt to total runoff across the

region ranging from 8.7% in the monsoon-dominated east to 30% in the more arid mountains of the western HKH (Miller et. al. 2012), and from 20–62% in the upper basin areas (Lutz and Immerzeel 2013)). The runoff from five major river basins shows that glacier runoff is more in the Upper Indus and rainfall runoff in the Upper Ganges (Figure 2). Model-based projections indicate an overall increase in runoff in the major rivers until at least 2050, mainly due to an increase in precipitation in the upper Ganges, Brahmaputra, Salween, and Mekong basins and accelerated melt in the upper Indus Basin (Lutz et al. 2014). However, this increased availability is linked to a pattern of intra annual variability that could result in more droughts and floods, with the additional flow coinciding with periods of already heavy rainfall. The impacts for communities directly dependent on snow and ice are already being felt, with water supplies severely affected by melting glaciers, and the increased threat of glacier lake outburst floods.

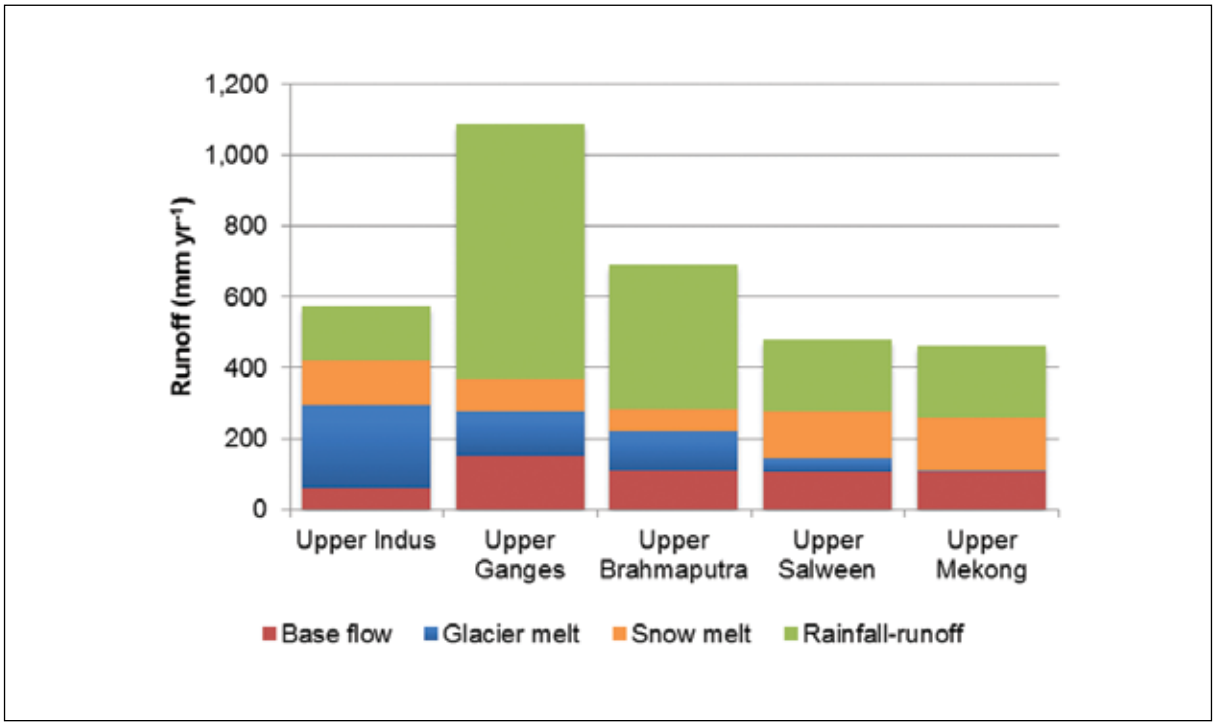

Figure 2: Hydrological regime 1998–2007 in upper river basins of the Himalayas
(Source: Lutz and Immerzeel 2013)

Black carbon resulting from incomplete combustion of biomass from cooking stoves, diesel fuel, agricultural burning, and forest fires is a regional issue of rising concern as it compounds climate change impacts. When black carbon is deposited on snow or ice it increases the rate of melt. Moreover it has profound impacts on human health and agriculture. It is a regional issue because much of the air pollution and black carbon originates in the plains and moves into mountain areas, and as such it will take a collaborative effort to reduce emissions (Panday 2013).

Climate Change Impacts

Climate change affects all aspects of life, making rainfall less predictable, changing the timing and length of the growing season, reducing cool days, and increasing the likelihood and severity of some extreme events such as floods and droughts(Lutz et al. 2014; Molden et al.2016). It is embedded in a matrix of drivers of change, which presents challenges in disaggregating the impacts from the effects of other factors. Nevertheless some likely impacts can be recognized relating to food security, biodiversity, hydropower, and disasters.

Agriculture is the economic sector most sensitive to climate change. Changes in temperature, precipitation, wind speed, and atmospheric condition can have a significant impact on crop productivity (Pradhan et al. 2015). More extreme weather events – floods, droughts, and storms – and increasing variability in rainfall will lower agricultural productivity (Kurvits et al. 2014). Even small shifts in mountain climates can cause major problems in food security (Schild and Sharma 2011), but the impacts are likely to vary across the region. The trends indicate warming and drought-proneness in China and the Koshi basin, increased winter water stress in South Asia, high variability in monsoon and flood-related disasters in the Upper Indus and plains of other basins, and warming at higher elevations in all basins (Kurvits et al. 2014). Higher temperatures will increase evaporation rates and thus the water requirement, while the increase in floods and droughts could have potentially severe impacts on agricultural systems in general. Already changes in the timing of peak flows, delayed start of the monsoon, and earlier starts to the growing season are shifting normal agricultural patterns, and farmers increasingly have concerns about water availability at the right time. The increasing temperatures are also affecting crop productivity, with reductions in the productivity of crops grown close to their temperature threshold and increases where cooler areas are becoming more suitable for cropping (Pradhan et al. 2015).

Changes in climate can also be expected to affect biodiversity (Singh et al. 2011; Chettri et al. 2010; Chettri and Sharma 2015), although impacts are difficult to assess as baseline data are sparse. Observational evidence indicates that climate warming is already leading to visible effects in the HKH region with indications of changes in phenology (Hart et al. 2014; Ranjitkar et al. 2013) and degradation of vegetation (Arthur et al. 2007). As a result of microclimatic variations, most organisms in the HKH are confined to specific ecosystems and often specific altitudinal belts. Globally, there is evidence of species shifting towards the north in latitude (Hickling et al. 2006) or to higher elevations (Wilson et al. 2007). But many species have limited scope for movement, with soils at higher elevations either nonexistent or unsuitable, and small populations isolated in 'islands' unable to move to more suitable locations. Highland species with their highly specialized adaptation to local conditions can be particularly sensitive to climate change and are more likely to be at risk of extinction (Pounds et al. 2006). Phenological changes may also have an impact on populations of pollinators, leading to changes in ecosystem productivity and species' composition (Thuiller et al. 2008).

The demand for energy and hydropower in the region is growing and there has been a marked increase in the construction of hydropower facilities in mountain areas. But changes in precipitation patterns and glacier, snow, and ice melt will have an impact on the functioning of both reservoirs and run of the river facilities. More intense

rainfall events may lead to increased floods and siltation, while droughts will lead to loss of operating power (Cheng et al. 2012).

The HKH region is highly vulnerable to a range of natural disasters including riverine and flash floods, glacial lake outburst floods, droughts, landslides, avalanches, and forest fires, and these are likely to increase with both climate change and human interactions with the environment. For example, climate change is likely to lead to an increase in landslides because of increases in intense rainfall (Huggel 2009). The number and size of glacial lakes are increasing as glaciers melt, and the likelihood of more glacial lake outburst floods will increase (Khanal et al. 2015). However, we must keep in mind that these natural hazards are only disasters when there is loss of human life or property, and that the way people manage the environment – building houses on floodplains, poorly constructed roads – contribute greatly to the actual disaster.

Adaptation and Resilience of Mountain People

Communities in the HKH are particularly vulnerable to the impacts of climate change (Macchi et al. 2014; Gerlitz et al. 2015; ICIMOD 2015a). They are highly dependent on the natural resource base for their livelihoods, and tend to live a subsistence lifestyle, making the most of marginal lands in a challenging climate with limited resources and little opportunity to build up surplus resources as a buffer against disaster. At the same time they are faced with changes related to economic development, urbanization, rapid population growth, and migration, particularly out migration of men for work. Climate change further compounds the already challenging problem of ensuring sufficient food, water, and energy to meet growing demand (Rasul 2014). But people are adaptable, and adaptation in the HKH as elsewhere means a process both of adjusting to climate and other change and exploiting the opportunities they present to achieve a positive transformation (ICIMOD 2015a).

The very characteristics that make mountain communities vulnerable to climate change are those that offer a basis for building resilience. The long tradition of survival and adaptation to climatic variation, the isolation and need to rely on local resourcefulness, and the knowledge handed down through generations are assets that can be harnessed in addressing the new challenges and exploiting opportunities. But they need to be nurtured. With the many changes in mountain areas, the dependence on the natural resource base is decreasing, the local knowledge base is eroding as people look to other opportunities to make a living beyond subsistence agriculture.

The individual HKH countries have also recognized the importance of regional understanding and developing frameworks for national action on climate change, and a number of countries have prepared or are preparing National Adaptation Programmes of Action (NAPAs) and Local Adaptation Programmes of Action (LAPAs). India has taken a step further in preparing a 'National Mission for Sustaining the Himalayan Ecosystem' as one of the eight missions in addressing climate change, which aims to improve understanding of the cryosphere; establish an observational and monitoring network for the Himalayan environment; and promote community-based management through incentives to community organizations for protecting forested lands.

Change Brings Opportunities

While change can be quite disruptive it can also bring opportunities. There is considerable scope for action to mitigate, adapt to, and even bring about transformation from the changes that are taking place.

Protective adaptation

With increasing hazards, it is essential to build measures to reduce risk. There is an urgent need to increase

preparedness at community, national and regional levels. End-to-end flood information systems that include enhanced data collection, modelling, early warning systems, and community engagement show promise to reduce disaster risk from floods for the HKH region (Shrestha et al. 2015). There is also a role for community-based early warning systems, and ICIMOD and partners are piloting simple technologies and community engagement to give warnings about floods (Shrestha et al. 2014). Satellite remote sensing has also been shown to offer a promising approach to give early warning on fire hazards.

Transformative adaptation

Opportunities arise with change, even with climate change. The key is to diversify livelihood opportunities, and there are a range of options. For example, increased urbanization brings a greater demand for niche, organic, and high-value products, many of which can only be grown in mountain and hill areas. Warming at higher elevations could increase the range of products that can be grown for sale in the plains, while value chains can be developed to ensure that the mountain people benefit from exploiting these opportunities. Tourism, especially ecotourism, is another area that can provide alternative livelihood opportunities while benefiting the mountain environment. With increased migration, there are also increased funds available through remittances that can be invested into sustainable mountain development, as can funds accruing from benefit-sharing and compensation mechanisms.

Conservation plus development

For Himalayan ecosystems to continue to provide a flow of services for this generation and many more to come, they must be conserved. At the same time, to realize the benefits, ecosystems, have to be managed. Unfortunately, at present the trend is more towards environmental degradation as people exploit the ecosystems for short term gains. Cordyceps harvesting is a typical example, where to meet the huge demand, rampant harvesting is underway causing considerable environmental degradation and social conflict. Thus one of the challenges is to simultaneously meet the two goals of conservation and development. Experience shows that with determination and goodwill, this is possible. Pilots under the Kailash Sacred Landscape initiative are showing good results in this area taking a landscape approach. The international symposium on 'Transforming Mountain Forestry' held in Dehradun, India in January 2015 (ICIMOD 2015b) made a number of recommendations designed to address meeting the challenges of conservation and inclusive development while identifying transboundary opportunities. They emphasize such areas as sustainable use, forest diversity, improving forest management by involving and engaging communities, and developing markets, underpinned by appropriate policies and knowledge exchange.

Managing natural resources

Mountain and hill people continue to struggle to gain access to adequate supplies of water, whether in the high rainfall areas of the 'wet desert' of Cherapunji or the far inner valleys of Ladakh. In the hills, there is increasing anecdotal evidence of drying springs, often attributed to climate change but now known to have many causes including increased tapping of water sources, degraded forests and change of land use, and loss of traditional water storage mechanisms. Managing exploitation, keeping a healthy vegetation cover, and storing water will be keys to the future viability of springs (ICIMOD 2015c).

Mountain forests are recognized as a pool of carbon with an important role to play in mitigating the negative effects of climate change, and their conservation is of vital importance. Yet for many mountain communities use of forest resources is essential for survival. Programmes like REDD+ (Reducing Emissions from Deforestation and Forest Degradation plus) show promise in bringing incentives from national and global parties for local

communities to conserve forests; and the HKH communities have demonstrated that they can manage forests to sequestrate carbon for the benefit of the globe while maintaining the local benefits (Karky 2013).

Transforming agriculture

Addressing the challenges of climate change also offers opportunities for transforming agriculture using a forward looking perspective to develop new management approaches. Farmers in the HKH have already developed a range of adaptation and coping strategies in response to changes in water availability (Pradhan et al. 2012; Reid and Schipper 2014). They include crop management approaches such as changes in crop rotation and mixed cropping to reduce the risk of crop failure and susceptibility to pests; and adjusting crop timing, for example delaying or early sowing of crops according to shifts in rainfall patterns and changes in the onset of the monsoon. In some areas, farmers have selected drought resistant or other appropriate types of seed, or are planting new crops to take advantage of a more favourable climate. Other strategies include water storage, and careful use of agricultural water, for example through drip irrigation, or changing to crops with a lower water demand (Pradhan et al. 2015).

Building on traditional knowledge and utilizing genetic resources

People across the HKH have adapted to a huge range of climatic conditions, from wet to dry and hot to cold, and different slopes and soil types. If climatic conditions in one location in the HKH change, it is likely thatsolutions are to be found among peopleliving somewhere else with similar conditions. The key is to recognize this tremendous knowledge base, and promote knowledge sharing amongst communities. At the same time the indigenous and agricultural biodiversity resources of the region represent a huge genetic resource with vast numbers of genes related to adaptation to extreme conditions that may prove useful for future adaptation. There is an urgent need to find ways to conserve both the biodiversity and the traditional knowledge for use by future generations; which means providing incentives to communities. Mechanisms for benefit sharing from genetic resources and traditional knowledge provide scope to do this, but they require a good policy and institutional environment.

Mountain specific policies

Food security cannot be achieved without enhancing livelihood options, and the livelihoods of poor communities cannot be improved unless productive resources – such as water, land, forests, rangelands, biodiversity, and the natural environment – are conserved and communities' access to and use of ecosystem services are ensured. Mountain environments and social systems have specific characteristics that cannot be addressed using generic solutions appropriate for and tested in plains areas, and it is important to develop mountain specific policies to address mountain issues. However, to develop such mountain specific polices requires mountain specific knowledge.

Building the evidence base – seeking the truth

Unfortunately we do not have an adequate evidence base for the HKH to properly support the development of new policies and practices. And the lack of reliable evidence continues to fuel controversies about glaciers, hydropower, and forests. The first step in building a firm evidence base for decisions is to make strides to fill in knowledge gaps, also an important first step in 'seeking the truth'. The IPCC's Fourth Assessment Report (IPCC 2007) showed the HKH as a white spot with inadequate data. Since then considerable efforts have been made across the region to fill the gap, although much remains to be done. For example, much progress has been made in the field of the cryosphere, with increasing knowledge about the state and fate of glaciers and the

impacts of climate change (e.g. Bajracharya and Shrestha 2011; Lutz et al. 2014; Shea 2015). ICIMOD's transect approach, and vulnerability analysis has added a considerable amount of information about both society and ecosystems (e.g. Macchiet al. 2014; Gerlitzet al. 2014; Chettri et al. 2015).

Obtaining enough data and information about remote regions in the HKH presents its own challenges, yet making enough sense of the information to provide information for policy and practice requires a special kind of science. Combining the multiple interacting socio-ecological drivers of change with the immense diversity on the ground requires science that transcends disciplinary borders. We need science that directly addresses mountain problems, that simultaneously addresses ecological and social issues, that values traditional knowledge, and that informs policy. We need to actively ensure that the science connects practitioners in the field with policy makers, and supports both. This is challenging, yet scientists and researchers need to be oriented in this direction.

Regional cooperation

The mountain areas of the HKH region often have more in common with each other than with their plains counterparts in their own countries. A collaborative, regional response is needed both to address cross boundary issues and to maximize the use of available information and knowledge. Cooperation is required to deal with glacier melt and the increased threat of floods that cross borders, as well as for biodiversity conservation and management. Recognizing this, India's 'National Action Plan for Climate Change' – released by the Prime Minister in 2008 – identified eight national missions, including one on 'Sustaining the Himalayan Ecosystem' which identified opportunities for collaboration with neighbouring countries to address pressing climate change issues. We are glad to see GBPIHED taking a lead role on the Himalayan Mission of the Climate Action Plan.

National, regional, and global engagement for mountains

Mountain people cannot afford to maintain ecosystem services that benefit the plains at the cost of their own survival. Global, regional, and national mechanisms need to be developed that recognize and compensate mountain communities for their contribution to maintaining ecosystem services that have national, regional, and global benefits, whilst ensuring development of the mountain economy. Policies need to provide incentives to mountain communities to conserve the natural resources and enhance the provision of ecosystem services, whilst encouraging investment in such areas as ecotourism and development, processing, and marketing of niche products to improve economic returns. Examples of such approaches include specialized subsidies for mountain areas, payments for ecosystem services (PES) in the form of compensation to watershed communities for improved watershed management and wetland services, and payments for reducing emissions from deforestation and forest degradation (REDD+) as a contribution to mitigation.

The Role of ICIMOD

The International Centre for Integrated Mountain Development (ICIMOD) is a regional intergovernmental learning and knowledge sharing centre serving the eight regional member countries of the Hindu Kush Himalayan (HKH) region – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. Mountains are important global ecosystems facing especially rapid socioeconomic and environmental changes, particularly the impacts of climate change. Our aim is to influence policy and practices to meet environmental and livelihood challenges emerging in the HKH region. To do this we bring together researchers, practitioners, and policy makers from the region and around the globe to generate and share knowledge, support evidence-

based decision making, and encourage regional collaboration. ICIMOD delivers impact through its six regional programmes of Adaptation to Change, Transboundary Landscapes, River Basins, Cryosphere and Atmosphere, Mountain Environment Regional Information System, and Himalayan University Consortium (emerging). These regional programmes are supported by the four thematic areas of Livelihoods, Ecosystem Services, Water and Air, and Geospatial Solutions, underpinned by Knowledge Management and Communication. ICIMOD seeks to improve the lives and livelihoods of mountain women and men, now and for the future.

As an intergovernmental learning and knowledge sharing centre, ICIMOD is working with its regional member countries to help develop policies and practices that meet the emerging environmental and livelihood challenges. Many of these activities contribute to increased understanding of climate change and its impacts, as well enhancing adaptation and resilience. In recent years, ICIMOD has taken strides together with G. B. Pant Institute of Himalayan Environment and other partners to

- address new and changing issues in the HKH to assist in adaptation and transformation;
- fill its regional mandate as an intergovernmental organization, working across boundaries to co-generate knowledge with partners from different countries, and to share this knowledge;
- promote development of more information and more integrated and transdisciplinary science to fill key knowledge gaps and inform policy and practice;
- work in close partnership with governments and organizations in regional member countries to enhance learning, capacity building, and implementation;
- develop and outscale innovative approaches for conservation and development of mountain ecosystems;
- critically evaluate knowledge through a comprehensive assessment of the HKH, bringing scientists and science to address issues of relevance to mountains;
- engage the youth to become mountain champions, and develop a Himalayan University Consortium to develop a cadre of mountain scholar leaders who can lead the change; and
- use innovative communication means, like the proposed Climate + Change exhibition in the Indian Himalayan Region, to share scientific evidence and create awareness for informed action at multiple levels.

Conclusion

Climate change, compounded by a range of other socio-ecological changes – climate plus change – is profoundly reshaping mountain societies. We already witness the impact of these drivers of change in mountain societies and environments, from migration to loss of habitats, to degradation of traditional knowledge. On the other hand, change brings opportunities, and there are many means to meet the dual goals of mountain ecosystem conservation plus mountain development that can both address vulnerabilities and transform mountain societies – as outlined in this paper. This will require better knowledge and evidence, and more cooperation in the HKH region between upstream and downstream people, as well as working across borders. It will require new kinds of transdisciplinary research to seek the truth and bring this to policy makers and practitioners.

While championing the cause of mountain communities, Pandit Pant was at the forefront of effecting people centric changes, including community-based forest management. The van panchayats established in the early 1930s in Uttarakhand are a vivid testimony to such far-sightedness, and an indicator of what can be

achieved with right mind set. A vital message is to focus on mountain people, who ultimately are the caretakers of the vital mountain resources. Mountains are often viewed simply as the source of resources for people downstream, and mountain people are often marginalized in decision making. The result is that benefit flows and development often bypass the mountain people, and they are not able to maintain the resources optimally. For a sustainable future and a healthy mountain environment, investing and sharing benefits with mountain people will pay enormous returns.

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Notes

G.B. Pant Memorial Lectures

I
Dr. M.S. Swaminathan, Director, CRSARD, Madras – 1991

II
Dr. T.N. Khoshoo, Jawaharlal Nehru Fellow, TERI, New Delhi – 1992

III
Mr. V. Rajagopalan, Vice President, World Bank, Washington – 1993

IV
Prof. U.R. Rao, Member, Space Commission, New Delhi – 1994

V
Dr. S.Z. Qasim, Member, Planning Commission, New Delhi – 1995

VI
Prof. S.K. Joshi, Vikram Sarabhai Professor, JNCASR, Bangalore – 1996

VII
Prof. K.S. Valdiya, Bhatnagar Research Professor, JNCASR, Bangalore – 1997

VIII
Prof. Vinod K. Gaur, Distinguished Professor, IIA, Bangalore – 1998

IX
Prof. H.Y. Mohan Ram, INSA Senior Scientist, University of Delhi, New Delhi – 2000

X
Prof. J.S. Singh, Emeritus Professor, BHU, Varanasi – 2004

XI
Prof. Madhav Gadgil, Centre for Ecological Sciences, IISc, Bangalore – 2005

XII
Dr. S.S. Handa, Ex-Director, RRL (CSIR), Jammu – 2006

XIII
Dr. Lalji Singh, Director, CCMB, Hyderabad – 2007

XIV
Prof. Roddam Narasimha, Chairman, EMU, JNCASR, Bangalore – 2008

XV
Dr. R.S. Tolia, Chief Information Commissioner, Govt. Of Uttarakhand, Dehradun – 2009

XVI
Prof. Raghavendra Gadagkar, CES & CCS, IISc, Bangalore – 2010

XVII
Prof. Vidyanand Nanjundiah, IISc, Bangalore – 2011

XVIII
Dr. Kirit S Parikh, Chairman, Expert Group for LCSIG, Planning Commission, GoI– 2012

XIX
Prof. Jayanta Bandyopadhyay, Advisor, Water Diplomacy Programme, Fletcher School of Diplomacy, Tufts University, USA – 2013

XX
Prof. T.S. Papola, Honorary Professor, Institute for Studies in Industrial Development (ISID), New Delhi