5 Sustaining Biodiversity and Ecosystem Services in the Hindu Kush Himalaya

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Chapter Overview

Key Findings

1. **The mountain ecosystems of the Hindu Kush Himalaya (HKH) are diverse with one of the highest diversity of flora and fauna providing varied ecosystem services to one fourth of humanity**. With four out of 36 global biodiversity hotspots the HKH is a cradle for 35,000+ species of plants and 200+ species of animals. At least 353 new species—242 plants, 16 amphibians, 16 reptiles, 14 fish, two birds, and two mammals, and at least 61 invertebrates—have been discovered in the Eastern Himalaya between 1998 and 2008, equating to an average of 35 new species finds every year.
2. **The HKH has numerous seeds of good practices in conservation and restoration of degraded habitat along with community development which need upscaling and out scaling**. These participatory and community-based approaches have had large ecological, economic, and social positive impacts. Substantial degraded forest areas are regenerating, as decentralized practices reverse deforestation trends. Local communities have gained institutional space to decide for themselves

on issues related to forests, income, inclusion, and social justice.

3. **Global and regional drivers of change on biodiversity and ecosystem loss are prevalent and increasing in the HKH.** These drivers include land use and land cover change, pollution, climate change, invasive species, solid waste, habitat degradation, and overexploitation of resources, among others, impacting biodiversity, ecosystem services, and human wellbeing.

Policy Messages

1. **Regional efforts will enhance the resilience of HKH ecosystems to extreme events while conserving biodiversity and promoting sustainable development.** Climate change and other drivers are altering the structure and population of some HKH ecosystems and species, including their distribution range, with risks to biodiversity and resilience. Because many of these critical HKH ecosystems are transnational, regional cooperation is essential for translating conservation and development challenges into sustainable development opportunities. Attaining the Sustainable Development Goals (SDGs) will depend on such cooperation.
2. **The mountain ecosystems of the HKH need an integrated and transboundary ecosystem approach at the landscape scale for conservation and sustainable development.** It should be managed as a mosaic of integrated socio-ecological systems across political boundaries. Efforts are needed to build on existing traditional practices, promote regional cooperation, and increase national and global investments.
3. **Investments in mountain ecosystems should be made where they are most needed to conserve biodiversity, alleviate poverty, and enhance sustainable livelihoods**. A large population in the HKH region still lives in poverty and is highly dependent on ecosystem services for livelihoods, especially in remote areas and developing nations. Because of varying priorities and resource availability, HKH countries are at different levels of investment in managing the mountain ecosystems. Therefore, more investment should be set aside for enhancing resilience with win-win trade-offs in the remote areas and developing countries.

Mountains make up 24% of the world's land area, are home to 20% of the world's population, provide 60–80% of the world's fresh water, and harbour 50% of the world's biodiversity hotspots (***well-established***). The United Nations recognized the importance of mountain ecosystems, both for conserving biological diversity and for sustaining humanity, in Chap. 13 of Agenda 21. More generally, ecosystem diversity, species diversity, genetic diversity, and functional diversity all play key roles in the ecosystem services that benefit people and communities (***well-established***).

All these types of diversity are fundamental for the mountains of the HKH. With its unique high mountains and numerous micro climates, the HKH contains varied ecological gradients that set the stage for species evolution. The result is the youngest global mountain biome and one of the most ecologically diverse ecosystems in the world (***well-established***). Between 1998 and 2008, an average of 35 new species were discovered each year in the Eastern Himalaya alone (***well-established***).

The ecological diversity of the HKH has long been modified by extraction, trade, culture, and land use (***established but incomplete***). Of the region's population, 70–80% live in rural areas, while 60–85% subsist directly through ecosystem services (***well-established***). Now, however, the region is being subjected to pressures that are more aggressively unfriendly to ecosystems. Climate change is one of these pressures; unprecedented development is another (***established but incomplete***).

Global and regional drivers of biodiversity loss—such as land use change and habitat loss, pollution, climate change, and invasive alien species—are prevalent and increasing in the HKH (***established but incomplete***). For example, by the year 2100 the Indian Himalaya could see nearly a quarter of its endemic species wiped out (***inconclusive***). Countries in the region already place a premium on functional ecosystems and ecosystem services: more than 39% of all land in the HKH lies within a protected area network (***well-established***). Even so, ecosystems are in stress or subject to risks from a changing climate, from varying government policies, and from expanding markets—at all levels (***established but incomplete***).

Broadly, ecosystem services have four kinds of value:

- Social—for public benefit
- Cultural—for aesthetic and communal significance
- Ecological—for environmental conservation and sustainability
- Economic—for livelihoods through goods and services production.

We generally know less about social and cultural value in the HKH than about ecological and economic value (***established but incomplete***). All four kinds of value, however, have received little attention—either qualitative or quantitative—compared with such widely researched topics in the region as carbon, water, and hydropower (***well-established***). For example, recreation is a growing principal livelihood activity in the Himalaya. Some analyses acknowledge the positive economic gains, but also negative impacts on biodiversity and ecosystem services (***established but incomplete***). However, many of these studies focus on a small area and lack the holistic view needed to inform policy decisions (***well-established***).

Better management of HKH ecosystem services entails learning more about the state and trends of coupled socio-ecological systems. The diverse landscapes of the region provide multiple services with complex, dynamic interrelations. Some studies based on integrated systems analysis (most emerging from hydrology and geology) have traced upstream-downstream links at both the catchment and the basin scale. Common drivers, affecting multiple ecosystem processes and interactions among ecosystem services, can create both synergies and trade-offs between ecosystem health and the flow of services (***established but incomplete***). Trade-off analysis is thus critical for integrating ecosystem services into landscape planning, management, and decision making—especially in looking at alternate paths to sustainable land use (***well-established***).

Recent decades have seen considerable development in concepts of biodiversity conservation—from perspectives that focused on species while excluding people, to new approaches centred on people and communities (***well-established***). As a result, biodiversity conservation in the HKH has changed along with natural resource management. Participatory models have emerged and been accepted in various sectors, with the region generally adopting the 'ecosystem approach' advocated by the United Nations Convention on Biological Diversity (1992). Traditional ecological knowledge, beliefs, and culture have contributed substantially towards meeting conservation goals (***established but incomplete***).

These participatory and community-based approaches have had large ecological, economic, and social positive impacts. Substantial degraded forest areas are regenerating, as decentralized practices reverse deforestation trends. Local communities have gained institutional space to decide for themselves on issues related to forests, income, inclusion, and social justice. As people make their own decisions rather than reacting to orders from government officials, rural residents have been able to avail themselves of more local economic opportunities. Progressive policies have driven this paradigm shift (***established but incomplete***).

And yet the challenges facing the region could have cascading effects, especially for communities highly dependent on ecosystem services (***established but incomplete***). The transformative changes to date were driven mainly by a changing climate and land use change. As a result, changes to production systems are required to address potential resource crises arising from a growing population and increasing demand. Special attention must now be paid to governance effectiveness and implementation of evolving policies (***established but incomplete***).

Despite successes in community-based conservation and development, conserving the global assets of the HKH remains a challenge (***established but incomplete***). The HKH ecosystems provide crucial ecosystem services to 1.9 billion people, more than any other mountain system (***well-established***). As they continue to provide these services both within and outside the region, how can their biodiversity be sustained and the continued flow of services assured? The solution will be to manage the HKH as a mosaic of integrated socio-ecological systems across political and sectoral boundaries, linking upstream and downstream conservation action with local climate adaptation strategies (***established but incomplete***).

We still need to improve our understanding of biodiversity and ecosystem functions and services in the HKH (***well-established***). Only with improved technical knowledge, policies, and practices can environmental security be assured. It should also be strengthened through integration of traditional practices with science-based conservation, regional cooperation, and national and global investments (***established but incomplete***).

Biodiversity, Ecosystems and the Sustainable Development Goals

Building the social and ecological resilience of HKH mountain ecosystems will be essential for attaining Sustainable Development Goal (SDG) 15: *Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.* Most specifically relevant is Target 15.4: "By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development."

In addition, sustaining the flow of HKH ecosystem services can help attain SDGs 1 (alleviating poverty), SDG 2 (zero hunger), SDG 5 (addressing gender and social equity), SDG 6 (water, sanitation, and water for productive purposes), and SDG 7 (access to clean energy). Here, inclusive and transformative change is needed—recognizing the role of mountain communities in providing ecosystem services, adding new incentives, generating opportunities. Policies should develop and support markets for mountain niche products, and should enable investment in the mountains.

5.1 Mountain Biodiversity and Ecosystem Services: A Major Global Asset Under Threat

Mountains make up 24% of the world's land area, are home to 20% of the world's population, provide 60–80% of the world's freshwater, and harbour 50% of globally recognized biodiversity hotspots (Mittermeier et al. 2004; Rodríguez-Rodríguez et al. 2011; Maselli 2012). Mountain ranges act as barriers to some organisms and bridges to others, and therefore facilitate species isolation, speciation, extinction, and migration (Körner and Ohsawa 2005). The mountain ecosystems provide key livelihood resources such as food, timber, fibre, and medicine and a wide range of services such as fresh air and water, climate regulation, carbon storage, and the maintenance of aesthetic, cultural, and spiritual values (Grêt-Regamey et al. 2008; Schild 2008; Bhat et al. 2013; Sandhu and Sandhu 2014; Ahmad and Nizami, 2015; Hamilton 2015). The natural and semi-natural vegetation cover on mountains helps to stabilize headwaters, prevent flooding, and maintain steady year-round flows of water by facilitating the seepage of rainwater into aquifers, vital for maintaining human life in the densely populated areas downstream. As a result, mountains have often been referred to as 'water towers' (Schild 2008; Mukherji et al. 2015; Molden et al. 2016). Recognizing the importance of mountains for biodiversity and sustaining ecosystem services, Chap. 13 of Agenda 21 (1992) has recognized mountains as a significant habitat for support of all forms of living organisms, animals (including humans), and plants (UN 1992).

Driven by plate tectonics, the mountains of the HKH have unique ecosystems with altitudinal variation giving rise to numerous micro climates and diverse ecological gradients. The HKH is the youngest and one of the most diverse ecosystems among the global mountain biomes, with extreme variations in vegetation, climate, and ecosystems resulting from altitudinal, latitudinal, and soil gradients (Xu et al. 2009a; Sharma et al. 2010). This diverse biophysical habitat sets the stage for a rich biodiversity and species evolution (Miehe et al. 2014; Hudson et al. 2016). The region is the source of 10 major river systems with productive landscapes and strong upstream downstream linkages (Xu et al. 2009a), and includes all or part of four global biodiversity hotspots—Himalaya, Indo-Burma, mountains of Southwest China, and mountains of Central Asia (Mittermeier et al. 2004; Chettri et al. 2010)—which contain a rich variety of gene pools and species with high endemism and novel ecosystem types (Fig. 5.1.) In addition, the region supports more than 60 different ecoregions, many of them Global 200 ecoregions (Olson and Dinerstein 2002). The ecosystem services from the HKH sustain 240 million people in the region and benefit some 1.7 billion people in the downstream river basin areas (see Box 1.1) and have been well recognized by many scholars (Quyang 2009; Xu et al. 2009a; Molden et al. 2014a; Sharma et al. 2015).

The natural and semi-natural landscapes of the HKH have been altered, modified, and influenced by human history, culture, and traditional practices for thousands of years (Deterra 1937; Ives and Messerli 1989; Goldewijk et al. 2010, 2011; Ellis 2015). The HKH has witnessed human intervention since circa 5000 years BP, bringing crop diversity, cattle farming, and cultural congruence from east and west and leading to the creation of dynamic landscapes (Gurung 2004a; Miehe et al. 2009, 2014; Chen et al. 2015a). These dynamic landscapes have brought higher biological diversity through use, diversification, and promotion of plants, animals, agrobiodiversity, and traditional knowledge (Xu et al. 2005; Uprety et al. 2016). The diverse social networks across the region and rapid development of trade facilitated the exchange of cultures, knowledge, and materials (Chaudhary et al. 2015a, b). They evolved into coupled socio-ecological systems which have been significant not only for the people living in the mountain areas, but also for those beyond who benefit from the ecosystem services (Blaikie and Muldavin 2004; Nepal et al. 2014a, b).

The HKH is now being subjected to further change, including climate change (Shrestha et al. 2012) and unprecedented development that is environmentally unfriendly (Pandit et al. 2007; Grumbine and Pandit 2013; Xu and Grumbine 2014a). There are examples of both negative and positive impacts of the various drivers resulting in change in wildlife population, plant phenology, and ecosystem productivity across the region (Bawa and Seidler 2015; Singh and Borthakur 2015; Chaudhary et al. 2016a, b). Moreover, an increase in the number and severity of natural disasters as well as a breakdown of traditional systems of management is an indicator of the decreasing resilience of the HKH system (Elalem and Pal 2015). Global drivers of biodiversity loss, namely land use land cover change, habitat change, overexploitation, pollution, invasive alien species, and climate change, are prevalent in the HKH (Maxwell et al. 2016) and are increasing (Chettri and Sharma 2016). Solid waste management and haphazard development are bringing additional challenges (Kala 2014; Posch et al. 2015). Although there are a number of examples of best practices in community-based

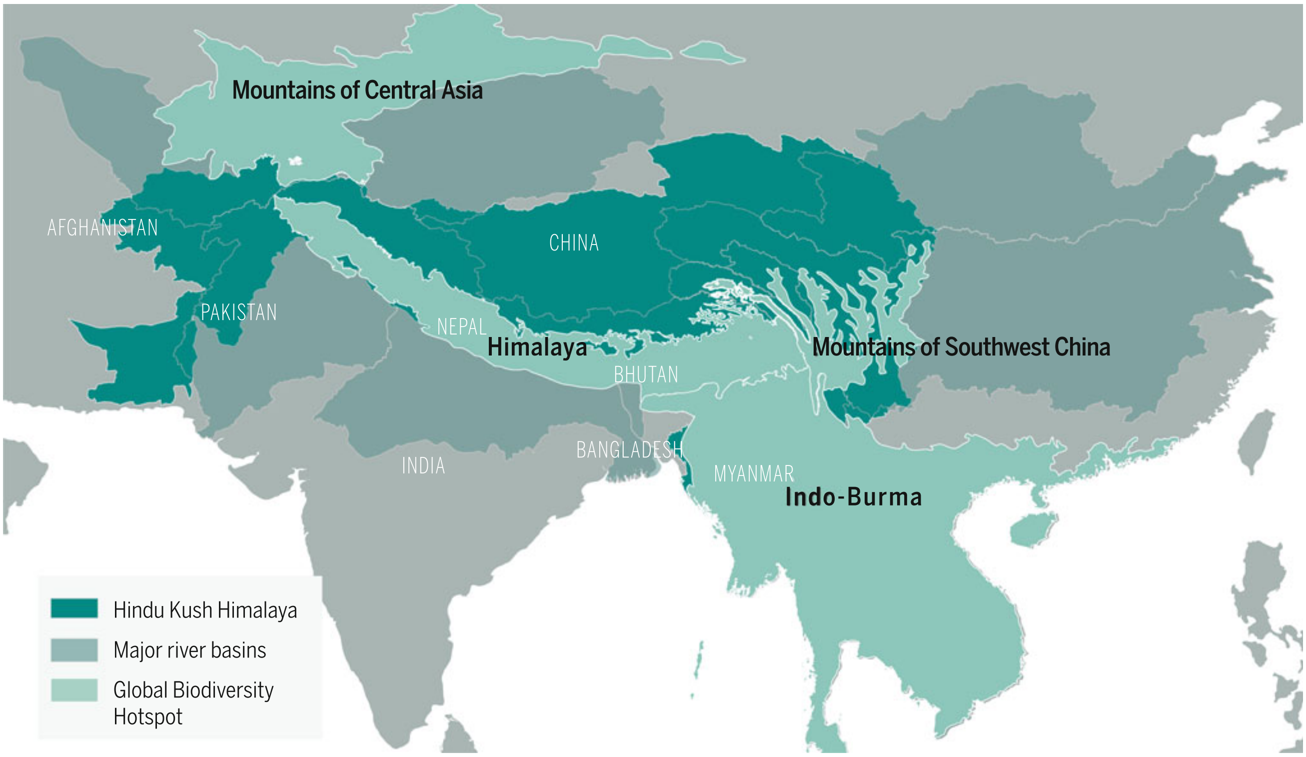

Fig. 5.1 Four global biodiversity hotspots and 10 river basins of the HKH

conservation and development initiatives, the challenges still exist in terms of good governance (Pai and Dutta 2006; Sharma et al. 2010). Sectoral and piecemeal approaches are among the limiting factors as they do not create many incentives for local communities to conserve biodiversity and water resources (Rasul 2014). Despite this, the Himalaya continue to provide ecosystem services that sustain societies both within the region and beyond. The diverse cultures and traditions manifested by over 1,000 ethnic groups (Turin 2005) continue to nurture the ecosystems at various spatial scales. In addtion, innovative practices have also promoted the production, restoration, and conservation of ecosystems and the services that they provide (Banskota et al. 2007; Sharma et al. 2007a, b, c; Aase et al. 2013).

In order to ensure the sustainability of ecosystems and continuity of ES, it is critical that biodiversity be managed as a mosaic of integrated socio-ecological systems. This should encompass systems across political and sectoral boundaries, and link upstream and downstream conservation action with local climate adaptation (Xu and Grumbine 2014a). To gain a better knowledge of the ecosystem services that people depend on for benefits and values, it is necessary to understand the state and dynamics of biodiversity and ecosystem functions. This understanding could be strengthened through deeper understanding of traditional practices and integrated with science-based conservation, regional cooperation, and national and global investments on policy and practices for environmental security (Fig. 5.2). In this chapter we move forward with this integrated approach to biodiversity conservation and ecosystem services and try to visualize their provision spatially and temporally. The content is basically drawn from learning and good practices from the past and lessons from the present, and we try to sow seeds for the sustainability of these services in the future with recommendations for future policy and practice.

Due to the extremely wide scope of the chapter and large volume of literature available, we have attempted to focus only on the key thematic areas of biodiversity and ecosystem services, with some examples to illustrate the trends observed across the HKH. We have structured our chapter to (1) contextualize the state of biodiversity and ecosystem status; (2) highlight the status and trends in biodiversity and ecosystem services; (3) document the current state of the coupled socio-ecological system; (4) highlight conservation and management practices; and (5) identify gaps and suggest strategic directions for mountain sustainability.

5.2 The Rich Biodiversity of the HKH Region

The Convention on Biological Diversity gives a formal definition of biodiversity in Article 2: “biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other

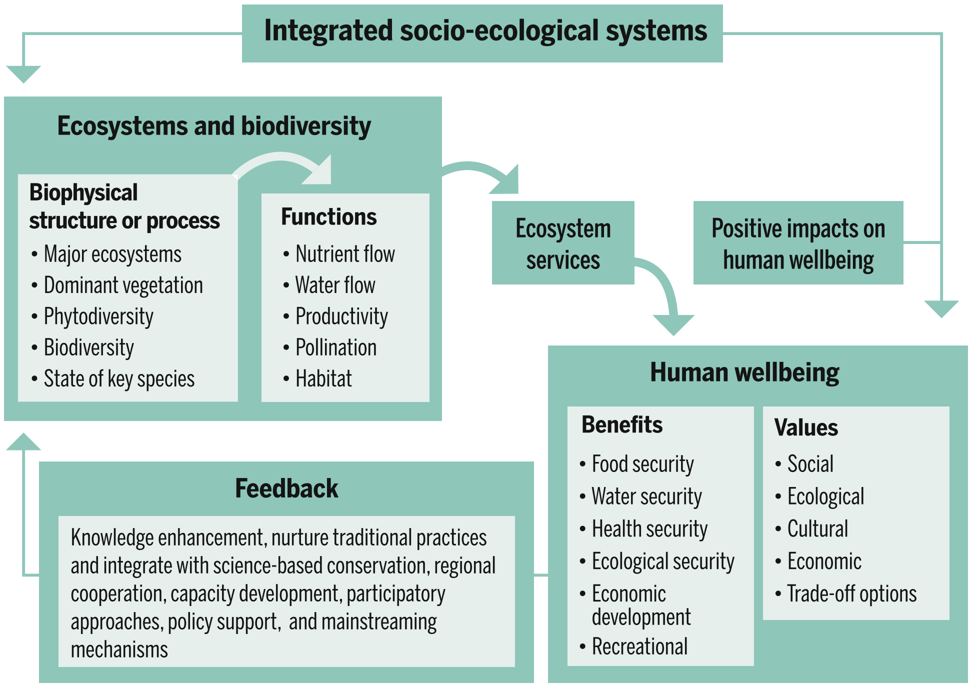

Fig. 5.2 Linkages between ecosystems, biodiversity, and human wellbeing (adapted from de Groot et al. 2010)

aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems". The HKH exhibits high levels of diversity and heterogeneity, partly in response to the high climatic variability and rugged topography. Very high levels of biodiversity and species richness (Myers et al. 2000; Sharma et al. 2010; Zomer and Oli 2011) are the result of a combination of several biophysical and geographical factors (Ives and Messerli 1989; Miehe et al. 2015a), including altitudinal zonation along a long and steep elevation gradient that ranges from near sea level at the base of the foothills up to the highest mountains in the world, with a prominent rain shadow zone on the Tibetan Plateau; a moisture and precipitation gradient that goes from generally wetter in the east to semi-arid and drier zones in the west; and the blocking effect of the high mountain barrier which allows tropical conditions to flourish in deep valleys by blocking cold continental northern winds from protruding further south, even though physically these mountains are outside the tropics. Rainfall in the HKH is primarily fed by the Indian summer monsoon, which weakens as it moves from the eastern reaches of the Himalaya northwest towards the Hindu Kush, and by winter storms which bring moisture in from the Arabian Sea (Barlow et al. 2005). The interaction of these two main precipitation regimes with the altitudinal gradient results in pronounced spatial, but also temporal, gradients in temperature and precipitation throughout the HKH, and consequently high levels of ecosystem diversity.

Additionally, the steep slopes of the HKH have high levels of erosion (Ives and Messerli 1989), which provide nutrient-rich sediments that help to sustain ecosystem flow to the 10 Asian river basins emanating from these highland water towers and impact the agricultural productivity of the floodplains. Equally, the high levels of erosion also result in habitat degradation and biodiversity loss (Xu et al. 2009a).

The mountain building, driven by plate tectonics, have created a diverse landscape, climate variability, ecological gradients, and physical habitats that set the stage for ecosystem differentiation (Hua 2012) and species evolution (Hoorn et al. 2013; Tremblay et al. 2015). The initial uplift of the Himalayan and Hindu Kush ranges from the mid to late Eocene, and the more recent (early Pliocene) uplift of the Hengduan Mountains, have enabled the development of a large number of recognized 'biodiversity hotspots' (Hughes and Atchison 2015; Mittermeier et al. 2015; Rodríguez-Rodríguez et al. 2011). The high levels of species richness found here are derived from both endemic speciation from local ancestors and migration of organisms from distant locales, noting that this region represents a congruence of two different floristic realms (Palearctic and Indomalayan) (Olson and Dinerstein 2002). Likewise, the region is also one of the most productive and intensively cultivated mountain regions in the world, with a high population density and ethnic diversity, which likewise has led to high levels of agrobiodiversity, farming system and agro-ecosystem differentiation, and domestication of many important food plants and animals (Gorenflo et al. 2012; Pandit et al. 2014; Karan 2015).

The bioclimatic zones range from hot tropical moist to lush green and humid valleys in the central and eastern midhills along the ranges, extensive mountain forests,

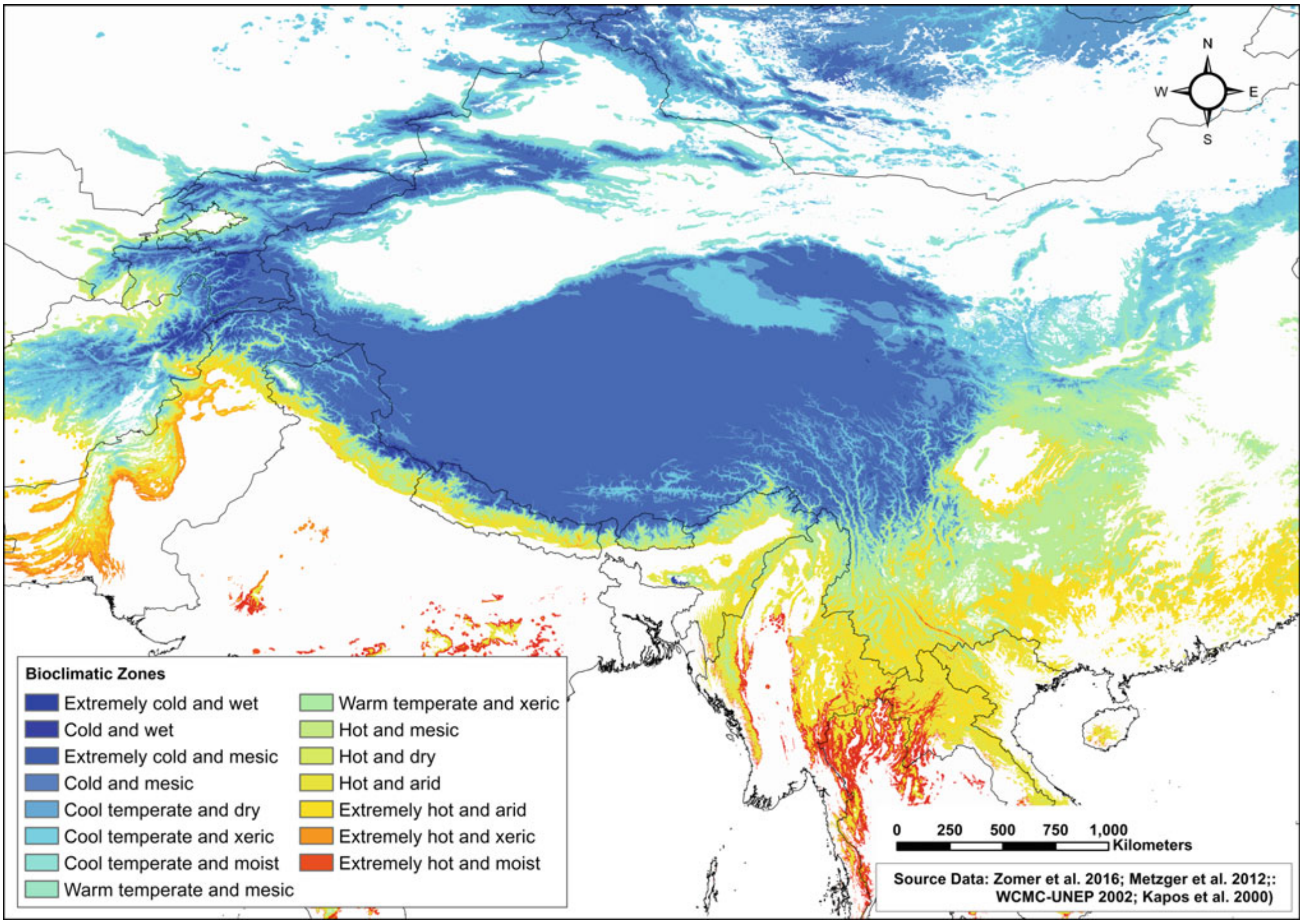

Fig. 5.3 Major bioclimatic zones, based on the Global Environmental Stratification (Metzger et al. 2013), found within the mountainous and highland regions of Asia. Mountains and highland areas are identified based on Kapos et al. (2000) using data from WCMC-UNEP (2002)

moist alpine meadows, remote and arid trans-Himalayan valleys, the cold Tibetan Plateau and vast areas of high altitude grasslands and steppe, and arid and semi-arid regions in the west, as well as extensive areas of permanent snow and ice. Zomer et al. (2016) found that 105 of 125 bioclimatic strata worldwide (Metzger et al. 2013), each representing a broad set of unique but homogenous bioclimatic conditions, were found within the HKH and its associated downstream river basins (Fig. 5.3). This bioclimatic and geographic heterogeneity has given rise to an array of ecosystems, biomes, and forest types (ranging from moist tropical broadleaf to temperate oak forests, alpine conifers, alpine pastures, and high altitude grasslands) providing habitat for a diversity of wildlife (including tiger, Asian elephant, musk deer, blue sheep, snow leopard, Tibetan antelope, and many other rare and endangered species). Many of the highest levels of diversity worldwide, in terms of plants and animals, are found in these mountain ranges, in three major global biodiversity hotspots—Himalaya, Indo-Burma, and the mountains of Southwest China (Allen et al. 2010). This area represents an important habitat for a high proportion of endemic and threatened mammals (Hoffmann et al. 2010); fish, molluscs, and dragonflies (Allen et al. 2010); birds (Dunn et al. 2016); and agrobiodiversity (Chettri et al. 2010), for which the HKH is renowned.

The Indo-Burma hotspot is one of the most significant hotspots, with rich diversity and a high proportion of endemism (Table 5.1). However, high levels of endemism are found throughout these mountains (Myers et al. 2000) amongst a vast array of plants, mammals, birds, reptiles, and other taxa, many of which are threatened or endangered. Recently, the region has been mentioned prominently within various listings of crisis ecoregions, endemic bird areas, megadiverse countries, and Global 200 ecoregions (see Brooks et al. 2006). However, the predictive models indicate that about 70–80% of the original habitat has already been lost and that loss may increase to 80–87% by 2100 (see Jantz et al. 2015 and Table 5.2).

Table 5.1 Distribution of total and endemic (in parentheses) species in the four biodiversity hotspots in the HKH

Biodiversity	Himalaya	Indo-Burma	Mountains of Southwest China	Mountains of Central Asia
Plants	10,000 (3,136)	13,500 (7,000)	12,000 (3,500)	5,500 (1,500)
Mammals	300 (12)	433 (73)	237 (5)	143 (6)
Birds	977 (15)	1,266 (64)	611 (2)	489 (0)
Reptiles	176 (48)	522 (204)	92 (15)	59 (1)
Amphibians	105 (42)	286 (154)	90 (8)	7 (4)
Freshwater fish	269 (33)	1,262 (553)	92 (23)	27 (5)

Source Conservation International (2016)

5.2.1 Ecosystem Diversity

The variation in species richness and diversity are mainly driven by ecosystem diversity (Tews et al. 2004). When there is a mosaic of habitats comprised of different ecosystems such as forest, grassland, water bodies, agriculture and so on, species diversity increases due to interspecific facilitation (Cardinale et al. 2002). This is one of the reasons biodiversity is not equally distributed across the HKH; the western part of the region is comparatively homogenous with arid and semi-arid vegetation (Fig. 5.3). A recent analysis identified the dominant terrestrial ecosystems to be high altitude grassland (54%), followed by forest (20%), shrubland (15%), and agricultural land (5%), with the remaining 6% composed of barren land, rocky outcrops, built-up areas, snow cover, and water bodies (Xu et al. 2009a).

In socio-ecological systems, people are directly or indirectly dependent on their surrounding ecosystems; forest, rangeland (alpine), agriculture, and wetland ecosystems play an important role in the HKH in this context. The most widespread ecosystem in the HKH is rangeland; it is mostly distributed in the western Himalaya and Tibetan Plateau, and provides habitat for many globally significant plants and animals including one of the highest densities of domesticated animals such as yak (*Bos grunniens*) (Schaller 1998; Foggin 2012). The forest ecosystem, with about 20% of the land cover, is one of the most important ecosystems both for local communities and for wildlife living in tropical and temperate conditions. Forest has provided fodder, fuel, medicine, fibre, and many other services for people, and a habitat and corridor for wildlife, for millennia (Uprety et al. 2016; Wang et al. 2016). Although the agriculture ecosystem only covers 5% of the total area, it is key to the direct provision of food and food security and nutrient supply (Rasul and Sharma 2015). The majority of people are subsistence farmers with comparatively small landholdings compared to their counterparts in lowland areas (Hussain et al. 2016). The region has one of the largest number of high altitude wetlands in the world, around 36 of which are designated as Ramsar sites (Upadhaya et al., 2009). These wetland ecosystems are a repository for a wide range of flora and fauna including threatened and endemic species (Jain et al. 2000; Savillo 2009; Sharma et al. 2016), and many of them are vital to culture and tourism (Maharana et al. 2000; Anand et al. 2012).

The ecosystem diversity is further supported by elevation, micro climate, and aspect variations leading to gradients of forest and other ecosystems along the altitudinal variation (see Fig. 5.4). The gradient from tropical (<500 m) to alpine ice-snow (>6000 m), 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, brings more ecosystem diversity. The variation in ecosystem functions and processes provides different ecosystem services to people and different opportunities to support livelihoods (Miehe et al. 2015b). Some of the ecosystems such as wetlands provide more than 85% of gross household income locally (Sharma et al. 2015).

Table 5.2 Current and future (seven climate-change scenarios) estimates of loss of area in individual biodiversity hotspots relative to the year 1500

	Current estimates of loss (%)		Year 2100 estimates of loss[a] (%)						
Hotspot	Mittermeier et al. (2004)	Modelled 2005	RCP2.6	RCP2.6	RCP4.5	RCP6.0	RCP6.0	RCP8.5	RCP8.5
Himalaya	75	77	93	91	91	95	93	86	92
Indo-Burma	95	38	71	64	63	68	64	83	61
Mountains of Central Asia	80	69	76	77	77	72	77	77	76
Mountains of Southwest China	92	66	97	97	97	83	97	78	96
Total	86	70	84	78	77	82	80	87	80

[a]See Jantz et al. (2015) for descriptions of the land-use change scenarios
RCP = representative concentration pathway

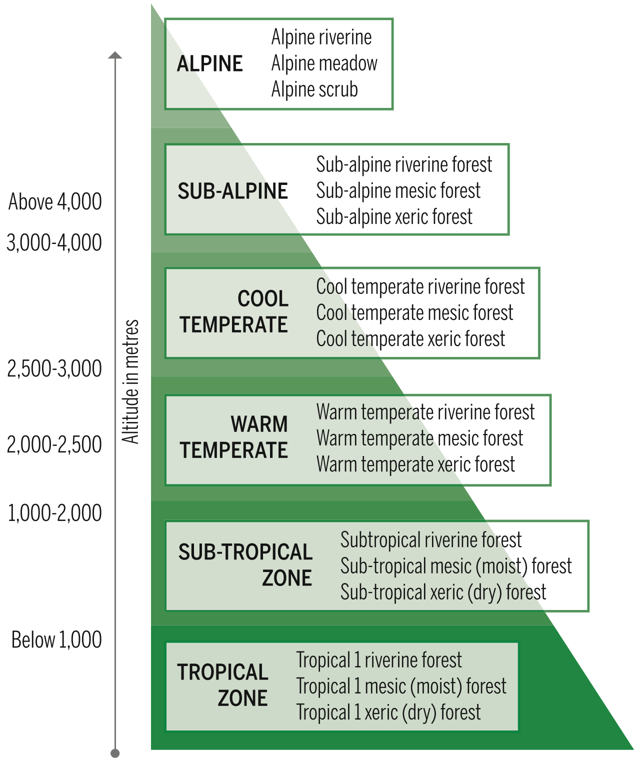

Fig. 5.4 Vegetation zones and dominant forest types found across the HKH (Chettri et al. 2010)

5.2.2 Species Diversity

The variation in ecosystems, land use, and landcover across the HKH is reflected in the species distribution, with high diversity and richness in megadiverse countries like China, India, and Myanmar and comparatively less diversity and richness in arid and semi-arid regions such as Afghanistan (Table 5.3). At least 353 new species were discovered in the Eastern Himalaya between 1998 and 2008, an average of 35 new species finds per year. The discoveries included 242 plants, 16 amphibians, 16 reptiles, 14 fish, 2 birds, 2 mammals, and at least 61 invertebrates (Thompson 2009). In addition, the HKH region—mostly the Eastern Himalaya—is also known for some iconic species such as *Rhododendron*. With seven species of *Rhododendron* have been reported in the western Himalaya, with increasing diversity shown towards the Eastern Himalaya (Nepal, Sikkim and Darjeeling in India, Bhutan, and North East India), and the highest number of species in China (Milleville 2002; Pradhan et al. 2003; Singh 2009; Shu 2005). As many as 46 *Rhododendron* species have been classified as rare or threatened in the India area of the Eastern Himalaya alone (Menon et al. 2012). In addition, orchids, medicinal and aromatic plants, and wild edible plants also play an important role in livelihoods and local economies and are abundant in the region (Kalita et al. 2014; MoEF 2014). Interestingly, the region also contains, wholly or partially, three of Vavilov's eight centres of origin of cultivated plants (Simpson and Ogorzaly 1986).

5.2.3 Genetic Diversity

Genetic diversity, defined as the variety of alleles and genotypes present in a population, is a fundamental source of biodiversity (Hughes et al. 2008). It is critical for the survival and adaptability of a species, helping organisms to cope with current environmental variability, reducing the potentially deleterious effects of close relative breeding, and increasing disease resistance (Frankham 2005). Maintaining diversity at a genetic level also holds significance for species

Table 5.3 Reported species richness in the countries of the HKH

Country	Area (km^2)[9]	Floral diversity		Faunal diversity				
		Angiosperms	Gymnosperms	Mammals	Birds	Reptiles	Amphibians	Fish
Afghanistan[1]	652,230	3,500–4,500	NA	137–150	428–515	92–112	6–8	101–139
Bangladesh[2]	144,000	3,723	7	128	650	154	49	712
Bhutan[3]	38,394	5,603	NA	200	700	124	61	91
China[4]	9,596,960	34,984	NA	556	1,300	1,186	380	279
India[5]	2,387,590	17,926	74	423	1,233	526	342	3,022
Myanmar[6]	676,577	11,800	NA	251	1,000	279	82	350
Nepal[7]	147,181	6,973	26	208	867	123	117	230
Pakistan[8]	882,000	5,757	38	198	696	177	22	>1,000 marine; 198 freshwater

Sources [1]ANBSAP (2013); [2]DoE (2015); [3]MoAF (2014); [4]MoEPC (2014); [5]MoEF (2004, 2008); [6]MoECF (2011); [7]MoFSC (2014); [8]CCD (2014); [9]Chettri and Sharma (2016) (except Nepal)
NA = data not available
Except for Bhutan and Nepal, the numerical data are for the whole country and not segregated for the HKH region

evolution, and through agricultural biodiversity contributes to sustaining and strengthening food, nutrition, health, and livelihood security (Notter 1999; Esquinas-Alcázar 2005). The origin of the chicken and its domestication (*Gallus gallus domesticus*) is thought to be in the region, particularly in India and China (Liu et al. 2006). The huge variety of traditional crops and cultivars used in the subsistence farming system, including swidden agriculture, is very little known outside the region. These species harbour an enormous genetic diversity (landrace/varieties) of both regional and global significance. For example, 2,500 landraces of rice (*Oryza sativa*) have been identified in Nepal (Gupta et al. 1996). The number could increase significantly if reviewed; the western Himalaya alone adds 100 types of basmati rice (Salgotra et al. 2015). Taro (*Colocasia esculenta*) is another widely distributed food crop, which is believed to be from the Eastern Himalaya (Xu et al. 2001). Studies have shown that the indigenous crop varieties traditionally cultivated and maintained by farmers contain high levels of genetic diversity and can serve as potential genetic resources for improving yield, resistance to pests and pathogens, and agronomic performance, thereby helping to maintain future food security in the light of the changing climate (Brush 1995; Hoisington et al. 1999; Mandel et al. 2011).

Despite being a repository of genetic resources of the global significance, the region has received comparatively little attention in terms of genetic research and in situ conservation. For example, in a recent review of biodiversity research, Kandel et al. (2016) noted that only around 2% of the research on the Kangchenjunga Landscape is at genetic level, compared to 20% at the ecosystem level and 78% at the species level. The identification and recording of species are still at an early stage, the necessary baseline data for identifying genetic diversity are not available, and the constant monitoring needed to examine population dynamics as a function of changing climate impacts is sorely lacking. The scant amount of genetic-level research could be due to very limited financial resources, lack of institutional capacity, an inadequate knowledge base, lack of accessible sophisticated technologies, and restrictive government policies towards such research in the region (Grajal 1999; Bubela and Gold 2012).

5.2.4 Functional Diversity

Functional diversity is a component of biodiversity that generally concerns the range of things that organisms do in communities and ecosystems. A variety of definitions exist, such as “the functional multiplicity within a community” (Tesfaye et al. 2003) and “the value and range of those species and organismal traits that influence ecosystem functioning” (Tilman et al. 2001). But the term is frequently used without definition or reference, normally considering phenotypic trait and/or trophic levels (Tilman et al. 2001). The framework of this paper (see Fig. 5.2) indicates that functional diversity among the individual species within an ecosystem is vitally important for the production and flow of ecosystem services. The physiological interaction among biotic and abiotic elements with a production function is instrumental in the derivation of ecosystem services (see de Groot et al. 2010). Among these, nutrient production from decomposition, water from evapotranspiration, and food from pollination services are important ecosystem functions resulting from functional diversity (see Fig. 5.2). In recent years monitoring the functional values of the ecosystems for monitoring has been recognized for better understanding of the ecosystems (Gagic et al. 2015).

Containing some of the youngest mountain ecosystems on Earth, the HKH ecosystem continues to be shaped and reshaped by anthropogenic and geological processes, leading to diversity. This diversity is manifested by thousands of phenotypic traits and their interaction at different trophic levels supporting species evolution and richness. A very high diversity and wide range of climatic zones are found across this highly heterogeneous region, associated with steep elevational gradients and continental, oceanic, and latitudinal influences. Out of 125 bioclimatic strata identified in the Global Environmental Stratification (GEnS) worldwide, more than 105 are found within the HKH and its associated downstream basins (Metzger et al. 2013). This wide range of bioclimatic diversity, combined with the heterogeneous terrain and topographic and orographic effects, and along with the confluence of several major floristic zones across the region, has enabled a rich and highly diverse biodiversity to develop, with a high degree of endemism (Fig. 5.4). This diversity is likewise reflected in the many cultures and languages found across and along these mountains.

Functional diversity plays a pivotal role in the provision of ecosystem services, which can also be considered as the benefit from nature for people’s wellbeing (Díaz et al. 2015). Functional diversity at ecosystem, species, and genetic levels is fundamental for the lives of the majority of the rural communities living in the HKH. In many parts, 70–80% of the population live in rural areas, and the majority (60–85%) are still directly or indirectly dependent on this diversity for their livelihoods (Sharma et al. 2015).

Human colonizers of the Himalaya over past millennia devised a wide range of foraging systems, from nomadism to shifting cultivation, from sedentary agriculture to fishery. The earliest human settlement identified on the Tibetan Plateau was established some 5,200 years before the present (Chen et al. 2015a) (see Fig. 5.5). Ecological and societal feedback shape the flow of services and may promote, reduce, or unravel such bundles during the constant

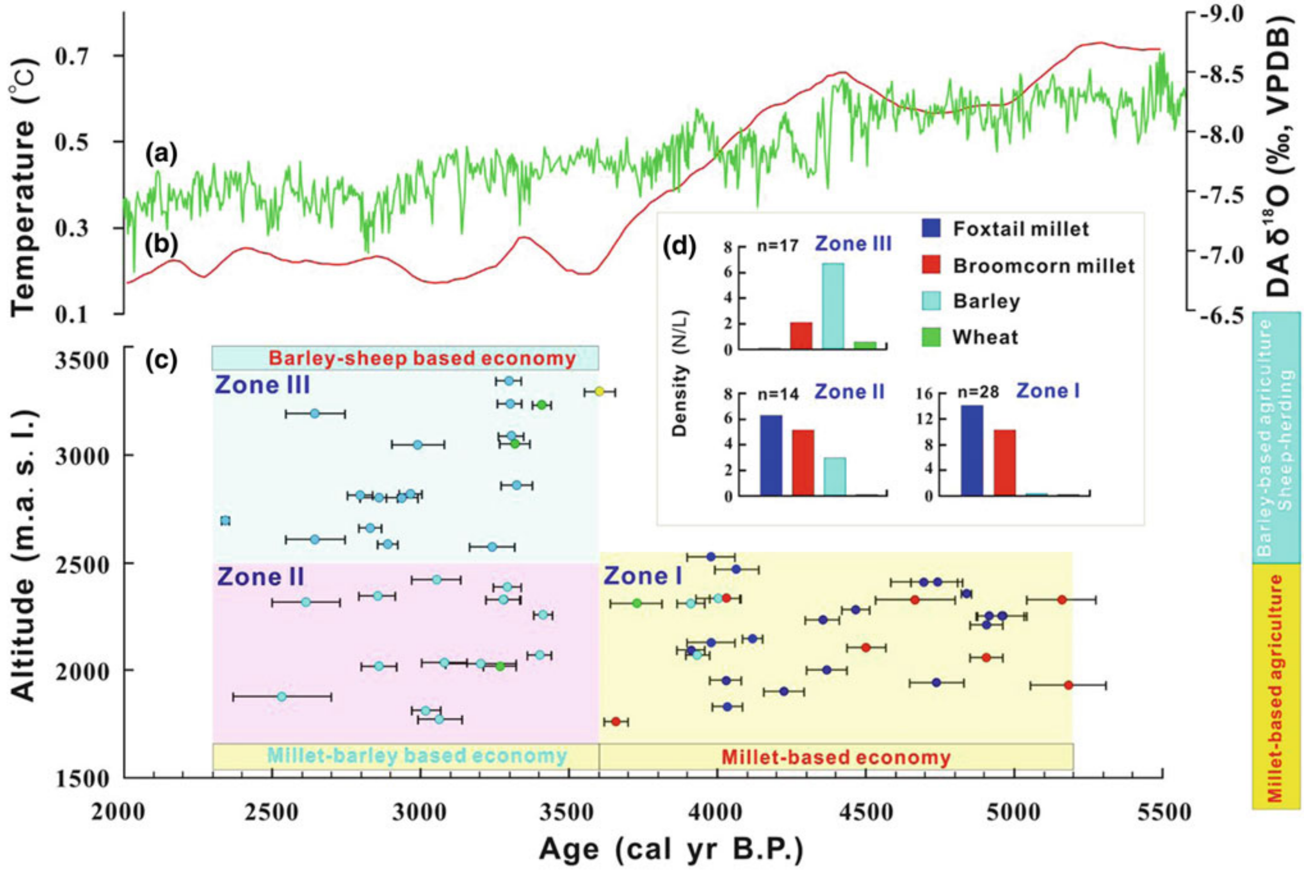

Fig. 5.5 Climatic records, radiocarbon dates, and charred cereal grain records from 53 investigated sites from different archaeological cultures on the northeastern Tibetan Plateau. **a** Asian summer monsoon changes indicated by Dongge Cave speleothem oxygen isotopes. **b** Northern Hemisphere (30° to 90° N) temperature record compared to 1961–90 instrumental mean temperature. **c** Calibrated AMS radiocarbon dates of charred grains (solid symbols with 2*s* error bar) from the 53 sites at different elevation; Zone I includes 25 sites below 2500 masl dated between 5200 and 3600 calendar years BP; zones II and III include 12 sites below and 17 sites above 2500 masl dated between 3600 and 2300 calendar years BP. Circle colours indicate crops as in (**d**), with the addition of capers indicated in yellow. **d** Density variation of crop remains from flotation samples from zones I, II, and III; N = number of charred grains, n = number of flotation samples (Reproduced from Chen et al. 2015a)

negotiation of different trade-offs. In the HKH, cultural diversity is a key contributor to shaping the ecosystems and biodiversity (Turin 2005; Gorenflo et al. 2012). Both ecosystems and cultures have adapted to exist in these relatively remote habitats; for example, the villagers in the Pamir integrated the human body into the seasons and rhythms of their ecological cycle to generate 'calendars of the human body' (Kassam et al. 2011). These coupled socio-ecological systems—facilitating the material, energy, and information flows not only between natural systems and social systems but also among different social systems—may be regarded as cultural landscapes (Taylor and Lennon 2011). In them, a range of cultural beliefs and mores combine taboos, language, technical practices, knowledge transfer, and customary institutions for social consent and governance (Xu et al. 2005). The result may be called traditional ecological knowledge.

5.3 Ecosystem Services—The Source of Human Wellbeing

The diverse ecosystems of the HKH are important natural capital and play a critical role in protecting the life-support systems in the HKH and beyond (Maharana et al. 2000; Kubiszewski et al. 2013; Sharma et al. 2015). A large proportion of the population in the region still lives in poverty (Gerlitz et al. 2012) and is highly dependent on ecosystem services for their livelihood and daily requirements (Paudyal et al. 2015; Sharma et al. 2015; Chaudhary et al. 2016a, b). Biodiversity has a great significance for the societal benefits derived from ecosystems, as manifested in a myriad customs, traditions, and sacred values (Zomer and Oli 2011), and as a result, there is an inextricable link in the HKH between biodiversity, livelihoods, and culture (Aase et al.

2009; Xu et al. 2009b). Degradation of these values affects the availability and accessibility of ecosystem services for people, which ultimately increases the demand for these resources leading to more pressure on the ecosystems and human society (Badola et al. 2014; Paudyal et al. 2015; Sharma et al. 2015; Chaudhary et al. 2016a, b).

While the importance of protecting mountain ecosystems has been widely accepted (UN 1992), conventional conservation approaches have become a matter of debate and the concept of ecosystem services has risen to prominence (Singh 2002; Naidoo et al. 2008; Chaudhary et al. 2015a, b). Over the past two decades research and publications on ecosystem services have grown exponentially and the concept has been discussed and mainstreamed in many decision-making processes (Chaudhary et al. 2015a, b; Díaz et al. 2015). The idea of ecosystem services dates back to Westman (1977), who suggested that the social value of the benefits that ecosystems provide could potentially be quantifiedso that society can make more informed policy and management decisions (Grêt-Regamey et al. 2012). Many of these ecosystems are long-term premium assets, with benefits that reach far beyond their source (see, for example, Fig. 5.6). They can have multiple functions at different times and scales (Creed et al. 2016). However, one of the challenges that policy makers and managers face while addressing the threats to the ecological integrity of the Himalayas, is the fact that there is still not enough information available about ecological status and human impacts in the region to enable prediction of the losses that will occur as a result of the impacts of natural and human-induced disturbance (Chettri et al. 2010; Thompson and Warburton 1985). Globally, ecosystem values can be broadly categorized into four value systems (Körner 2004):

- Social value: both marketed and non-marketed biodiversity used for social benefits and development
- Cultural value: diverse cultures, species, and landscapes as historical treasures of society
- Ecological value: the interdependence, interaction and co-evaluation of species for maintaining ecological processes and functions
- Economic value: directly generating livelihoods from quality and quantity of desired products as well as providing insurance against failure of crops and livestock.

5.3.1 Social Value of Ecosystem Services

Over the past two decades, the ecosystem service concept—the benefits that humans obtain from ecosystems (MA 2005)—has gained importance among scientists, managers, and policymakers as a way to communicate societal dependence on ecological life-support systems integrating perspectives from both the natural and social sciences (Chaudhary et al. 2015a, b). Although the methodology for ecosystem valuation is still debated, the interdependence of human wellbeing and ecosystem health and biodiversity has now been recognized (Díaz et al. 2015). Biodiversity and the ecosystem services derived from diverse ecosystems have been recognized as important sources since time immemorial of societal development in the HKH (Rai et al. 1994; Awasthi et al. 2003; Chen et al. 2015a). The social value of ecosystem services is critical, as people have relied substantially on these diverse ecosystems for food, shelter, medicine, and so on (Pei 1995; Luck et al. 2009; Joshi and Negi 2011). Transformative change has been possible in many mountain

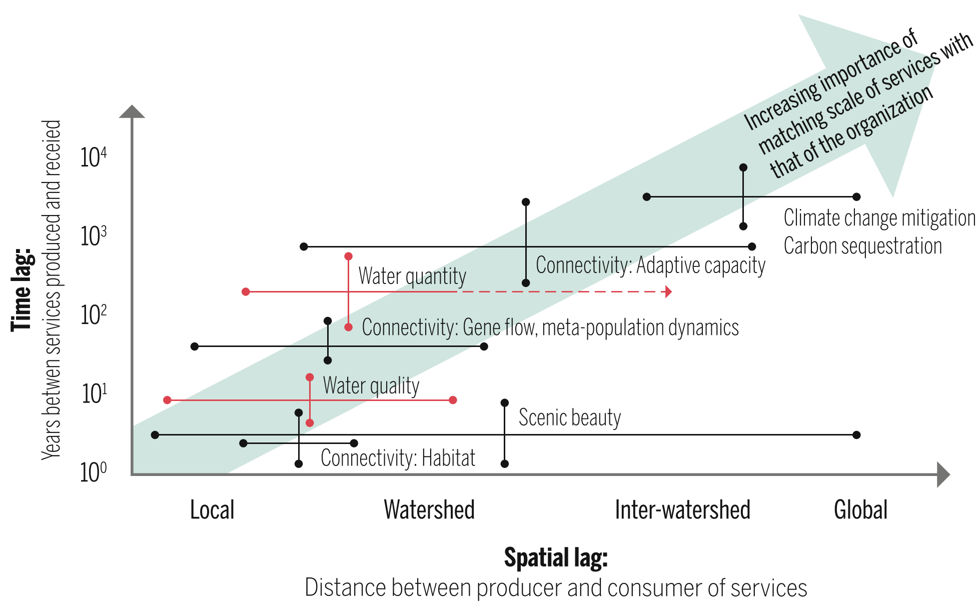

Fig. 5.6 Forest aquatic ecosystem services affect people long after the time and far from where forest management decisions are made. The vertical axis shows the time lag in terms of multi-decadal recovery and the scale of impacts ranging from local to national and global (*Source* Creed et al. 2016)

areas based on the dependence on varied ecosystems for subsistence livelihoods. For example, the community living around Koshi Tappu, a Ramsar site in Nepal, indicated 85% dependency on various ecosystem services (Sharma et al. 2015). Similarly, rangeland and forest ecosystems have provided diverse ecosystem services in most of the rural areas in the HKH (Badola et al. 2010; Dong et al. 2010; Joshi and Negi 2011; Pant et al. 2012). Efforts have been made to understand the complexity of socio-ecological linkages in rangeland (Dong et al. 2010), wetland (Chaudhary et al. 2016a, b), and forest ecosystems (Joshi and Negi 2011). In summary, the ecosystem services derived from the various ecosystems in the HKH have a high value for social development and poverty alleviation.

5.3.2 Cultural Value of Ecosystem Services

Cultural services are defined as the "nonmaterial benefits people obtain from ecosystems" and include the "cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation and ecotourism" of an ecosystem (MA 2005). These services are often considered subjective, intangible, and difficult to quantify in monetary terms, and thus, are often neglected or completely excluded from valuation (Chan et al. 2012; Daniel et al. 2012). The failure to recognize and integrate cultural services into ecosystem assessment might lead to biased and misleading trade-off assessments, ecosystem management, and landscape planning (Schaich et al. 2010). The cultural linkage of an ecosystem elicits a positive attitude from the local community towards conservation; systems which have associated cultural beliefs are less disrupted and better maintained (Gao et al. 2013). Cultural services are crucial for sustaining the psychological aspects of human wellbeing and contribute significantly to the overall value of a system to societies.

The HKH is home to varied ethnic communities with vast socioeconomic and cultural diversity (Turin 2005). This cultural diversity is associated with the management of the landscape and natural resources, and has been a part of the co-evolution of society and ecosystems with inextricable links between rural livelihoods, land use, human health, and climate change (Wilkes 2008; Xu et al. 2008). Religious beliefs and rituals, traditions, and customs of local communities often have embedded conservation ethics and have influenced the biophysical conditions of an ecosystem. These landscapes include sacred groves and forest streams, holy mountain peaks, traditional agroforestry systems, and sacred lakes. Many such landscapes in the region have been well studied for their biodiversity and tourism value (for example, Maharana et al. 2000; Anthwal et al. 2010), but very few studies have assessed their cultural services (Sharma et al. 2007a, b, c).

5.3.3 Ecological Value of Ecosystem Services

The ecological value of the HKH is well appreciated and reported (Chettri et al. 2008; Sharma et al. 2010). Various publications rationalize the ecological value of globally significant species, diversity in ecosystems, and ecosystem functions (Myers et al. 2000; Mittermeier et al. 2004; Brooks et al. 2006). Attempts have also been made to understand the distribution of species (Acharya et al. 2011; Bhardwaj et al. 2012) and ecosystems (Chettri et al. 2012; Zomer et al. 2014). The region's ecological value cannot be overstated considering its species richness and diversity, particularly as the habitat for some of the most fascinating and globally significant species in the world. Moreover, the ecosystem of the HKH includes Mount Everest and is the highest biome in the world, unmatched by any other mountain systems. The value of this diversity has long made the HKH one of the most favoured destinations for naturalists, geologists, and explorers (Kandel et al. 2016). In recent years, the contribution of forest, rangeland, and wetland ecosystems to carbon sequestration and soil conservation have been widely acknowledged (Upadhyay et al. 2005; Banskota et al. 2007).

5.3.4 Economic Value of Ecosystem Services

In recent years, efforts have been made to rationalize the significance of ecosystem services in terms of economic value (Costanza et al. 2016). Although research on ecosystem services has progressed significantly, the proportion of research on actual valuation in economic terms is negligible. This is mainly due to limitations in the methodology and the geographical complexities prevailing in the HKH (Rasul et al. 2011a). However, the growing body of literature clearly states that the economic value of both marketed and non-marketed goods is high for rural communities who depend largely on ecosystem services. One of the most comprehensive assessments is from Bhutan, and although preliminary, is revealing. The total estimated value of ecosystem services was approximately USD 15.5 billion per year, significantly greater than the gross domestic product of USD 3.5 billion per year, while 53% of the total benefits accrue to people outside Bhutan, and 47% to those inside (Kubiszewski et al. 2013). The wetland ecosystem is critical for many local communities. For example, some wetlands provide 85% of the total household income (see Sharma et al. 2015). The forested ecosystem is equally important, contributing 80% of household income through provisioning services in some places (Pant et al. 2012).

5.3.5 Changing Ecosystem Services of the HKH Region

Meta-analysis considering the available literature review, trend of research on ecosystem services in the HKH was made using search engine such as google scholar. About 400 peer review articles were collected using search word such as 'ecosystem services' and the name of the countries. The results showed, in general, knowledge base and understanding of ecosystem services is increasing (Fig. 5.7). However, despite a wide range of studies on thematic subjects such as hydropower, water, and carbon storage, there are very few qualitative or quantitative assessments of ecosystem services. Although the number of publications has increased as shown by the increasing trend, the overall ratio between numbers of publications reporting decline or an increase in the value of the ecosystem services provided by the HKH has also changed over the last decade. There is also a regional bias in the studies among the countries in the region; most are from India, followed by China, Nepal, Pakistan, Bangladesh, and Bhutan (Fig. 5.8). We did not find any mountain-specific studies from Myanmar, while studies from Afghanistan were limited to reviews. Most of the studies from India have concluded that the ecosystem services provided by the Indian Himalaya have degraded due to rapid developmental activities and population growth. However, studies from China indicate that the flow of ecosystem services has increased after implementation of the Natural Forest Conservation Programme, Sloping Land Conversion Programme, and Grain for Green Programme (Song et al. 2014). This may also be an outcome of the increased number of studies from China over the last decade and innovative programmes.

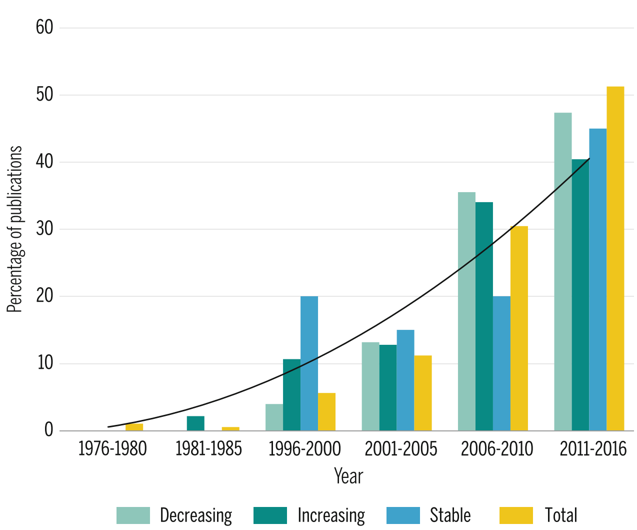

Fig. 5.7 Trend in number of publications on ecosystem services in the HKH, and number of these that predict/suggest/report a decline, increase, or stable state of ES

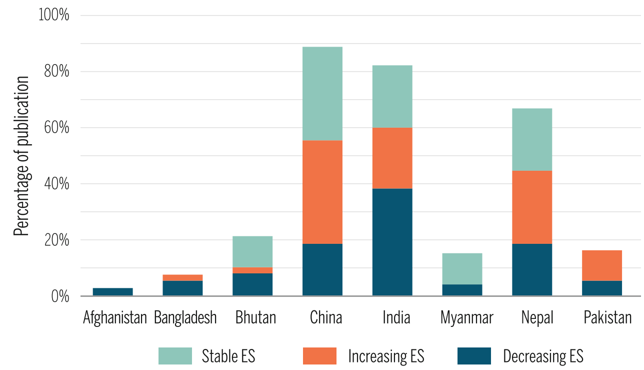

Fig. 5.8 Percentage of publications (1977–2016) and trends predicted in ecosystem services value in the HKH by country

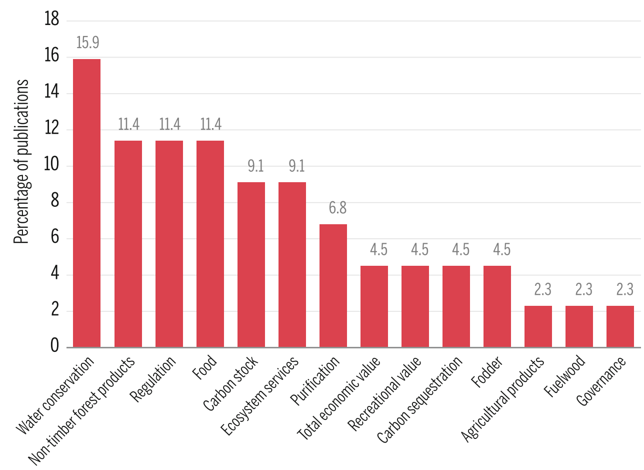

Fig. 5.9 Percentage of publications on different categories of ecosystem services in the HKH

Most of the studies have assessed the benefits people are deriving directly from the natural ecosystems in terms of freshwater, fuelwood, fodder, non-timber forest products (NTFPs), and hydropower. The Himalaya are known as a water tower, contributing immensely to the freshwater needs of the region (Schild 2008; Molden et al. 2014a). Water conservation is the most studied ecosystem service; very few publications have focused on the governance and management of the services in the region (Fig. 5.9).

The overall trend in the provision of ecosystem services increased in recreational value and related activities in the region as most of the areas have become accessible to the visitors. The recreational value is one of the major sources of income for livelihood activities in the area (Nepal 1997; Maharana et al. 2000; Badola et al. 2010). Both NTFPs and water conservation show a stable trend, while biodiversity value and overall ecosystem services show a declining trend (Fig. 5.10). One of the relatively understudied aspects is the role of Himalayan ecosystems in health security (Xu et al. 2008; Sarkar 2011). This is important in view of the climate

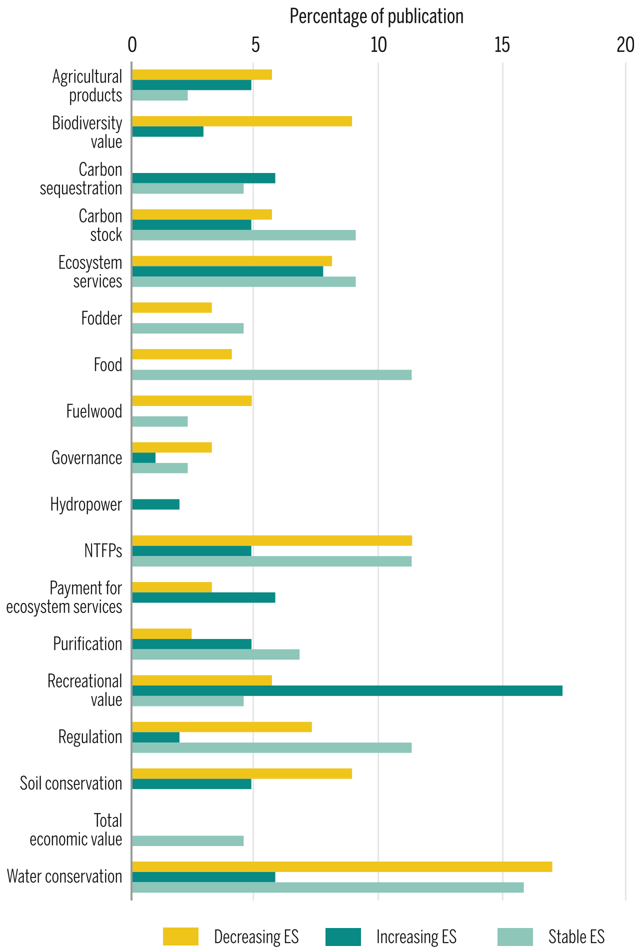

Fig. 5.10 Reported trends within different categories of ecosystem services theme in the HKH

change-induced expansion of vector-borne diseases, as pathogens take advantage of new habitats at elevations that were formerly unsuitable, and diarrheal diseases result from changes in freshwater quality and availability (Ebi et al. 2007; Dangi et al. 2017).

A review of the studies revealed that most focused on a limited topic and lacked a holistic view that would aid better understanding of upstream-downstream linkages; thus they are of limited significance for policy decisions. Large scale studies looking at catchment and basin scales have mainly emerged from the fields of hydrology and geology. An understanding of hydrological dynamics is crucial for sustainable planning and management of water resources in the HKH. However, the lack of hydro-meteorological data in the region, especially for high elevation areas, hinders the process of understanding the system dynamics (Nepal et al. 2014a, b). A huge difference also exists between basins in the extent to which climate change is predicted to affect water availability and food security (Immerzeel et al. 2010). The issue of scale is very important for such assessments. Different issues are relevant at different scales, and the nature of the impacts varies as the scale changes.

The scenarios for the economic values of terrestrial ecosystems services in the HKH countries (Kubiszewski et al. 2016) show a discouraging trend (Table 5.4). The data analysis revealed a 34% decrease in the value under the Fortress World (FW) scenario compared to the 2011 baseline, and a 28% decrease in the Market Forces (MF) scenario; Policy Reform (PR) could reduce the trend to −3%. At the country level, Afghanistan showed the greatest losses in ecosystem services value under both the FW and MF

Table 5.4 Terrestrial values for the ecosystem services in the HKH countries in 2011 (as base) and percentage change estimated under each of four future scenarios till 2050

Country	GDP.PPP (million USD)	ESV (million USD/yr)	SI-MF (million USD/yr)	MF % change from 2011 (%)	S2-FW (million USD/yr)	FW % change from 2011 (%)	S3-PR (million USD/yr)	PR % change from 2011 (%)	S4-GT (million USD/yr)	GT % change from 2011 (%)
Afghanistan	49,338	198,662	56,919	−71	45,434	−77	178,554	−10	271,418	37
Bangladesh	395,684	145,974	107,655	−26	69,847	−52	146,427	0	175,642	20
Bhutan	5,040	14,862	13,255	−11	11,766	−21	14,936	0	17,804	20
China	13,810,256	3,586,924	2,596,138	−28	2,314,370	−35	3,494,582	−3	4,524,762	26
India	5,845,362	1,825,052	1,562,620	−14	1,357,683	−20	1,833,906	0	2,203,965	21
Myanmar	51,920	369,447	305,517	−17	261,775	−29	370,543	0	443,431	20
Nepal	55,504	62,749	54,994	−12	48,631	−22	63,655	1	75,404	20
Pakistan	750,693	294,519	157,302	−47	137,519	−53	264,412	−10	413,554	40
Total	20,963,797	6,498,189	4,854,400	−28	4,247,025	−39	6,367,015	−0.3	8,125,980	26

Source Kubiszewski et al. (2016)
GDP.PPP = gross domestic product, purchasing power parity; ESV = ecosystem services value; Future scenarios: S1-MF = Market Forces; S2-FW = Fortress World; S3-PR = Policy Reform; S4-GT = Great Transition

scenarios (77% and 71%, respectively), followed by Bangladesh and China. Under the PR scenario, Afghanistan and Pakistan showed considerable losses of 10% in ecosystem services values. However, these two countries also showed the greatest gains under the Great Transitions (GT) scenario with a gain of 40% in Pakistan and 37% in Afghanistan. Of the eight countries in the region, Bhutan showed the least loss in ecosystem services value under MF (11%) and FW (21%), a 20% gain under GT, and no change under the PR scenario.

It is undeniable that Himalayan ecosystems provide crucial and valuable ecosystem services to a large part of humanity—more than any other mountain system (Grêt-Regamey et al. 2012). But the lack of data in the Himalaya is hindering understanding of the socio-ecological processes. A concerted effort should be made to fill the knowledge gaps through more focused and coordinated collection of relevant data, especially from the high mountain areas. It is important to improve scientific understanding of ecosystem structures and functioning and drivers of change as a basis for formulating comprehensive ecosystem management approaches and strategies that link to human wellbeing and poverty alleviation. Information on the status of human wellbeing and its linkages with the condition of natural resources is required at the scale where a holistic approach can be taken to address the issues. This knowledge would enable informed decision making, especially where trade-offs among conservation, livelihoods, development, and culture are involved, so that an increase in the supply of one service (such as food or fibre) at the expense of others (such as clean water and self-regulation of pests and diseases) is done with some knowledge of spatio-temporal consequences and who would face them.

5.3.6 Trade-offs and Synergies—Implications for Development

The diverse landscapes of the HKH provide multitudinous services that interrelate in a ‘complex dynamic’ manner (Birch et al. 2014; Måren et al. 2013; Paudyal et al. 2015). Common drivers affecting multiple ecosystem processes and the interactions among ecosystem services can result in trade-offs and synergies between ecosystem services (Bennett et al. 2009). Trade-offs between ecosystem services arise when one service increases at the cost of another (Ziv et al. 2012), while synergies occur when both services increase or decrease in tandem (Bennett et al. 2009; Haase et al. 2012). Trade-off analysis is a key issue that must be considered when integrating ecosystem services in landscape planning, management, and decision making (de Groot et al. 2010), particularly when analysing alternate pathways leading to sustainable land use in the future (Rounsevell et al. 2012). Any ecosystem management practice that fails to take this into account when attempting to maximise the production of one or more ecosystem services can bring about substantial declines in the provision of other ecosystem services (MA 2005; Bennett et al. 2009). According to the concept of Jointness in Production, there are two different causes for interactions between ES, namely, biological interdependencies and economic interdependencies (Abler 2004; Baumgärtner and Quaas 2010). In landscapes where the provision of ecosystem services is strongly influenced by human activities and vice versa, both these interdependencies are of particular consequence.

The complexity of interactions among ecosystem services is high in managed mountain ecosystem services (Grêt-Regamey et al. 2008), where marginally or periodically productive sites may be relatively more sensitive to climate and socioeconomic shifts (Sharma et al. 2009). The heterogeneity of topography and other landscape characteristics in mountain ecosystems makes spatial dynamics more important than temporal, and climate change may influence the elements of the ecosystem differently (Shrestha et al. 2012). Therefore, when managing trade-offs in the provision of mountain ES, the spatial distribution of ES, the trade-off dynamics over time, and their interaction with structural changes in agriculture and forestry must be accounted for (see Box 5.1 and Table 5.5 for examples).

Box 5.1 Trade-offs: hydropower development and ecosystems in the HKH

Perennial in nature, the Himalayan rivers are regarded as important sources of hydropower generation and have a cumulative hydropower potential that exceeds 500 gigawatts (Pandit et al. 2014). Access to energy for sustenance, agriculture, industries, and other economic activities is critical to the growing population of the HKH region. The large number of rivers that flow out of this region have the potential to fulfil the energy demand and contribute to the wellbeing of the people. There are more than 550 hydropower projects in existence or under construction in the Bhutanese, Indian, Nepalese, and Pakistani Himalayan regions (Pandit et al. 2014). However, it is imperative for hydropower generation in these fragile ecosystems to take into consideration the wide scale impacts that are known to be prevalent while altering these natural resources. For example, most of the dams and hydropower plants located/proposed in the biodiversity rich area of the Indian Himalaya have potential impacts that include forest loss, species extinction, habitat fragmentation, loss of ecosystems, and loss of species diversity (Pandit and Grumbine 2012). Elsewhere, constructing dams on rivers is known to change downstream ecological processes and set in motion complex chain reactions that transform floodplain

Table 5.5 A few examples of synergies and trade-offs between ES

Driver	Service A	Service B	Shared driver	Response type	Interaction type	Synergy or trade-off
Large-scale afforestation and short rotation coppice plantations	Biodiversity	Biomass production	Yes	Opposite	None	Trade-off
Large-scale afforestation and short rotation coppice plantations	Biomass production	Soil organic carbon	Yes	Similar	Unidirectional (Positive)	Synergy
Substitution of extensively used grassland	Food	Biodiversity	Yes	Opposite	None	Trade-off
Substitution of farmland with forest	Carbon sequestration	Protection from gravitational hazard	Yes	Similar	None	Synergy
Natural forest conversion for exotic tree plantations	Biodiversity	Carbon storage	Yes	Similar	None	Synergy
Natural forest regeneration on agricultural and grazing land	Biodiversity	Carbon storage	Yes	Similar	None	Synergy
Agriculture expansion/Fertilizer use	Agricultural production	Water quality	Yes	Opposite	None	Trade-off
Maintaining forest patches close to coffee plantations	Pollination	Agricultural production	No	NA	Unidirectional (Positive)	Synergy
Trail building	Cultural tourism	Agricultural production	No	NA	None	None
Afforestation	Carbon sequestration	Water quantity	Yes	Opposite	Unidirectional (Negative)	Trade-off

Source Bennett et al. (2009)
NA = data not available

vegetation dynamics (Wieringa and Morton 1996). With impacts ranging from changes in river geomorphology and hydrology (Brandt 2000) to impairment of the ecological integrity of rivers through the extirpation of species and loss of ecosystem services (Richter et al. 2003), river regulation is the most substantial and widespread anthropogenic effect on riverine ecosystems (Pandit and Grumbine 2012).

5.4 Conservation and Management Practices

In recent decades, the HKH has witnessed significant conceptual development in biodiversity conservation, from 'people exclusionary' and 'species-focused' to 'people-centred community-based' approaches. The United Nations Conference on Environment and Development (UNCED) in 1992 placed a premium on people's participation and promotion of this conceptual shift in both natural resources management and biodiversity conservation (UN 1992). In response, participatory approaches evolved as the accepted means in various sectors in the HKH (Sharma et al. 2010). The classical approach of biodiversity conservation, which started with an emphasis on the conservation of flagship species (Yonzon 1989; Wikramanayake et al. 1998), evolved to landscape level conservation, with the understanding that 'conservation and management of biodiversity are impossible without people's participation' (Chettri et al. 2010; Zomer and Oli 2011; Bajracharya et al. 2015). Since the 1980s, de-centralization and devolution of authority for biodiversity conservation have been evident in governments' efforts across the HKH (Desai et al. 2011; Sharma et al. 2010; Sunam et al. 2015). During the process, it was realised that biodiversity management by local people is more effective when the utility value and benefit to communities is evident (see Gurung and Seeland 2008). After the late 1990s, conservation approaches in the HKH took on a new dimension with the concept of linking the existing protected areas with biological corridors (Sherpa and Norbu 1999). This approach, while addressing the biophysical advantages of corridors for migration and habitat contiguity, also supports species refugia for restoration, and shifting of species and habitat types in response to environmental pressures such as climate change. Subsequently, the concept of landscape-level conservation approaches evolved in the region, generally adopting the ecosystem approach advocated by the Convention on Biological Diversity (CBD) (see Sharma et al. 2010). These evolutions comprised both ex situ and in situ approaches. In addition, inclusion of traditional ecological knowledge, belief, and culture also contributed substantially in addressing the conservation goal.

5.4.1 Flagship and Keystone Species Conservation

As a result of its ecosystem diversity, the HKH is one of the most biodiverse areas in the world with the highest number of species and endemism (Myers et al. 2000; Mittermeier et al. 2004). Large mammal in situ conservation has a long history. It has been practised since 1950 with species like the greater one-horned rhinoceros (*Rhinoceros unicornis*), Asian elephant (*Elephas maximus*), and Bengal tiger (*Panthera tigris tigris*) in the tropical lowlands, red panda (*Ailurus fulgens*) and Asian black bear (*Ursus tibetanus*) in the temperate region, and snow leopard (*Panthera uncia*) and Himalayan musk deer (*Moschus leucogaster*) in the alpine region. The status of many of these species is facing additional challenges (see Table 5.6). Despite tireless efforts towards conservation, the majority of species are being driven towards extinction. The exceptions are Tibetan antelope or chiru (*Pantholops hodgsonii*) and the giant panda (*Ailuropoda melanoleuca*), which were removed from the endangered species list by the International Union for Conservation of Nature (IUCN) in 2016.

Some of the iconic species in the HKH have been researched more than others (Kandel et al. 2016). Understanding of the ecology of the greater one-horned rhinoceros has considerably improved (Dinerstein and Price 1991; Pradhan et al. 2008); the population is either stable or has increased in its present range countries (Thapa et al. 2013). However, the historical range that extended along the floodplains of the Ganges, Brahmaputra, and Sindh Rivers from Pakistan to the Indo-Burma border (Amin et al. 2006) is now restricted to nine populations in protected areas (PAs) in India and Nepal (Menon 1966). With the exception of the populations in Chitwan National Park in Nepal and Kaziranga National Park and Jaldapara Wildlife Sanctuary in India, the populations each number less than 150 individuals. Notably, Nepal has made significant progress in reversing the decreasing trend of rhinoceros (Fig. 5.11) and has also celebrated three consecutive years of zero poaching (Acharya 2015). Likewise, periodic status reports from the snow leopard home range countries have added to the limited knowledge about this elusive species (Karmacharya et al. 2011; Ale et al. 2014; Alexander et al. 2016). New dimension of species range with sub-species was recently added for now leopard (Janecka et al. 2017). However, analysis of the impact of climate change on the range of snow leopards predicts a contraction in suitable habitat and a fragmentation of distribution—both of which could cause a significant contraction in the range of the species (Forrest et al. 2012; Li et al. 2016). Red panda is another flagship species in the temperate forest, confined to three global biodiversity hotspots—Himalaya, Indo-Burma, and the mountains of southwest China (Kandel et al. 2015). Although it is one of the most researched species in the Eastern Himalaya (Kandel et al. 2016), very little is known about its ecology and distribution (Yonzon 1989; Wei et al. 1999; Choudhary 2001; Pradhan et al. 2001; Groves 2011; Dorji et al. 2012). Red panda has been sighted in five of the eight HKH countries (Bhutan, China, India, Nepal, and Myanmar), and has an estimated habitat area 32,600 km^2 within the region (Kandel et al. 2015). However, unlike snow leopard, tiger, and rhinoceros, the red panda has yet to receive global attention for conservation.

5.4.2 Protected Areas Management

The HKH has made significant progress in the establishment of PAs in recent decades (Chettri et al. 2008). As of 2007, there were 488 PAs (IUCN category I–VI) within the HKH, covering more than 1.6 million km^2 or about 39% of the region's terrestrial area (Table 5.7), with significant growth witnessed over the last three decades (Fig. 5.12). Although PA coverage has been identified as a key indicator for assessing progress in reaching the Aichi targets (Secretariat of CBD 2014), many scholars have pointed out that the percentage of area protected in a given country or biome is not a strong indicator of actual conservation needs or effective action (Oli et al. 2013). In particular, this indicator overlooks the fact that biodiversity is unevenly distributed across the region. For example, the Brahmaputra Basin in the Eastern Himalaya is significant for both aquatic and terrestrial biodiversity with a high level of endemic species and high proportion of rare, endangered, and threatened species compared to the western Himalaya (see Allen et al. 2010). More significant, perhaps, is the fact that actual implementation of conservation measures within PAs varies greatly across the region. In Myanmar, for example, human-induced pressure and lack of financial and skilled human resources are impinging on the effective management of PAs (Rao et al. 2002). Bawa (2006) also points out that local challenges, such as a lack of economic opportunities, interdisciplinarity in conservation actions, institutional development, skilled human resources, and large-scale conservation approaches hinder conservation. In spite of these challenges, half of the HKH countries—Bhutan, China, Nepal, and Pakistan—have either reached, crossed, or are heading towards the global target of 17% area covered by PAs by 2020 (see Table 5.7).

5.4.3 Conservation Through Traditional Knowledge

Management of resources to sustain the flow of ecosystem services was, and still is, widely practised by many communities in the Himalaya as part of their traditional

Table 5.6 Current population trends of key mammal species in the HKH (1996 and 2016)

Common name	Scientific name	Reported distribution	IUCN category (IUCN 1996)	IUCN category (IUCN 2016–17)	Current population trend (IUCN 2016–17)
Alpine musk deer	*Moschus chrysogaster*	China, eastern Nepal, Bhutan, and north-eastern India	NT	EN	↓
Himalayan musk deer	*Moschus leucogaster*	Across the Himalaya of Bhutan, northern India (including Sikkim), Nepal, and China (southwest Xizang)	NT	EN	↓
Black musk deer	*Moschus fuscus*	China (north-western Yunnan and south-eastern Tibet), northern Myanmar, north-eastern India (Arunachal Pradesh), Bhutan and eastern Nepal	NT	EN	↓
Forest musk deer	*Moschus berezovskii*	Most of the alpine regions in eastern Nepal, Bhutan, North-east India and Southern and South-eastern China	NT	EN	↓
Elk (MacNeill's deer)	*Cervus canadensis ssp. macneilli*	Central and SW China (N Qinghai, Gansu, Shaanxi, W Sichuan and E Xizang)	NE	NE	?
Elk (Tibet red deer)	*Cervus canadensiswallichi*	SW China (SE Xizang), Bhutan	NE	NE	?
Kashmir stag	*Cervus hanglu*	North India (Kashmir)	EN	LC	?
White-lipped deer	*Cervus albirostris*	China (Gansu, Qinghai, Yunnan)	VU	VU	?
Argali	*Ovis ammon*	Afghanistan, China India, Nepal and Pakistan (above 3000 m)	VU	NT	↓
Argali (Marco Polo sheep)	*Ovis ammon polii*	North western edge particularly in Pamir mountains(Afghanistan, Pakistan, China)	NE	NE	?
Argali (Tibetan argali)	*Ovis ammon ssp. hodgsoni*	Central and eastern high mountains	NE	NE	?
Mouflon	*Ovis orientalis*	Afghanistan, North-western India (Kashmir) and Pakistan	VU	VU	↓
Blue sheep	*Pseudois nayaur*	Central and eastern high mountains in Bhutan, China, India, Myanmar, Nepal and Pakistan	–	LC	?
Dwarf blue sheep	*Pseudois nayaur ssp. schaeferi*	China (Sichuan, Tibet [or Xizang], Yunnan)	EN	EN	↓
Przewalski's gazelle	*Procapra przewalskii*	Around Qinghai Lake in China	CR	EN	↓
Goitered gazelle	*Gazella subgutturosa*	Afghanistan, northwest China and Pakistan	NT	VU	↓
Tibetan gazelle	*Procapra picticaudata*	Qinghai-Tibet Plateau in China and and Ladakh and Sikkim in India	NT	NT	↓

(continued)

Table 5.6 (continued)

Common name	Scientific name	Reported distribution	IUCN category (IUCN 1996)	IUCN category (IUCN 2016–17)	Current population trend (IUCN 2016–17)
Tibetan antelope (chiru)	*Pantholops hodgsonii*	Qinghai-Tibet Plateau in China and north-eastern Ladakh in India	VU	NT	↑
Brown bear	*Ursus arctos*	Widely distributed across Afghanistan, China, India and Pakistan and small population in Nepal	LC	LC	→
Giant panda	*Ailuropoda melanoleuca*	Sichuan, Shaanxi and Gansu provinces in China	EN	VU	↑
Red panda	*Ailurus fulegns*	Along a narrow elevation Himalayan belt (2500-4000 m) in Bhutan, China, India, Myanmar and Nepal	EN	EN	↓
Dhole	*Cuon alpinus*	Across Himalaya in Bhutan, China, India and Nepal	VU	EN	↓
Gray wolf	*Canis lupus*	All the HKH countries except Bangladesh	LC	LC	
Eurasian lynx	*Lynx lynx*	Higher elevations in Afghanistan, China, India, Nepal and Pakistan	LC	LC	→
Red fox	*Vulpes vulpes*	All the HKH countries	LC	LC	→
Siberian ibex	*Capra sibirica*	North western edge inAfghanistan, China, India and Pakistan,	LC	LC	?
Snow leopard	*Panthera uncia*	Across Afghanistan, Bhutan, China, India, Nepal and Pakistan, primarily in higher elevation	EN	VU	↑
Pallas's cat	*Otocolobus manul*	Across Afghanistan, Bhutan, China, India (Jammu & Kahmir), Nepal and Pakistan, primarily in higher elevation	LC	NT	↓
Takin	*Budorcas taxicolor*	Bhutan, China, northeast India (Arunachal Pradesh and Sikkim) and northern Myanmar	VU	VU	↓
Tibetan fox	*Vulpes ferrilata*	Tibetan Plateau including Nepaland India	LC	LC	?
Kiang	*Equus kiang*	Southern edge and Himalaya in China, India, Nepal and Pakistan	LC	LC	→
Wild yak	*Bos mutus*	China and India (Ladakh), primarily scattered populations in Tibetan plateau and Kunlun mountains in China	VU	VU	↓
Greater one-horned rhino	*Rhinoceros unicornis*	Himalayan foothills of India and Nepal	EN	EN	↓

Sources Chettri et al. (2012) and IUCN (2016, 2017). CR—critically endangered; EN—endangered; VU—vulnerable, NT—near threatened; LC—least concern; NE—not evaluated. ↑ = Increasing; ↓ → = decreasing; = Stable and ? = unknown

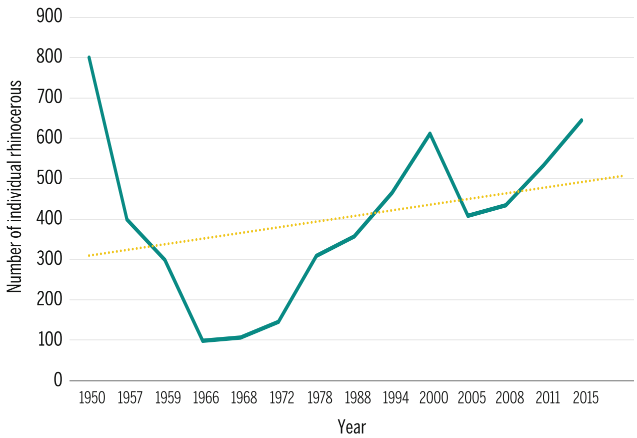

Fig. 5.11 Population of the greater one-horned rhinoceros in Nepal from 1950 to 2015 (*Source* Acharya 2015)

Table 5.7 Number and area of PAs in the HKH (as of 2007)

Country	Number of PAs	PA coverage (km^2)	% of PA coverage with respect to country	% of PA coverage with respect to total area of HKH
Afghanistan	6	2,461	0.44	0.06
Bangladesh	5	632	1.70	0.01
Bhutan	10	16,396	42.71	0.38
China	221	1,522,172	15.15	35.50
India	135	62,417	8.99	1.46
Myanmar	16	23,967	5.32	0.56
Nepal[a]	20	34,357	23.34	0.80
Pakistan	76	18,721	11.85	0.44
Total	489	1,681,123	NA	39.21

Sources Sharma et al. (2010); [a]CBS (2014)

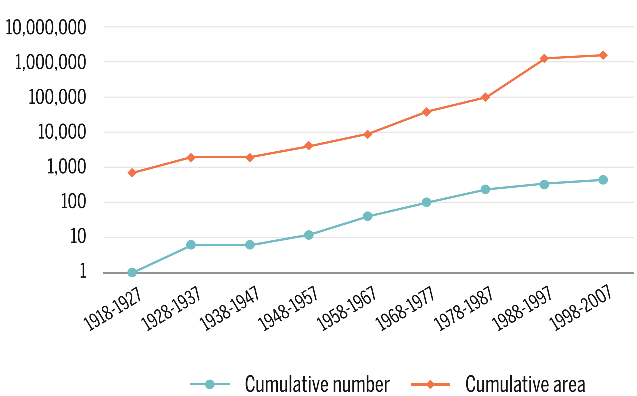

Fig. 5.12 Trend (log value) in number and coverage of protected areas in the HKH from 1918 to 2007 (Chettri et al. 2008)

ecological knowledge system (Dudley et al. 2009; Singh et al. 2011). The blending of cultural, religious, and traditional knowledge systems has contributed substantially to the overall goal of conservation of species, ecosystems, and genetic diversity (Salick et al. 2007; Anthwal et al. 2010). There are numerous plants, animals, and ecosystems (forests, ponds, rivers, mountain peaks) across the region which have been conserved effectively through traditional practices. For example, there are numerous examples in the Himalayas of conservation of sacred groves maintaining significantly higher diversity compared to other areas (Khumbongmayum et al. 2005; Arora 2006). Traditional conservation practices are also regulated by customary laws through participatory decision-making processes. This is evident, for example, in the grazing and other resource management practices regulated through Dzumsa in North Sikkim (Acharya and Sharma 2012), and in the northern part of Humla District, Nepal, in the Kailash Sacred Landscape (Zomer and Oli 2011; Basnet and Chaudhary 2017). Such practices focus on management of ecosystems (Anderson et al. 2005), species (Mehra et al. 2014), or resource use patterns (Acharya and Sharma 2012). Many of these practices are categorised as community-conserved areas (CCA) or key biodiversity areas (KBA) and are being mainstreamed in national conservation practices. These CCAs and KBAs are increasing the focus of conservation interventions outside formal PA systems.

Religious and cultural beliefs related to natural resources have also played an important role in the conservation of the resources in the Himalaya, with the use and exploitation of certain plant and animal species prohibited in many areas (Negi 2005). For example, some of the forests in Garhwal and Kumaon in Uttarakhand, such as the Hariyali Sacred Landscape and Haat Kali Sacred Grove, cannot be used by anyone because they are dedicated to a deity and the forests and streams originating from them are considered sacred (Negi 2005; Sinha and Mishra 2015). In Chhyangru village in Byas Village Development Committee in the Api Nampa Conservation Area, Nepal, people decided to establish a temple in the forest called 'Shyanchho' to prevent further deforestation and degradation and conserve the forest as sacred forest (Chaudhary et al. 2017). Buddhist beliefs have been influential in conserving natural landscapes as ecocultural landscapes, including high elevation lakes and their basins in Ladakh and Sikkim (Maharana et al. 2000; Chandola 2012). In China, there are a few examples where cultural diversity manifested in social and cultural values of natural resources has played an important role in conservation (Anderson et al. 2005; Brandt et al. 2013a). Similarly, the Apatani ecocultural landscape in Arunachal Pradesh is protected by a mix of social and religious institutions which make use of traditional ecological knowledge in sustainable resource management. Hence, there is a growing recognition of a form of environmental governance that acknowledges the role of local communities and their traditional practices to restrain unrelenting forest degeneration while ensuring ecological and economic benefits for the community (Paul and Chakrabarti 2011; MoAF 2014).

Table 5.8 Landscape initiatives in the HKH

Landscape initiative	Geographical coverage	Main themes	Source
Bhutan biological conservation complex	Bhutan	Protected areas and conservation corridors	Sherpa and Norbu (1999), NCD (2004)
Everest complex	China and Nepal	Regional cooperation, information sharing, and developing decision-making tools	Sherpa et al. (2003), Bajracharya et al. (2010)
Terai arc landscape	Nepal and India	Community-based conservation in protected areas and conservation corridors	Gurung (2004b), MoFSC (2015a)
Kangchenjunga landscape	Eastern Nepal, Sikkim and north Bengal in India, and western Bhutan	Conservation and development in protected areas and conservation corridors	Sharma and Chettri (2005)
Kailash sacred landscape	Western Nepal, Uttarakhand in India, and Tibet autonomous region in China	Conservation and development around sacred sites and in protected areas	Zomer and Oli (2011)
Far-Eastern himalaya	Arunachal Pradesh in India, Kachin State in Myanmar, and Yunnan in China	Conservation and development in biodiversity hotspots	Guangwei (2002), Shakya et al. (2011)
Karakoram pamir	Afghanistan, China, Pakistan, and Tajikistan	Conservation and development in arid ecosystems	Ning et al. (2014)
Chitwan-Annapurna landscape	Nepal from Chitwan national park in the south to Manaslu, Langtang, and Annapurna in the north covering 19 districts	Conservation and development in the Gandaki river basin from tropical lowland Terai to alpine high mountain and cold and dry trans-Himalaya	MoFSC (2015b)
Sacred himalayan landscape, Nepal	Koshi basin covering Langtang national park to Makalu Barun national park	Protected area management, river basin management, community forest and cultural conservation	MoFSC (2016)
Western mountain landscape	Fourteen mountain districts in the Mid-western and Far-western development regions in Nepal	Chure, mid-mountains, high-mountains, protected area management, community forest, protection forest, Karnali, Bheri and Seti river basin	MoFSC (2017)

Adapted and modified from Chettri and Sharma (2016)

5.4.4 The Landscape Approach—Recognizing Complexity and Understanding Linkages

Landscape-level biodiversity conservation is an evolving concept in the HKH. The concept has emerged primarily out of recognition that strict protection through a network of PAs (national parks, sanctuaries, wildlife reserves, and others) is an essential but insufficient strategy for biodiversity conservation (Wikramanayake et al. 2004). Now, the focus has shifted from preserving isolated patches of sustained wilderness in the form of PAs to maintaining landscape integrity (Chettri et al. 2008; Wikramanayake et al. 2011) and seeing—and conserving—ecosystems as part of larger agro-ecological and sociocultural landscape (Zomer and Oli 2011). These efforts, including protection through policy and practices, have resulted in an increase in population of many wildlife species (Acharya 2015). The transboundary landscape approach is also gaining prominence in many areas in the search for solutions to reconcile conservation and development trade-offs (see Sharma et al. 2007b; Zomer and Oli 2011). In addition, the approach is addressing the need for regional cooperation, knowledge and information sharing, and opportunities for cross-learning and capacity building from best practices. There are a number of landscape-level initiatives for biodiversity conservation in the HKH at different development levels (Table 5.8). The majority of these initiatives have looked at ways of reconciling conservation with development with a focus on community wellbeing. However, differences in conservation policies and practices have led to differences in reaching conservation goals (see Box 5.2).

Box 5.2 Results of diverse policies and practices

The Kangchenjunga Landscape, a transboundary complex shared by Bhutan, India, and Nepal, has 19 protected areas (see ICIMOD, WCD, GBPNIHESD, RECAST 2017), 17 in India and one each in Bhutan and Nepal. Nine are transboundary in nature, with differences in their protected category on different sides of the border. They include the Kangchenjunga Conservation Area in Nepal which is contiguous with the Khangchendzonga National Park and Biosphere Reserve in India; the Buxa Tiger Reserve in India which is connected to unreserved areas in Bhutan; the Jigme Khesar Strict Nature Reserve in Bhutan which is connected to Neora Valley National Park and Pangolakha Wildlife Sanctuary in India; and the Singhalila National Park in India which is contiguous with unreserved areas in eastern Nepal. These variations in protected area management systems have led to variations in effectiveness in terms of performance and reaching conservation goals (Oli et al. 2013).

5.4.5 Participatory Forest Resources Management Practices

The rapid depletion and degradation of forest resources in the last few decades has resulted in a serious threat to rural livelihoods and environmental sustainability in the HKH. Increasing awareness of the critical situation amongst all actors has led governments to endorse a set of new forest policies and legal frameworks over the last 15–20 years that have enabled forest management practices to flourish. Different types of management system have been introduced—community forestry (CF) and leasehold forestry (LHF) in Nepal, joint forest management (JFM) in India, community-based natural resources management (CBNRM) and an integrated conservation and development programme (ICDP) in Bhutan, and others—but in all the main objective was to address the issue of degrading forest resources through decentralized governance systems. Bangladesh, Bhutan, India, and Nepal, in particular, have shifted their forestry policies from highly centralized approaches to a participatory type of forest management.

Participatory forest management (PFM) began in Bangladesh in the early 1980s under the banner of social forestry (SF). By 2005, more than 40,000 ha of forestland were under SF, which has now become an integral part of the country's forest management (Chowdhury and Koike 2010). In Bhutan, CBNRM, which includes SF and CF, was initiated in the early 1980s. The Ninth Five Year Plan (2002–2007) emphasized PFM as a primary driver of forest management; the number of community forest management groups increased from 31 in 2006 to 677 in 2016, benefiting 28,311 households (Rasul et al. 2011b; MoAF 2016). JFM in India brought an important breakthrough in the relationship between the Forest Department and the community, and is now the primary driver of forest management in India, spreading over 28 states and covering 21.44 million ha of forest (Mukerji 2006). The ecodevelopment projects of the Great Himalayan National Park, Nanda Devi Biosphere Reserve, Hemis National Park, and Rajaji National Park in the Indian Himalaya are among the best examples (Badola et al. 2014). CF was introduced in Nepal in the late 1970s; now, 18,500 community forest user groups are managing more than 1 million ha of forest, accounting for about one-third of total forest area (MoFSC 2015a). In China, the Collective Forest Reform implemented in 2004 has given complete rights to local farmers to manage forestlands (Xu et al. 2010). Pakistan formulated the National Forest Policy (MoCC 2015) to expand, protect, and promote sustainable use of forests, protected areas, natural habitats, and watersheds in order to restore their ecological functions and improve livelihoods and human health, in line with the national priorities and international agreements. The forest-rich areas of North West Frontier Province (now Khyber Pakhtunkhwa) in Pakistan saw an improvement in natural and financial capital for local people with the

Table 5.9 Community-based forest resource management practices and their coverage in the HKH

Country	Terms used to denote participatory forest management	% forest in total area of country	Area of community forestry	
			million ha	% of country's forest area
Afghanistan	Community-based forest management	2.0	NA	0.0
Bangladesh	Social forestry	17.5	NA	0.0
Bhutan	Community based natural resources management	70.4	0.07	2.5
China	Community-owned forests or collective forestlands	NA	NA	58.0
India	Joint forest management	3	21.0	28.5
Myanmar	Community forestry	27.1	NA	NA
Nepal	Community forestry	44.7	1.79	30.3
Pakistan	Community-based forest management of Guzara forests	NA	0.8	20.0

NA = data not available

Forestry Sector Project that institutionalized participatory forest management in the area (Ali et al. 2007).

The outcomes of these participatory and community-based approaches have largely had positive ecological, economic, and social impacts. Ecologically, regeneration of substantial areas of degraded forests has improved and there has been a visible impact in reversing the trend towards deforestation and forest degradation (Gurung et al. 2013). Socially, they have given institutional space for local communities to make their own decisions on a range of issues related to forests, income, inclusion, social justice, and so on. Economically, they have contributed to the economic opportunities available to local rural people (Xu et al. 2010; Birch et al. 2014). Bhutan, China, India, and Nepal have made good progress and Myanmar is trying hard to move, whereas Afghanistan, Bangladesh, and Pakistan have yet to make progress to achieve a visible impact from community forestry (Table 5.9). However, some of the approaches have limitations and shortcomings, such as elite capture, social disparity, inequitable benefit-sharing, and exclusion of poor and marginalized groups (Gurung et al. 2013). Special attention is needed to make participatory forestry inclusive with equitable benefit-sharing and a pro-poor focus.

5.4.6 National and International Policies and Legislations—Support for Biodiversity Conservation

The HKH has witnessed a significant paradigm shift for biodiversity conservation during the last few decades. The alarming forest condition of the Himalaya (Ives and Messerli 1989; Pandit et al. 2007), increasing human population and overexploitation of biodiversity (Sandhu and Sandhu 2014; Chettri and Sharma 2016), and the increasingly changing alpine meadow of the Tibetan Plateau (Klein et al. 2004; Luo et al. 2010) have highlighted numerous conservation and management challenges for biodiversity conservation in the region (see Sharma et al. 2009; Shrestha et al. 2012). However, with adaptive management and appropriate policies, the perception of conservation has changed significantly over the pre- and post-1992 periods (see Fig. 5.9). Since the new thinking in conservation and environmental management began in 1972 at the Stockholm conference, a number of key influential global developments have taken place. The Convention on Biological Diversity of 1992 (UN 1992) was an important milestone in the history of biodiversity conservation. Although a number of conventions were already in place before 1992 (such as the Ramsar Convention, World Heritage Convention, Convention on International Trade in Endangered Species of Wild Fauna and Flora, International Treaty on Plant Genetic Resources, and others), the CBD was instrumental in focusing on conservation and sustainable use of biodiversity (see Fig. 5.13).

The founding of the International Geosphere-Biosphere Programme and Millennium Development Goal agendas during 1992–2000 brought additional support. The perspective of biodiversity conservation totally changed when the Millennium Ecosystem Assessment (MA) processes advanced and the CBD initiated supporting programmes on PAs and mountain biodiversity during 2001–2010. With advancement of the MA, global communities accepted more strongly the concept of ecosystem services as a means of rationalizing the significance of biodiversity to human wellbeing, and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) was established. Progressive change continued in the global arena with the 2020 Aichi targets in 2010 and Sustainable Development Goals and UNFCCC Paris Agreement in 2015 (Fig. 5.13).

In the HKH, several policies were formulated and practised before 1992, beginning with the Forest Act 1927, which is still instrumental in India and Pakistan. This was followed by the Wildlife Protection Act of 1972 in India and the Islamabad Wildlife (Protection, Preservation, Conservation, and Management) Ordinance 1979 in Pakistan. In Nepal, the National Parks and Wildlife Conservation Act of 1973 was the pioneering legal instrument, while the first formal conservation instrument in China was the law on the Protection of Wildlife 1988. Since 1999, China has been addressing deforestation progressively with the ‘Green for Grain’ policy and practices, with commendable success (Box 5.3). The first national policy for Bhutan was the forest policy formulated in 1974; which was followed by the Forest and Nature Conservation Act 1995, which dedicates two chapters to biodiversity conservation, with several sections on PAs and conservation of wildlife.

Box 5.3 Grain for green

The Grain-for-Green policy, the largest land reforestation/afforestation program in China, was launched in 1999 to mitigate land degradation by returning steeply sloping cultivated land to forest or grassland. Although the initiative showed variations, it has contributed significantly leading to a doubling of forest cover and increased carbon sequestration (Chen et al. 2015b). The value of nutrient cycling, regulating gases, organic material provision, and soil conservation increased by 64, 39, 40, and 18%, respectively (Song et al. 2015). The initiative is expected to sequester 110.45 Tg C by 2020, and 524.36 Tg C by the end of the century, with economic benefits ranging from USD 8.84–44.20 billion between 2000 and 2100, which may exceed the current total investment (USD 38.99 billion) on the program (Liu et al. 2014). The results indicate that a large-scale initiative with policy support can bring significant change towards addressing climate change.

GLOBAL POLICIES	KEY NATIONAL POLICIES	KEY NATIONAL LAWS	REMARKS
2010-2016			
IPBES established (2010) CBD: Strategic Plan 2010-2020 with Aichi targets (2010) UNFCCC: Paris Agreement (2015) Sustainable Development Goals (2015)	Pakistan: National Climate Change Policy (2012)		ES mainstreamed through IPBES Mountain Ecosystem recognized as important ecosystem by SGD 15
2001-2010			
Millennium Ecosystem Assessment launched (2001) Earth Summit (2002) MEA Framework launched (2003) International Treaty on Plant Genetic Resources for Food and Agriculture (2004) MEA report for policy makers launched (2005) Programme of Work on Protected Area (2004) Programme of Work on Mountain Biodiversity (2004)	India: The Wildlife Action Plan (2002-2016) India: National Action Plan on Climate Change (2008) India: National Biodiversity Strategy and Action Plan (2009) Nepal: Biodiversity Strategy (2002) Pakistan: National Environment Policy (2005) Pakistan: National Forest Policy (2008) Pakistan: National Vision 2030 on forest biodiversity conservation (2008)	India: Wildlife Protection Act (1972) and Amendment Act (2002) India: Biological Diversity Act (2002) Nepal: National Parks and Wildlife Conservation Act, Nepal (1972) and Amendment (2002)	Landscape approach mainstreaming Connectivity and corridor concept embedded in practice Transboundary cooperation in conservation brought into practice Importance of wetland ecosystems highlighted Recognition of community forest practices Biodiversity conservation linked to human wellbeing
1992-2000			
Convention on Biological Diversity (1992) International Geosphere and Biosphere Programme (1997) Millennium Development Goals (2000)	Bhutan: Biodiversity Action Plan (1994) Bhutan: National Forest Policy (1995) China: National Biodiversity Action Plan (1999) Nepal: Environment Policy and Action Plan (1993)	Bhutan: Forest and Nature Conservation Act (1995) India: Panchayati Raj Act (1996) India: Wildlife Protection Act (1972) and Amendment Act (1991) Nepal: Nepal Forest Act (1993) Pakistan: Environmental Protection Action (1997)	Emphasis on government managed to people managed Centralized funding to decentralized funding at the local level Collaborative management of forest, wetlands, and protected areas Participatory and inclusive conservation Emphasis on benefit sharing institutional growth Punitive action to participatory action Concept of landscape and corridor emerged
Pre-1992			
Ramsar Convention (1971) World Heritage Convention (1972) CITES: Washington Convention (1972)	India: Forest Policy (1952) India: National Forest Policy (1988) India: National Conservation Strategy and Policy Statement (1992) Myanmar: Forest Policy (1995) Nepal: New Forest Policy (1978) Nepal: National Conservation Strategy (1988) Pakistan: Forest Policy Statement (1991) Pakistan: National Conservation Strategy (1992) Pakistan: National Biodiversity Action Plan (1998)	China: Forest Law (1984) India: Indian Forest Act (1927) and amendments (1980) India: Environment Protected Act (1986) India: Wildlife Protection Act (1972) Nepal: Legal Code 'mulikhi ain' (1854) Nepal: Forest Nationalization Act (1957) Nepal: Forest Act (1962), amendment (1968) Nepal: National Parks and Wildlife Conservation Act, Nepal (1972) Pakistan Forest Act (1927) Pakistan: Islamabad Wildlife Ordinance (1979)	The word 'ecosystem services' coined (1981) The word 'biodiversity' coined (1986) Disempowerment of people from resources Resources brought under eminent domain Government control over biological resources No people's participation Motive mainly on revenue generation

Fig. 5.13 Development of modern biodiversity conservation at the international level and its impact on conservation policies and laws of HKH countries

Many of the earlier versions of policies and laws prohibit human influences on an ecosystem once the area has been declared as a national park or wetland of international importance. Even areas outside PAs may be under forest or wetland law in which usufruct rights were denied to the local communities. As a result, the degradation of Himalayan ecosystem was strongly predicted during this time (Ives and Messerli 1989). To address Himalayan degradation and other conservation issues, from 1992, the policies and legislation in the Himalayan countries were amended and improved several times and new laws for local resources management were promulgated, mainly driven by the global development and establishment of numerous conventions, including the CBD. The Panchayat (Extension to Scheduled Areas) Act 1996 and Biological Diversity Act 2002 in India, and the Conservation Area Rules 1996, National Parks and Wildlife Conservation Act (1972) and its amendment (1993), Forest Act (1993), Forest Policy (2015), and Buffer Zone Management Regulation 1996 in Nepal are good examples of policy changes towards conservation. Each case represented, in several fundamental ways, a devolution of control from government authorities to local communities—a major shift. As an adaptive social process, these moves strived to create sufficient future forest opportunity to satisfy potentially competitive/conflicting interests that would diminish the forest if left unresolved (Singh et al. 2010). The change has been further boosted by the declaration of the National Mission for Green India targeting the afforestation of 6 million hectares of degraded forest lands and expanding forest cover from 23 to 33% of India's territory through people's involvement, and enlarging the landscape under conservation (GoI 2008). The development of modern biodiversity conservation at the international level and its impact on the conservation policies and laws of HKH countries (Fig. 5.13) has brought about a new paradigm in conservation and sustaining ecosystem services in the HKH.

5.5 Sustaining Ecosystems—Challenges, Opportunities, and Strategies

The local communities in the HKH face uncertainties and challenges as they strive to use, nurture, and sustain the diverse ecosystems at landscape scale where they live and on which they depend. The most powerful contemporary forces that influence both biological and cultural diversity and livelihoods include government policies, expansion of regional and global markets, and climate change, among others. Some of these forces are positive, others are not (Xu and Grumbine 2014a). With increasing awareness of upstream and downstream linkages, biodiversity and ecosystem services have been recognized for their ecological, sociocultural, and economic values (Rasul 2014). While acknowledging that some indigenous communities are more resilient than others, the knowledge, innovations, and practices of local groups can be strengthened with appropriate assistance from partnerships with governments, non-governmental organizations, and the commercial sector to ensure equitable access and sustainable management of natural resources. These partnerships must be based on participatory processes, intercultural dialogues, and co-designing and co-production of hybrid knowledge among different stakeholders (Xu and Grumbine 2014b). They are also an important instrument for ecological restoration and poverty alleviation, especially in the upstream headwater areas (Grêt-Regamey et al. 2012; Sandhu and Sandhu 2014; Bawa and Seidler 2015; Feng et al. 2016). There are examples where increasing financial investment is being made for conservation and restoration of ecosystems. China has launched the Natural Forest Conservation Program (NFCP) and Sloping Land Conversion Program (SLCP), the largest payment for ecosystem service programs in human history (Uchida et al. 2005; Chen et al. 2015b). The cumulative total investment through the NFCP and SLCP exceeds USD 50 billion, and the SLCP alone benefits more than 120 million farmers in 32 million households (Ouyang et al. 2016). Ecosystem sustainability has been increasingly integrated into environmental, biodiversity conservation, and sustainable development agendas (Maselli 2012; Secretariat of CBD 2014; Díaz et al. 2015). The current trends of environmental degradation and the effects of projected climate change in the region necessitate the inclusion of local knowledge and institutions into environment management and conservation practices driven by cutting edge science.

This global natural capital and the Himalayan 'water tower' have been facing multiple drivers of change (see Chettri and Sharma 2016; Chap. 2). Traditional drivers such as deforestation, habitat loss, habitat degradation and fragmentation, overharvesting of biological resources, illegal hunting and poaching, monoculture plantation, agricultural intensification and loss of genetic resources, shifting cultivation with insufficient fallow period, human-wildlife conflict and livestock and crop depredation, invasive alien species, and atmospheric pollution are often recognized as having an adverse impact on conservation and sustainable use of biodiversity and ecosystem services (Aryal and Kerkhoff 2008; Zomer and Oli 2011; Chettri and Sharma 2016; ICIMOD, WCD, GBPNIHESD, RECAST 2017). However, the effects of indirect drivers related to socioeconomic and sociocultural factors, urbanization, poverty, and poor governance and weak institutional frameworks are poorly understood and managed. The HKH has become a centre of rapid and unplanned development through mining operations, urbanization, haphazard construction of dams for hydropower, and poorly planned and constructed roads resulting in changes in this vulnerable and fragile region (Pandit and Grumbine 2012; Pandit et al. 2014). Though at varied scales, forest degradation has been continuous across the HKH except Bhutan (Pandit et al. 2007; Uddin et al. 2015; Chakraborty et al. 2016). The impacts of climate change add to the severity of the problems in the area and have been prominently featured as one of the drivers (Xu et al. 2009a; Shrestha et al. 2012), and alien and invasive species have visibly altered the overall composition of the ecological variables (Kohli et al. 2004; Bhattarai et al. 2014). The direction and trends predicted for climate change and bioclimatic conditions generally indicate accelerated change and major disruption for the region (Shrestha et al. 2012). Rising temperatures, changes in precipitation patterns, and reduction in the volume of glaciers (Xu et al. 2009a; Panday et al. 2014) create a host of cascading effects and will have a major impact on ecosystems, biodiversity, and livelihoods throughout the region (Immerzeel et al. 2013; Zomer et al. 2014, 2015, 2016). The changes have resulted in a decrease in the resilience capacity of the natural systems which is impacting human wellbeing.

There is increasing evidence of the impacts of climate change on biodiversity and ecosystems. Instances of changes in phenology (Ranjitkar et al. 2013; Hart et al. 2014) and shifts of species towards higher elevation (Valley 2003; Joshi et al. 2012; Brandt et al. 2013b; Telwala et al. 2013) have been reported. Such changes are likely to be profound with extraordinary levels of biotic perturbation (Shrestha et al. 2012). Overall, the ability of species to respond to climate change will largely depend on their ability to 'track' the shifting climate by colonizing new territory or to modify their physiology and seasonal behaviour (such as periods of flowering or mating) to adapt to the changed conditions (Thuiller et al. 2008). The efficiency of species' responses under climate change is likely to be highly idiosyncratic and difficult to predict (La Sorte and Jetz 2010). The heterogeneity of the mountain terrain provides both biological refugia and natural dispersal corridors, but can also present a variety of challenges to the migration of species. Niches for shifting mountain species along elevational gradients decrease in size with increasing elevation, or disappear at the mountains' top (Körner 2007). Likewise, rapid changes in seasonal variations, such as the timing and length of the growing season, or warmer winter temperatures, perturb ecosystem functioning, disrupting finely tuned pollinator interactions (as when cycles between the insect and the plant it specializes on become unsynchronized), affecting emergence or migration of either predator or prey species, or allowing for the overwintering and survival of pests and pathogens.

Many of these impacts can be expected to manifest before 2050 (Mora et al. 2015; Zomer et al. 2016). The cascading effects will also impact agricultural and pastoral systems (Maikhuri et al. 2001). Agricultural systems, mountain communities, and mountain livelihoods are susceptible and will be profoundly affected. Local communities, highly dependent upon ES, may be able to adapt through the expansion of cropping systems into new areas, the introduction of new varieties or new technologies, or the modification of existing production practices, and by relying on traditional ecological knowledge for coping with variability and maintaining socio-ecological resilience. The highly diverse and environmentally fine-tuned agrobiodiversity of this region may both provide options and be threatened, including the many genetic lines and landraces of various important food crops and livestock breeds found in the HKH. Although conditions may possibly improve for production in places (e.g., warmer and wetter), erratic and highly variable patterns of rainfall, increases in extreme events, occurrence of drought, or changes in the intensity and duration of the monsoon will create major adaptation challenges (Ramesh and Goswami 2007).

The magnitude and speed of these bioclimatic changes are likely to have an impact on the conservation effectiveness of the many PAs and other conservation efforts within the HKH (La Sorte and Jetz 2010; Zomer et al. 2015). For example, ecological conditions within PAs may change beyond limits conducive for the species currently found there as species ranges shift. The ability to survive, adapt to, or benefit from the changes is species- and site-specific and depends on factors such as population dynamics, seed dispersal mechanisms, habitat availability and/or fragmentation, and physiological adaptability (Corlett and Westcott 2013). Improving our understanding of the responses of the species found in the HKH is imperative if conservation strategies and policies designed to meet these challenges are to be effective. This is equally true for maintaining agricultural production for food security and contributing to sustainable development in the HKH, particularly concerning the traditional mountain agricultural systems found in the region, which are generally highly adapted to specific climatic niches within the highly heterogeneous mountainous terrain.

The challenges could be translated into opportunities through development and implementation of appropriate strategies. The core issue identified from the analysis so far indicates that transformative changes have mainly been driven by either a constantly changing climate or land use change to enhance production systems to address resource crises due to the increasing demand of a growing population. The effectiveness of governance systems and implementation of evolving policies also needs special attention. The following broad strategic direction could be useful for long-term resolution.

5.5.1 An Integrated Approach—The Landscape as a Socio-Ecological System

Humans, unlike any other multicellular species in Earth's history, have emerged as a global force that is transforming the ecology of the entire planet. It is no longer possible to understand, predict, or successfully manage ecological patterns, processes, or change without understanding why and how humans reshape these over the long term. To investigate, understand, and address the ultimate causes of anthropogenic ecological change, not just the consequences, human sociocultural processes must become as much a part of ecological theory and practice as biological and geophysical processes are now. The 240 million people living in the HKH are strongly linked to the ecosystem health of the region that ensures the continuous flow of services for their subsistence livelihood (Xu et al. 2009a). This intricate linkage between ecosystem and human wellbeing has been shaping the ecosystems and helping in supporting diversity (Gorenflo et al. 2012). More important, this diversity, which also addresses poverty, needs socio-ecological understanding (Gerlitz et al. 2012).

The state of biodiversity and ecosystem services in the HKH is rapidly changing due not only to increasing synergistic effects of anthropogenic and natural drivers but also to weak governance and institutions' limited capacity to cope with such changes. An integrated, gender- and socially-inclusive, and national and inter-regional enabling policy approach can help in reforming governance policies and institutional and legal frameworks, and promote conservation and sustainable use of biodiversity and ecosystem services. The diverse ecosystems support tourism, agricultural production, water security, and clean energy development downstream. To sustain these services, and to ensure food, water, and energy security in the HKH, management of ecosystems including forests, wetlands, and rangelands is crucial (Rasul 2014). With increasing demand for and scarcity of land, water, energy, and natural resources for competing uses, the challenge is to minimize trade-offs and maximize synergies. Though the region has long witnessed a sectorial approach for conservation and development, it is essential to address the complexity of the HKH ecosystem and people's dependency through a cross-sector coordinated approach. Mountain tourism is one example where biodiversity conservation, cultural preservation, socioeconomic development, and environmental aspects could be better linked and coordinated (Nepal 2013). The socio-ecological systems are best dealt with by using a landscape approach (Sayer 2009). Strongly grounded in transdisciplinarity, the landscape approach has the potential to maximize synergy and secure integrated actions by multiple stakeholders (MoFSC 2016; ICIMOD, WCD, GBPNIHESD, RECAST 2017). The principles of the landscape approach, including transdisciplinarity, have been widely shared and applied across the countries of the HKH with varying degrees of success (Chettri and Sharma 2016). These principles have also been endorsed by the intergovernmental process dealing with biodiversity conservation and climate change mitigation and adaptation (Sayer et al. 2013). This approach could be used at different scales considering the linkages for raising the adaptive capacity of people and resilience of ecosystems. The river basin, landscape, and ecosystem approaches practised in the region could be further strengthened for better synergy and coordination (Rasul 2014; Chettri and Sharma 2016).

5.5.2 Building Knowledge—Science in Support of Decision-Making

Science-based knowledge development in the HKH is currently undergoing a remarkable transformation driven by (1) new technologies for linking, producing and processing ecological information; (2) increasing economic interest in natural resources from the mountains; (3) the rising prominence of markets, even in remote villages; (4) greater awareness of ecological crises; and (5) efforts to expand the participation of communities in ecological governance (Oli et al. 2013; Molden et al. 2014b). There has been considerable work on the production of ecological knowledge—local knowledge, indigenous knowledge, gendered knowledge, and ethno-ecological knowledge (Khadka and Verma 2012; Uprety et al. 2016). This work has identified issues of competing knowledge, access, and representation of different social groups. There has also been considerable discussion about how to integrate local knowledge, scientific knowledge, and decision sciences, especially state policies. The last decades in the HKH have seen the emergence of new technologies (information technology, geo-spatial tools, and participatory approaches), new actors (youths, academic institution), new values, new institutions (civil society, international development partners), and new territories that have come to play an integral role in ecological decision-making and participation. There is an increasing imperative to explore how diverse ecological knowledge can enter into evolving governance practice. The key question is, how does this knowledge transformation influence the varying capacities of these actors to shape their worlds through these valuations and understanding, and through ecological governance in the HKH and beyond? There is an increasing trend to bring together scientific scholars, graduate students, and community-oriented partners to mobilize ecological knowledge in the HKH. For example, the National Natural Science Foundation of China has launched a regular funding mechanism for scientific research in ecology on the edge of the Tibetan Plateau and Himalaya, and the National Mission for Sustaining the Himalayan Ecosystem (NMSHE) and National Mission for Himalayan Studies (NMHS) in India have been launched to broaden the scientific knowledge base in the Indian Himalayan Region to inform policy and practice (GoI 2016, 2017).

5.5.3 Regional Cooperation for Regional Challenges and Opportunities

The ecosystems of the HKH are diverse and the distribution among countries heterogeneous, but the majority of them are contiguous across borders (Xu et al. 2009a) and many of the globally significant ecoregions are shared by different countries (Olson and Dinerstein 2002). Even the environmental strata are contiguous across countries providing upstream and downstream linkages (Zomer et al. 2016). Many iconic species also have a wider habitat and range across different countries (Dorji et al. 2012; Forrest et al. 2012; Kandel et al. 2015). Many of the HKH countries have also developed a strong interdependence in trade, culture, and tourism (Chettri 2011). Traditional barter systems are still prevalent in remote areas of Nepal and China (Chaudhary et al. 2015a, b). There are also instances of wildlife trade and human-wildlife conflict across borders (Rao et al. 2011; Acharya et al. 2016), while numerous PAs are also transboundary in nature (IUCN 2005; Chettri et al. 2008), and many conservation issues demand regional cooperation. Pereira et al. (2010) have indicated a scenario in which biodiversity will continue to decline over the 21st century; however, the range of projected change is much broader than most studies suggest, partly because there are major opportunities to intervene through better policies, but also because of large uncertainties in projections. This strongly suggests the need to fill the gaps in research-based knowledge, and develop management and communication strategies focusing on multiple sources and approaches that lead to policy intervention. To translate this range of conservation and development challenges into opportunities for sustainable development, regional cooperation among the countries sharing such critical ecosystems will be essential.

5.5.4 National and Global Investment—Securing Future of Biodiversity and Ecosystem Services

Investment in conservation is a wise trade-off for sustaining the continuous flow of ES, enhancing ecosystem resilience, and ensuring a bright future for coming generations. However, the investment is not happening where it is most needed (Wilson et al. 2016). The HKH hosts four of the world's 36 biodiversity hotspots (Mittermeier et al. 2011) and is vulnerable to various drivers of change including climate change. However, the investment in conservation and management has faced disparity and been given low priority even by developing countries (Watson et al. 2016). It was observed that China and Nepal are among the top in investing on gross domestic expenditure on research and development (Katsnelson 2016). It is high time for conservation communities to plan investment based on the priority areas where biodiversity is declining at an accelerated rate (Waldron et al. 2013). Though the conservation investment by HKH countries is at different stages due to varying priorities and resource availability, the countries need to set aside more investment as a trade-off for sustainable development goals.

5.6 Conclusion

The HKH region is the source of ten major river systems and includes all or parts of four global biodiversity hotspots. The rich biodiversity and diverse ecosystems play a critical role in sustaining the wellbeing of the 240 million people of the region, and the goods and services from the mountain ecosystem are estimated to benefit a further 1.7 billion people in the downstream areas. The diverse ecosystems provide services with four values: social—for public benefit, cultural—for aesthetic and communal significance, ecological—for environmental conservation and sustainability, and economic—for livelihoods through production of goods and services. However, these services are poised for major changes in the current scenario of threats, chiefly as a result of climate change; local, regional and global market forces; and the socio-political environment prevalent in individual countries. There are other factors like cross-sectoral policies and strategies that will have a potential impact on ecosystems, while the lack of interdisciplinary understanding and knowledge, governance systems, consumption patterns of a large and growing urban population, and others have further impacted biodiversity and the functions and flow of services from ecosystems. Equally, these threats and their drivers have provide the stakeholders of the HKH with an opportunity for closer regional co-operation at all levels, especially for sharing knowledge, practice, and experience to develop robust strategies for managing the socio-ecological systems that are dependent on the sustained flow of ecosystem services. There has been an unprecedented effort made towards finding innovations and going beyond conventional approaches in managing these life-supporting systems (e.g., from a species to a landscape and ecosystem approach). Yet much remains to be done to reach a stage where we can claim that there is adequate resilience in the ecosystems and the communities to withstand the threats brought about by large local, regional, and global changes.

Regional co-operation needs further strengthening at the government, civil society, private sector, and community levels. Policies and their implementation have yet to reflect the integration that is required across different sectors to address some of the challenges mentioned above. Decision makers at all levels need to be empowered and equipped with information and knowledge that is holistic, interdisciplinary, and exemplified with best practices from elsewhere. Further, there need to be large-scale studies and research to enhance knowledge and information about the four values that biodiversity and ecosystem services provide for informed decision making.

One of the critical factors for achieving some of the aspirations mentioned above is to have more investment in the HKH region from donors, governments, and the private sector to ensure the sustainability of the assets while pursuing the larger goals of poverty alleviation, economic development, and overall human wellbeing.

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