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Managing Ecosystem Services for Enhancing Climate Change Adaptation in the Hindu Kush Himalayas

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INTRODUCTION

Ecosystem services are benefits people derive from ecosystems, which include provisioning services (food and water); regulating services (regulation of floods, drought, land degradation, and disease); supporting services (soil formation and nutrient cycling); cultural services (recreational, spiritual or religious); and other non-material benefits (MA 2005). These services are critical to the functioning of the Earth's life support system that contributes to human welfare, both directly and indirectly, representing part of the total economic value of the planet (Costanza et al. 1997). Dynamic ecosystems and their services are intricately linked to human wellbeing and are linked with various drivers of change, such as excessive demands from a growing population, land use and cover change, and climate change to name a few, leading to biodiversity loss (SCBD 2010). The Millennium Ecosystem Assessment (MA) documented the importance of ecosystem services to human wellbeing and showed that continued supply of these services is threatened by unsustainable anthropogenic activities (MA 2005).

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Approximately 60% of the ecosystem services examined during the MA are being degraded or used unsustainably including food, freshwater, air and water purification, and the regulation of regional and local climate and natural hazards. As a result, the focus has been gradually widening from biodiversity conservation to management and sustenance of the ecosystems for adaptation to change on which are dependent for goods and services (TEEB 2010).

The Hindu Kush-Himalayas (HKH) is one of the most dynamic ecosystems in the world with a rich and remarkable biodiversity (Pei 1995, Guangwei 2002, Chettri et al. 2008a). Stretched over more than four million square kilometers, the HKH includes Bhutan and Nepal in their entirety and parts of six other countries: Afghanistan, Bangladesh, China, India, Myanmar and Pakistan. The region is endowed with a high level of endemism, diverse gene pools, species and ecosystems of global importance (Mittermeier et al. 2004). Numerous critical ecoregions of global importance can be found in this region (Olson and Dinerstein 2002). As a result, the HKH have been highlighted in many global conservation prioritization strategies (see Brooks et al. 2006). In terms of species diversity, the region is equally rich in flora and fauna (Chettri et al. 2008b, Chettri et al. 2010). It is a home to all four big cats of Asia: the snow leopard (*Uncia uncia*), tiger (*Panthera tigris*), common leopard (*Panthera pardus*), and clouded leopard (*Neofelis nebulosa*). Ungulates, a number of which are endemic, such as the Tibetan wild ass (*Equus kiang*), wild yak (*Bos grunniens*), Chiru (*Pantholops hodgsoni*), and Tibetan gazelle (*Procapra picticaudata*) are of special significance (Chettri et al. 2011).

This complex and fragile ecosystem with extreme heterogeneity in micro environments helps to stabilize headwaters, preventing flooding, and maintain steady year-round flows of ecosystem goods and services (Xu et al. 2009). These functions contribute to one third of the humanity for their wellbeing far beyond the immediate vicinity, benefiting entire river basins. As a result, the HKH have often been referred to as 'natural water towers' because they contain the headwaters of rivers, which are vital for maintaining human life in the densely populated areas downstream (Schild 2008). In addition, the HKH also represents a unique source of freshwater for agricultural, industrial and domestic use, and are an important economic component of tourism and hydro-electric power production and maintains water quality, regulates water flow (floods and droughts), and supports biodiversity (Trisal and Kumar 2008, Eriksson et al. 2009, Xu et al. 2009, Rasul et al. 2011). The region also plays an important role in mitigating the impacts of climate change by acting as carbon sinks (ICIMOD 2009, Trisal and Kumar 2008).

However, this diverse ecosystem of the HKH is facing overarching threats from various drivers of changes including climate change (Myers et al. 2000, Pandit et al. 2007, Xu et al. 2009, Singh et al. 2011). The ecosystems in the HKH are degrading mainly due to lack of incentive provisions for maintaining ecosystems and the goods and services provided by them. This is leading to development that is unsustainable including loss of biodiversity. Even the protected areas such as national parks, nature reserves and wildlife sanctuaries face tremendous pressures from external driving forces and communities living inside and outside (Sharma and Yonzon 2005). It is a paradox that in spite of being rich in biodiversity the region is also home to poorest of the world and the most vulnerable in the face of climate change (Chettri et al. 2010, Singh et al. 2011). So, there is a mounting challenge to balance conservation with development in the region. This chapter is an attempt to document the reconciling initiatives on maintaining ecosystem resilience through integrated conservation and development initiatives to address prevailing climate change challenges faced by the region with some evolving regional experiences.

Ecosystem Diversity, Their Services and Human Wellbeing

The ecosystems of the HKH are inherent component of the culture, landscape and environment of this high mountain area of Asia. Elevation zones across the HKH extend from tropical (>500 meters above sea level) to alpine ice snow (>6,000 meters above sea level), with a principal vertical vegetation regime composed of tropical and subtropical rainforest, temperate broadleaf deciduous or mixed forest, and temperate coniferous forest, including high altitude cold shrub or steppe and cold desert (Guangwei 2002, Pei 1995). The dominant vegetation types such as forests and rangelands have multiple functions: they harbor biodiversity, anchor soil and water, provide carbon sinks, regulate climate, and temper stream flow. Likewise the wetland ecosystems, which are the transitional ecosystems between terrestrial and aquatic habitats encompassing water, soil and organisms, supports rich agricultural and wild biodiversity as well as provides environmental services such as food, flood regulation, nutrient and sediment retention, maintenance of groundwater table and so on, that in turn, become valuable benefits to the society. They are also habitat for a wide variety of birds, mammals, reptiles, amphibians, fish and invertebrate species. They are sometimes described as 'the kidneys of the landscapes' because of the functions they perform in hydrologic and chemical cycles and as a store house of carbon as a result in the form of peat lands.

The HKH is characterized by five agro-climatic zones and farming practices viz. (i) specialized pastoralism (purely livestock based, high altitude transhuman subsistence livelihoods); (ii) mixed mountain agro-pastoralism (livestock, agriculture, and agroforestry livelihoods based in the mid hills); (iii) cereal based hill farming systems (agriculture based livelihoods in the low and mid hill areas); (iv) shifting cultivation (livelihoods based on rotational agroforestry with slash and burn practices); and (v) specialized commercial systems (livelihoods based on monoculture and other commercial crops). In each of these specialized zones there is a variation in crops and cropping patterns that supports a wide range of agrobiodiversity, which is the source of food, nutrients, and economic prosperity for the region (Sharma and Kerkhoff 2004). Among these farming systems, specialized pastoralism is one of the oldest and the most predominant systems in the HKH. Some of the well known pastoral communities found in the Himalayas are *Bakrawals*, *Gujjars*, *Gaddis*, *Kanets*, *Bhotias*, *Kaulis*, and *Kinnauras* of the North Indian Himalayas; *Bhotias* and *Sherpas* of the Khumbu valley of Nepal; the *Kirats* of eastern Nepal; *Lachungpas* and *Lachenpas* of Sikkim; *Changpas* of Ladakh; *Brokpas* of Bhutan; *Tibetans* of China; and the *Shimshal* of Pakistan. These people's age-old dependence on the high pastures and livestock products is embedded in their culture and practices, and governed by traditional knowledge and natural resources governance mechanisms (Chettri et al. 2012).

Ecosystems are capital assets of the HKH that provide a wide range of services. These include supporting services that maintain the conditions for life; provisioning services that provide direct inputs to livelihoods and the economy; regulating services such as those that provide flood and disease control; cultural services that provide opportunities for recreation, spiritual or historical sites; and supporting services that sustain and fulfill human life (MA 2005). The region supports 10 major river basins: the Indus, Ganges, Amu Darya, Brahmaputra (Yarlungtsanpo), Irrawaddy, Salween (Nu), Mekong (Lancang), Tarim, Yangtse (Jinsha), and Yellow River (Huanghe) basins (Table 9.1). Glacial melt makes an important contribution to river flow, varying from the lowest rate of 1.3% for the Yellow River to the highest rates of 40.2% for the Tarim and 44.8% for the Indus River Basin. It has been estimated that about 30% of the water resources in the eastern Himalayas are directly derived from the melt of snow and ice; this proportion increases to about 50% in the central and western Himalayas and becomes as high as 80% in the Karakoram (Xu et al. 2009). The region is also important for high altitude wetlands, source of freshwater resources, and plays an important role in water storage and regulating water regimes (Trisal and Kumar 2008). These regions also play an important role in mitigating the impacts of climate change by acting as carbon sinks. The peatlands on the Tibetan Plateau are one of the most important stores of carbon in the mountain region, storing 1500 to 4000 t ha^{-1} (Trisal and Kumar 2008).

During summer, the region further provides an anomalous mid-tropospheric heat source for southwestern Asia, and, thus, plays a prominent role in the Asian monsoon system (Yanai et al. 1992). Seasonal blocking episodes with associated anomalies in temperature and precipitation are

Table 9.1. The 10 major river basins in the Himalayan region.

River basins	Basin area (sq.km)	Countries	Population (x 1000)	Population density (per sq. km)
Amu Darya	534,739	Afghanistan, Tajikistan, Turkmenistan, Uzbekistan	20,855	39
Brahmaputra	651,335	China, India, Bhutan, Bangladesh	118,543	182
Ganges	1,016,124	India, Nepal, China, Bangladesh	407,466	401
Indus	1,081,718	China, India, Pakistan	178,483	165
Irrawaddy	413,710	Myanmar	32,683	79
Mekong	805,604	China, Myanmar, Laos, Thailand, Cambodia, Vietnam	57,198	71
Salween	271,914	China, Myanmar, Thailand	5,982	22
Tarim	1,152,448	Kyrgyzstan, China	8,067	7
Yangtze	1,722,193	China	368,549	214
Yellow	944,970	China	147,415	156
Total	8,594,755		1,345,241	

Source: Adapted from Eriksson et al. (2009).

also closely linked to the presence of mountains, which act as orographic barriers to the flow of moisture-bearing winds and control precipitation in neighboring regions (Manabe and Terpstra 1974, Kutzbach et al. 1993). For example, the Himalayas play an important role as a trigger mechanism for cyclogenesis through their perturbation of large-scale atmospheric flow patterns; they also act as a barrier to atmospheric circulation for both the summer monsoon and the winter westerlies. The summer monsoon dominates the climate of the region, but is longest in the eastern Himalayas, lasting five months (June–October) in Assam, four months (June–September) in the Central Himalayas, and two months (July–August) in the western Himalayas (Chalise and Khanal 2001). However, the Himalayas display a great variability in hydrometeorological conditions: the western Himalayas and north facing slopes are generally arid and dry, while the eastern Himalayas and south-facing slopes are generally humid and wet.

The livelihoods of people in the HKH are mainly based on forests, agro-forestry, wetland and rangeland resources (Chettri and Sharma 2006, Sharma et al. 2006). The long history of human presence in this ecosystem and maintenance of its fragility is a strong indicator of compatibility of satisfaction of community needs through traditional practices, with biodiversity conservation. The functioning of these systems, in which the human beings were also part of, greatly depended on surrounding ecosystem base for various goods and services. These natural resources were managed traditionally, with practices having been evolved by the local communities through trial and error over long period of time (Rai et al. 1994). Belief in Buddhism, Hinduism, and a varying blend with animistic beliefs cuts across all mountain people imparting a sense of compassion and awareness for all forms of life and the surrounding natural environment. Buddhist beliefs in 'hidden lands' or 'beyuls' (Sherpa 2003), and 'hidden treasures' or *ters* (Ramakhrishnan 1996) are often linked to the idea of conservation areas for human and nature and provide a strong organizing principle in how people relate to vast natural spaces and the biodiversity therein. Such beyuls are rich in biodiversity and often are named for dominant flora and fauna, such as the 'Beyul Khenpalung' or the 'Hidden Land of Artemisia' in Makalu Barun National Park in Nepal, and Demajong, or 'valley of rice' in Sikkim. These areas were usually marked by strict observances such as bans on hunting, mining, polluting rivers and streams, and harvesting of timber and plant resources. Transgressors were often punished through fines and other disciplinary actions. Likewise, the traditional natural resources management systems such as Dzumsa by the Pipons (village head) among the Lanchungpas in Sikkim (Rai et al. 1994), wise knowledge and sustainable natural resources use practiced among the Lepchas (Jha 2002), strong ethics for landscape level conservation among Sikkimese Buddhists (Ramakrishnan 1996), effective rangeland management by Kiratis and Limbuwans (Oli 2008) and Bhutias (Nautiyal et al. 2003) are some of the effective traditional conservation measures that address 'sustainability'. Thus, conservation was culturally enforced within many of these indigenous groups. This reveals that in the past, there was strong resilience between biological resources and the human needs. However, these practices, which are participatory and inclusive, have not been recognized by many of the national policies of the Himalayan region as effective conservation measures and are overshadowed by modern statuary strict and stringent obligations.

Potential Impact of Climate Change on Ecosystem Services

The HKH region is facing enormous pressures from an array of drivers of change including climate change (Erikson et al. 2009, Xu et al. 2009, Tse-ring et al. 2010). The region has shown consistent trends in overall warming during the past 100 years (Yao et al. 2007). Various studies suggest that warming in the HKH has been much greater than the global average of 0.74°C over the last 100 years (IPCC 2007, Du et al. 2004). For example, warming in Nepal was 0.6°C per between decades 1977 and 2000 (Shrestha et al. 1999). While the Fourth Assessment Report (4AR) of Intergovernmental Panel on Climate Change (IPCC) made a strong science-based rationale for the need for actions countering the potential ill effects of climate change globally (IPCC 2007), it also pointed out the lack of reliable data and limited data collection efforts in the HKH. It is evident that climate change in the HKH will affect all aspects of the climate, making rainfall less predictable, changing the character of seasons, and increase the risk to biodiversity (Xu et al. 2009, Chettri et al. 2010, Chettri et al. 2012). However, the impacts of climate change are not evenly distributed within the region, nor among different communities and sectors of society.

Potential impact ecosystems

Although there is no strict compartmentalization of vegetation along altitudinal gradients in the HKH region, elevation has important implications for its ecology, evolution, physiology and conservation and is highly relevant to species' composition and phenology patterns (Chettri et al. 2001, Carpenter 2005). As a result of microclimatic variations, most organisms found in the HKH are confined to specific ecosystems such as highland pastures, forests and so on. This is a special risk factor for highland species that are sensitive to climate change (Pounds et al. 2006) and more likely to be at risk of extinction. Globally, there is evidence of the shift of species towards the north in latitude (Hickling et al. 2006) or higher elevations (Wilson et al. 2007), especially for species in the transition zone between subalpine and alpine which are more vulnerable to climate change as they have limited scope for movement. Analyses for the Himalayas are few and limited to certain pockets of areas (Carpenter 2005). Observations have been made about the change in events related to plant and animal phenology and also to shifting of treelines and encroachment of woody vegetation into alpine meadows. Phenological changes, such as early budding or flowering and ripening of fruits in plants and hibernation, migration, and breeding in animals, could have adverse impacts on pollination patterns. Consequently, this may have an impact on the population of pollinators, leading to change in ecosystem productivity and species' composition in high-altitude habitats (Thuiller et al. 2008).

Potential impact species

Climate change increases the risk of extinction of species that use narrow geographic and climatic ranges but important for the ecosystem integrity (Hannah et al. 2007). According to the prevailing extinction theory, the larger and more specialized species are likely to be lost due to habitat destruction (Sodhi et al. 2004). This might be significant for the Himalayan region as habitat and forest destruction were seen to have increased although the quality of increasing and decreasing forests has not been assessed (Pandit et al. 2007). Since ecosystems in the Himalayas are layered as narrow bands along a longitudinal axis of the mountain range, they are greatly influenced and easily impacted by climatic variations. For example, the sub-tropical and temperate forests (broadleaved, coniferous, and mixed), include the tiger (*Panthera tigris*) and other members of the cat family (Felidae) which would be extremely vulnerable to climate change as would narrowly endemic taxa, such as Mishmi takin (*Budorcas taxicolor taxicolor*) and Hoolock gibbon (*Hoolock hoolock*), which are likely to face challenges to their conservation in the forests. The brow-antlered deer (*Cervus eldi*), locally known as Sangai, is endemic to the Manipur wetlands, especially Loktak Lake, and is the rarest and most localized subspecies of deer in the world.

Potential impact people's livelihood

The increasing risk for human livelihoods and wellbeing include increasing frequency and severity of extreme events such as cyclones, landslides and floods. Within the Himalayan ecosystems, the impact of these changes is often aggravated by existing environmental and socio-economic problems, such as poverty, water scarcity or food deficiency (Mertz et al. 2009). These in turn contribute to a downward-spiralling cycle with adversely impacting the livelihoods and driving people to desperate measures that decimate ecosystem services. Observational evidence indicates that the impacts related to climate warming are well underway on the Himalayas (Singh et al. 2011) and increasing threats to biodiversity and derived ecosystem goods and services (Chettri et al. 2010, Chettri et al. 2011). The poorer, more marginalized people of the high mountains are likely to suffer the earliest and the most. Given the evidence that many risks already threaten women disproportionately; and also the elderly, disabled, and indigenous groups, especially their poorer members; identifying changes in the cryosphere and alpine ecosystem most likely to affect them is of utmost importance. In addition, there are broader regional questions of which the more severe highland-to-lowland dangers relate to rapid melting events, floods caused by natural dam bursts, increased sedimentation, and droughts caused by reduced or changed flow patterns.

Potential and Evolving Adaptation Strategies

In the HKH, the classical approach of biodiversity conservation started with emphasis on the flagship species conservation. The assumption was that if the flagship species, which usually occupied the tip of the pyramid in the food web in an ecosystem, flourished, then the ecosystem was considered healthy. However, the approach changed significantly from species focused conservation to landscape level within last three decades (Sharma et al. 2010). As of 2007, there were 488 protected areas (IUCN category I–VI) within the region, covering more than 1.6 million km^2, representing about 39% of the region's terrestrial area (Chettri et al. 2008a). Interestingly, the proportion of terrestrial area covered by the protected areas in the region is much higher (39%) than in Central America (26%) (Chape et al. 2005). Such growth in the number and areas of protected areas is a significant achievement on the part of the region countries towards fulfilling their global commitment to conservation. Interestingly, the analysis showed that the protected areas in the HKH have adopted a shift away from strictly managed protected area systems to community based, as also observed by Zimmerer et al. (2004).

Several recent initiatives in the region offer significant opportunities for advancing and piloting innovative and regionally appropriate conservation and adaptation approaches. In particular, the importance of biodiversity conservation in protected areas, corridors and transboundary landscapes focussing on climate resilience by maintaining ecosystem integrity for enhancing flow of environmental goods and services have been the thrust for ICIMOD since last one decade. Here are some examples on the reconciling initiatives piloted by ICIMOD in the HKH.

Landscape/ecosystem approach in biodiversity conservation

Landscape/Ecosystem approach in biodiversity conservation is an evolving concept (Worboys et al. 2010). The concept has emerged primarily out of recognition that strict protection through a network of protected areas (e.g., national parks, sanctuaries, wildlife reserves) is an essential but insufficient biodiversity conservation strategy (Naughton-Treves et al. 2005, Ervin 2011). These researchers and others argue that protected areas are essential as these are the places where biodiversity conservation is the primary objective. However, many of the existing protected areas are too small to meet the ecological needs of viable population of wide ranging species in the changing climate (Ibisch et al. 2010). Thus, more than preserving isolated patches of sustained wilderness in the form of protected areas, the focus is now more on the necessity of maintaining landscape integrity, of viewing and conserving ecosystems as part of larger agro-ecological and socio-cultural landscapes to withstand the challenges posed by climate change (Worboys et al. 2010).

Application of landscape or ecosystem approach, as advocated by the Convention on Biological Diversity (CBD), recognizes the need of increased regional cooperation, in part due to the biophysical nature of these mountainous areas, the extreme heterogeneity of the region, inter-linkages between biomes, habitats and sectors, and the strong upstream –downstream linkages related to the provisioning of ecosystem services.

Seven critical 'Transboundary Landscapes' have been identified by ICIMOD (Fig. 9.1), highlighting the crucial role of improved cooperation amongst the countries of the region to enhance understanding the value of biodiversity and the potential impacts of environmental change on ecosystem goods and services. In these initiatives, ICIMOD is promoting transboundary cooperation for research and long term monitoring on both ecological and environmental aspects at a landscape level and piloted in a number of transboundary landscapes since late 1990s (see Sherpa et al. 2003, Sharma and Chettri 2005, Sharma et al. 2007, Zomer et al. 2010).

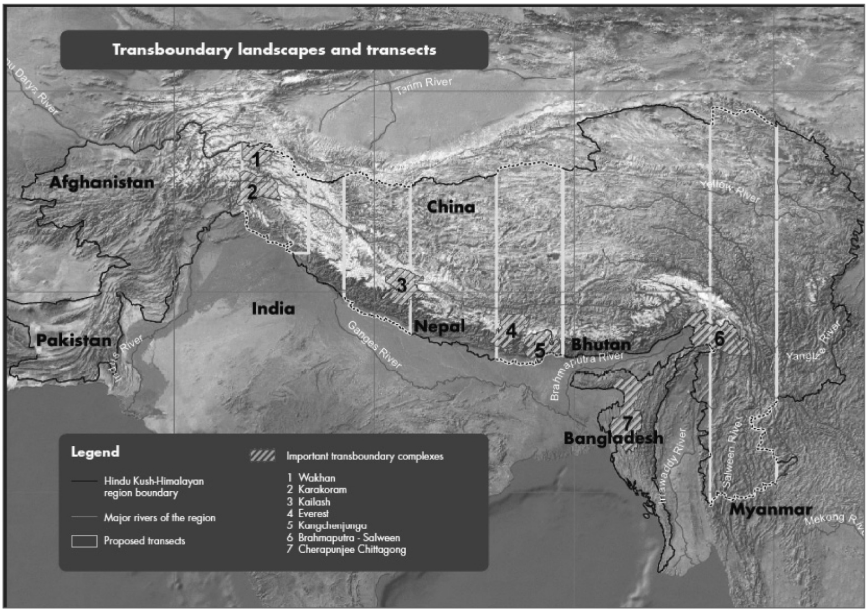

Figure 9.1. Map showing transbounday landscapes and transects in the HKH.

Color image of this figure appears in the color plate section at the end of the book.

Trans-Himalayan Transect approach

Climatic, environmental and other change processes across the HKH have both regional and global concerns (Messerli 2009). Nevertheless, the HKH is one of least scientifically studied or monitored areas in the world, and a 'data-deficit' region (IPCC 2007). Basic hydro-meteorological data are lacking, sparse or not readily available. This is true for other environmental data, e.g., biodiversity, land-use and land cover change, climate change impacts on various ecosystem goods and services, and carbon cycles. An improved understanding of these regional change processes is essential to provide the basis for informed decision making, risk and vulnerability mapping, adaptation and mitigation strategies and effective biodiversity conservation and management. ICIMOD, being an intergovernmental regional center, is working in the eight countries of the HKH and has been active in facilitating its regional member countries through various conservation and development approaches. The 'HKH Trans-Himalayan Transect', an approach to address the information gaps across the HKH, was conceptualized and discussed among global and regional stakeholders in 2008 (Chettri et al. 2009). Four 'transects' have been proposed considering representation from west to east, dry to wet and the south to north latitudinal expanse of the HKH region (Fig. 9.1). As indicated above, additionally, seven Transboundary Landscapes provide an initial opportunity for piloting of the concept and activities including a range of environmental monitoring and the initiation of long-term ecological and environmental research. The geographically defined 'transects' allow for co-locating research, monitoring and sampling sites, in-depth studies, and action research projects across the region, and for both comparative research and synergistic efficiencies. ICIMOD envisaged playing a facilitating role amongst the regional, national and local partners, and the global research community and other stakeholders through participatory and consultative processes encouraging regional cooperation and national ownership. On an experimental basis ICIMOD has initiated a number of pilot programs (Box 9.1).

Box 9.1. The Kailash Sacred Landscape Conservation Initiative (KSLCI).

Piloting the concept, ICIMOD has been engaged in partnership with UNEP, GTZ, and member countries in the Kailash Sacred Landscape. This transboundary landscape includes an area of the remote southwestern portion of the Tibetan Autonomous Region of China, and adjacent parts of northwestern Nepal, and northern India, and is comprised of a broad array of bioclimatic zones, rich natural and cultural resources, and a wide range of forest types. The initiative engages regional, national and local stakeholders in a consultative process for facilitation of transboundary, integrated approaches to sustainable development and conservation. Ecosystem management is promoted through the Regional Cooperation Framework development process, based upon a Conservation Strategy, supported by a Comprehensive Environmental Monitoring Plan, to address threats to the environmental and cultural integrity of this area, analyze change processes, and to develop a knowledge base upon which to build regional cooperation.

Zomer et al. 2010.

Valuation and rewarding ecosystem service providers

Humans benefit from biodiversity rich areas with the provision of ecological services such as climate regulation, soil formation and nutrient cycling; and from the direct harvest of biodiversity for food, fuel, fibers and pharmaceuticals. In the face of increasing human pressures on the environmental change, these benefits could act as powerful incentives to conserve nature (MA 2005), yet evaluating them has proved difficult because they are mostly not captured by conventional, market-based economic activity and analysis (Rasul et al. 2011). In the recent years, a new generation of conservation approaches with economic dimensions is rapidly emerging. They differ from traditional approaches in three critical and interrelated ways: a) they emphasize human-dominated landscapes; b) focus on ecosystem services, and c) utilize innovative finance mechanisms. Such concerns have moved beyond the science community to the global stakeholder and policy makers with the publication of the Millennium Assessment (MA 2005). The analysis acknowledges that biodiversity plays a significant role in directly providing goods and services as well as regulating and modulating ecosystem properties that underpin the delivery of ecosystem services. To rationalize the conservation value of biodiversity and the derived goods and services in the landscapes, ICIMOD developed an assessment framework paper (Rasul et al. 2011) and also identify and even quantify the ecosystems goods and services provided by conservation corridors (Pant et al. 2012). The economic benefits generated by the flow of selective forest ecosystem services in the three districts was around NPR 8.9 billion per annum (approximately US$ 125 million) equivalent to NPR 30,000 per ha/per year. Almost 80% of the total benefits (NPR 7.01 billion per annum or approximately US$ 98 million) was from provisioning services, i.e., goods from the forests used directly or indirectly. The average benefit per household from ecosystem services was estimated to be NPR 60,144 per year. The value of carbon sequestration services was also considerable at NPR 1.65 billion annually, close to 18% of the total value of the ecosystem services (see Pant et al. 2012). The study was important in terms of reconciling conservation and climate change as it rationalizes the need for enhancing ecological resilience through conservation intervention. Such studies have been replicated in other critical ecosystems such as Koshi Tappu Wildlife Reserve in Nepal (ICIMOD and MoFSC/GoN 2014) and Phobjikha Conservation Area of Bhutan (ICIMOD and RSPN 2014).

Ecosystem Resilience and Community Adaptation Opportunities

While acknowledging the significant diversity of ecosystems in the HKH region and the existence of a fair understanding of the important drivers of change, it is recognized that concerted efforts are needed to monitor and research the impacts of climate change on biodiversity. During the course of ICIMOD's learning, four priority thematic areas were identified to strengthen the reconciling process.

Long-term consistent monitoring of both climate change and biodiversity

The importance and need for establishing long-term, consistent monitoring of climate change and its impact on ecosystems and people's livelihoods have been clearly realized. Permanent plots and/or units need to be established on an altitudinal transect spanning the tropics to the alpine regions in order to monitor diverse ecosystems. An institutionalized monitoring system, however, requires standardization of monitoring parameters. In this respect a consistent, uniform methodology and a network of collaborative efforts to collect and analyze data and information regularly was made a prerequisite. Realizing the need for a facilitating institution at a regional level, ICIMOD has taken on the role by consensus. Academic and research institutions need to be engaged to establish and maintain the permanent research plots, carry out the regular monitoring and generate and analyze the data. The involvement of communities in the respective areas was seen to be critical in maintaining the plots, in participatory action research and in carrying out observations and sharing perceptions.

Focussed research on impacts, coping mechanisms and adaptation to climate change

Documentation on impacts is, as yet, anecdotal for the most part—there is a need, therefore, to document impacts as well as coping mechanisms of communities to change systematically. The most promising indicators seem to be agro-biodiversity, followed by other forms of biodiversity (both flora and fauna). Documentation of changes in crops and their performance and coping mechanisms of communities, focussing on changes in cropping patterns, crop shifts and cropping system management should be carried out on a priority basis. One important aspect requiring documentation and monitoring is the changes in nutritive value of crops as a result of the impacts of climate change. Systematic documentation and monitoring, however, will need a framework of institutional support and re-orientation of existing government research programs and institutions in regard to adaptive research.

Assessment of critical habitat linkages, protected area effectiveness, ecological and social vulnerabilities

In addition to the functional responses of existing protected areas to climate change (which could provide critical information about responses of natural systems to change and hence provide benchmark parameters), new critical habitats and the necessity for linkages of such habitats to existing ones need identifying. Existing protected areas will require constant monitoring to document changes in vegetation, identification, and census of indicative species (to monitor population dynamics as a function of changing climate impacts). The effectiveness of protected area management will have to be central to all research and feed into evolving responsive management approaches and technologies. Findings and conclusions from the above should provide insight into adaptive responses and into resilience of natural systems; and these will become critical elements in evolving decision-support systems and hence require priority. Research on institutional frameworks and their effectiveness in governance and assessments of good practices with examples of community-led conservation have to be central to formulation of an effective and responsive governance system. Strong emphasis has to be placed on indigenous knowledge systems, particularly in regard to natural resource management approaches and institutional frameworks, drawing upon traditional practices of management and governance especially in regard to sacred landscapes.

Policy analysis on climate change, adaptation and coping mechanisms; and relevant adjustments to existing policies

In order to support and strengthen community efforts to cope with change, an enabling policy environment is essential. Documentation and assessments indicate the need for policy dialogues focussing on areas identified. Policy dialogues would need to focus on areas where adjustments in existing policies are required, particularly in regard to economic benefits, governance frameworks, and local-level policy adjustments. A clear concern was the multiplicity of policy actors governing natural resource management and livelihood support and the need for convergence of different (often conflicting) policies under one forum for ease of implementation. Dialogues need to focus on this required convergence before moving on to sectoral details. There is a critical role for scientific institutions in regard to policy formulation concerning natural resource management, livelihood support and climate change. Policy makers require authentic data inputs and, more often than not, these are not available or not in a comprehensible form. Scientific institutions need to fill this gap so that policy making can be based on scientific findings.

Conclusion

Ecosystem services are benefits people derive from ecosystems. These services are critical to the functioning of the Earth's life support system and are intricately linked to human wellbeing. However, they are witnessing growing pressure increasing human population, land use and cover change, and climate change to name a few. The Hindu Kush Himalayas, with a complex and fragile ecosystem maintain steady year-round flows of ecosystem goods and services to one third of the humanity for their wellbeing far beyond the immediate vicinity, benefiting entire river basins. However, this diverse ecosystem of the HKH is facing overarching threats from various drivers of changes including climate change. Even the protected areas such as national parks, nature reserves and wildlife sanctuaries face tremendous pressures from external driving forces and communities living inside and outside. The most pressuring challenge faced by these protected areas is from the prevailing climate change.

The member countries sharing the Hindu Kush Himalayas are progressing towards adaptive measures through innovative and regionally appropriate conservation and adaptation approaches. In particular, the importance biodiversity conservation in protected areas, corridors and transboundary landscapes focussing on climate resilience by maintaining ecosystem integrity for enhancing flow of environmental goods and services have been the thrust for the region. As a regional knowledge development and learning center, ICIMOD is committed to strengthen the existing research network in the HKH and also facilitate data sharing mechanisms. In 2008, a framework on 'HKH Transboundary Landscapes and Trans-Himalayan Transect' was developed with the technical inputs from the recognized mountain experts with an objective to promote transboundary collaboration among the countries and filling the data deficit issue through seven representative landscapes across the gradients of precipitation, altitude and latitude. Since 2008, ICIMOD and its regional member counties have made significant progress in mainstreaming this Framework within ICIMOD through implementation of Transboundary Landscape Programme.

The need for biodiversity conservation has been rationalized by valuation of ecosystems services provided by various ecosystems, both inside and outside the protected areas. One of the studies showed that around NPR 8.9 billion per annum (approximately US$ 125 million) equivalent to NPR 30,000 per ha/per year worth of services are used by local communities from the forested ecosystem of which 80% of the total benefits (NPR 7.01 billion per annum or approximately US$ 98 million) was from provisioning services, i.e., goods from the forests used directly or indirectly. The average benefit per household from ecosystem services was estimated to be NPR 60,144 per year. The study was important in terms of reconciling conservation and climate change as it rationalizes the need for enhancing ecological resilience through conservation intervention.

The importance and need for establishing long-term, consistent monitoring of climate change and its impact on ecosystems and people's livelihoods have been clearly realized and the functional responses of existing protected areas to climate change and the effectiveness of protected area through policy analysis considering the contemporary challenges from climatic change and provision for adaptation and coping strategies were felt necessary.

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