International Journal of Biodiversity Science and Management 4 (2008) 164–178
DOI 10.3843/Biodiv.4.3:4

Status of a protected area system in the Hindu Kush-Himalayas: An analysis of PA coverage

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Key words: Conservation measures, management categories, biodiversity hotspots, ecoregions

SUMMARY

Multifaceted patterns of protected area (PA) expansion are reviewed considering: i) the increase in PA number and coverage; ii) distribution and extent of important bird areas (IBAs); and iii) distribution and coverage of global biodiversity hotspots and the Global 200 Ecoregions that fall within the Hindu Kush-Himalayas (HKH). The analysis revealed that biodiversity conservation is a priority for the eight regional member countries of the HKH, who have established 488 PAs over the last 89 years (1918 to 2007). The eight countries sharing the HKH have committed 39% of this total geographical area to the PA network and 11% to IBAs, which is quite significant when compared to the global target of 10%. There has been an increasing trend in PA establishment over the last four decades. The PA coverage within the HKH of China alone is significant (35.5%), followed by India (1.46%) and Nepal (0.58%). When IUCN management categories are considered, the majority of PAs belong to Category V (39%), followed by Category IV (29%). Only 0.6% of PAs are managed as Category I, and, in recent years, Categories V and VI have increased. Of the total HKH geographical area, 32% is covered by four global biodiversity hotspots and 62% by the Global 200 Ecoregions. However, only 25% of the global biodiversity hotspots and 40% of the Global 200 Ecoregions are part of the PA network. There are still numerous gaps in conservation in the HKH. Coordinated and committed efforts are required to bring other critical habitats within the PA network in the HKH.

INTRODUCTION

Mountains, due to their diverse habitats with varied micro-climatic and ecological conditions, have high levels of biodiversity (Price 2004; Kollmair *et al.* 2005; Brooks *et al.* 2006) and are therefore a priority for biodiversity conservation. The Hindu Kush-Himalayas (HKH), the working area of the International Centre for Integrated Mountain Development (ICIMOD), is one such dynamic landscape with a rich and remarkable biodiversity (Pei 1995; Guangwei 2002). Stretched over more than 4,000,000 km^2, the HKH includes Bhutan and Nepal in their entirety and parts of six other countries: Afghanistan, Bangladesh, China, India, Myanmar and Pakistan. Endowed with a rich variety of gene pools, species and ecosystems of global importance, the region hosts parts of four global biodiversity hotspots: Himalaya, Indo-Burma, and the mountains of southwest China and Central Asia

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(Mittermeier *et al.* 2004). Approximately 39% of the HKH is comprised of grassland, 20% is forest, 15% is shrub land and 5% is agricultural land. The remaining 21% includes barren land, rock outcrops, built-up areas, snow cover and water bodies. Elevation zones across the HKH extend from tropical (< 500 m) to alpine ice-snow (> 6000 m), with a principal vertical vegetation regime comprising tropical and subtropical rain forest, temperate broadleaf deciduous or mixed forest and temperate coniferous forest, including high-altitude cold shrub or steppe and cold desert (Pei 1995; Guangwei 2002).

The region, with its varied landscapes, soils, vegetation and climate, is known for its unique flora and fauna, high level of endemism (Myers *et al.* 2000) and numerous critical ecoregions of global importance (Olson *et al.* 2001; Olson and Dinerstein 2002). However, the rich biodiversity continues to be threatened by the loss and extinction of species, mainly due to habitat degradation and forest fragmentation (Myers *et al.* 2000; Ives *et al.* 2004; CEPF 2005, 2007; Pandit *et al.* 2007). All eight HKH regional member countries, being signatories to the Convention on Biological Diversity (CBD), are committed to conservation and, as a measure towards the immediate protection of globally significant landscapes, have set aside a considerable proportion of their most biologically rich terrain as various forms of protected areas (PAs). However, deforestation and degradation continued through human activities (Bawa *et al.* 2004; Pandit *et al.* 2007). Even strictly managed national parks, nature reserves and wildlife sanctuaries are under tremendous pressure from the communities living inside and outside the PAs (Sharma and Yonzon 2005).

PAs are an integral element of global biodiversity conservation (Brooks *et al.* 2002, 2004; Lovejoy 2006). Since the establishment of the first national park (Yellowstone, USA) in 1872, more than 104,791 PAs have been established worldwide, containing 12.2% of the global land area (Chape *et al.* 2005; Loucks *et al.* 2008). Advocating the significance of biodiversity, the Seventh Conference of the Parties (COP 7) to the CBD urged all signatories to effectively conserve at least 10% of the world's critical ecological zones (Secretariat of the CBD 2004a). PAs are a key indicator of global commitment to biodiversity conservation and sustainable development (UNDP 2003; Secretariat of the CBD 2004a, 2004b; Chape *et al.* 2005). However, global conservation measures that use only the number of PAs and their spatial coverage as indicators of effective conservation are unrealistic and inadequate in terms of protecting the values for which they were originally established (Gaston 2000; Rodrigues *et al.* 2004; Zimmerer *et al.* 2004; Chape *et al.* 2005). Many researchers (Brooks *et al.* 2002, 2004; Chape *et al.* 2005; Rodrigues *et al.* 2004) consider that several important habitat types and species are far from covered by the current PA network, and many existing PAs face severe habitat loss and fragmentation.

The majority of conservation priorities reflect the view of the HKH as a key region of biodiversity (Bryant *et al.* 1997; Mittermeier *et al.* 1997, 2004; Olson and Dinerstein 2002; Myers *et al.* 2000; Eken *et al.* 2004; Hoekstra *et al.* 2005; Ricketts *et al.* 2005; Langhammer *et al.* 2007). The HKH region contains many globally important conservation areas and is home to globally significant plant and animal species, as noted by Pei (1995) and Wikramanayake *et al.* (1998). The Indo-Burma hotspot alone is home to 7000 endemic plants and possesses 1.9% of the global endemic vertebrates (Myers *et al.* 2000). More than 7000 plant species, 175 mammal species, and over 500 bird species have been recorded in the Eastern Himalayas alone (WWF and ICIMOD 2001). Hence, biodiversity in the hotspots of the HKH is significant in terms of global conservation initiatives. Ricketts *et al.* (2005) also identified centres of imminent extinction in the HKH (where highly threatened species are confined to a single site), predominantly in Indo-Burma and the mountains of southwest China. Out of 14 such sites within the HKH, nine are still outside formal PA networks and the others are subject to intense human intervention.

Although PAs in the HKH region have increased considerably in number and area over the last few decades, knowledge of their present number, extent and effectiveness in terms of conservation is still lacking. There have been efforts in the recent past to understand the adequacy and appropriateness of conservation initiatives in the region (WWF and ICIMOD 2001; Wikramanayake *et al.* 1998, 2002; CEPF 2005, 2007), but analyses of conservation initiatives have mainly been conducted on a regional or global scale, with little effort put into understanding conservation effectiveness at the HKH level. ICIMOD initiated a PA review of the HKH in 2002 with the objective of understanding the present PA coverage and relating it to ongoing global conservation planning and prioritisation processes, such as the identification of global biodiversity hotspots (Mittermeier *et al.* 2004), Global 200 Ecoregions (Olson *et al.* 2001; Olson and Dinerstein 2002), and important bird areas (Birdlife International 2007). ICIMOD reviewed and analysed various data sets with respect to the spatial coverage and number of PAs; coverage of critical habitats and ecoregions; and IUCN management categories. The analysis was further supplemented by looking at IBAs. This paper is the outcome of this preliminary assessment of PA coverage in the HKH.

MATERIALS AND METHODS

The four major datasets used for analysis of PA status and trends in the HKH were: i) the World Database on Protected Areas jointly developed by the UNEP-WCMC and the IUCN World Commission on Protected Areas (IUCN, UNEP, WCMC 2005), crosschecked with the PA dataset compiled from various literature sources, reviews by individuals and from government documents of the eight regional member countries, including PAs established after 2005; ii) the IBA dataset (Birdlife International 2007); iii) Global 200 Ecoregions (WWF 2006); and iv) global biodiversity hotspots (Mittermeier *et al.* 2004).

PAs falling within IUCN Categories I–VI in the above four datasets were analysed with respect to their date of establishment, growth in number, extent of coverage and management category based on Hamilton and McMillan (2004). Categories I, II and III represent more strictly-defined protected areas, including strict nature reserves or wilderness areas (Category I), national parks (Category II) and natural monuments (Category III). Those with moderate or less strict management regimes are defined under Categories IV–VI and, basically, include habitat species management areas (Category IV), protected landscapes/seascapes (Category V), and managed resources protected areas (Category VI).

Using the global IBA dataset, all IBAs in the eight regional member countries were listed. Areas of key importance for biodiversity, such as the Global 200 Ecoregions and global biodiversity hotspots, were delineated for the entire HKH. The gaps in PA coverage were identified by overlaying the geographic coordinates (polygons and points) of PA Categories I to VI with those of IBA, and also overlaying these on designated Global 200 Ecoregion and global biodiversity hotspot datasets.

RESULTS

Number and extent of PAs

The countries within the HKH contain many of the world's major mountain PAs (Figure 1), which host a significant assembly of biological, social and cultural diversity. Table 1 summarises the total number of PAs and their respective coverage in each of the eight regional member countries in the HKH. In 2007, there were 488 PAs within the HKH, covering more than 1.6 million km^2, representing about 39% of the region's terrestrial area, with China and India contributing the most PAs, compared to the other six countries. China accounts for the largest PA coverage within the HKH, with 35.5%

Table 1 Number and area coverage of protected areas in the HKH region

Country	*Total area (km^2)*	*Total area within HKH (km^2)*	*Total number of PAs within HKH*	*PA coverage within HKH (km^2)*	*% of PA coverage with respect to total area of HKH*
Afghanistan	652225	390475	6	2461	0.06
Bangladesh	143998	13295	5	632	0.01
Bhutan	46500	46500	10	12681	0.30
China	9596960	2420266	221	1522172	35.51
India	2387590	461139	135	62417	1.46
Myanmar	676577	317629	16	23967	0.56
Nepal	147181	147181	19	24972	0.58
Pakistan	796095	489988	76	18721	0.44
Total	**14447126**	**4286473**	**488**	**1668023**	**38.91**

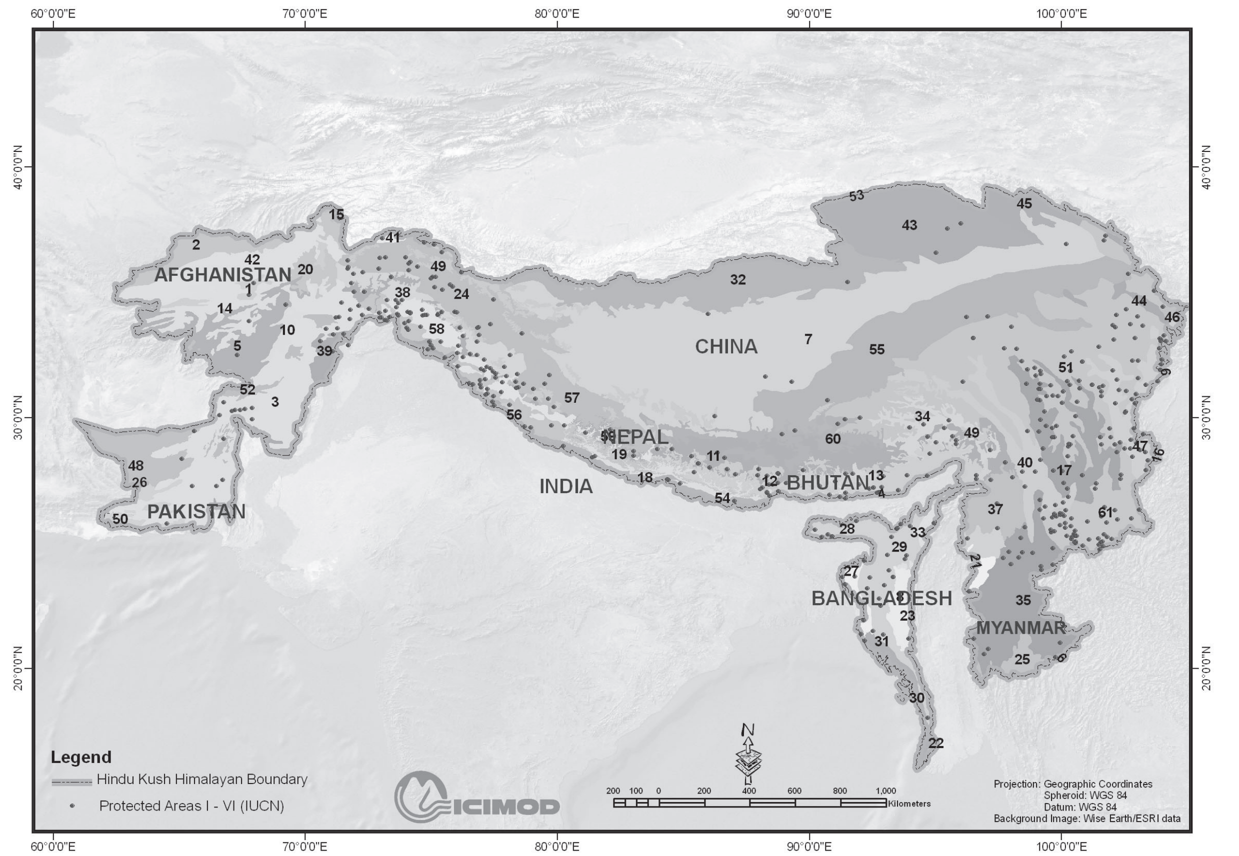

Figure 1 Spatial distribution of protected area in different ecoregions in the HKH (correspond to the numbers of the ecoregion names in Annex 1)

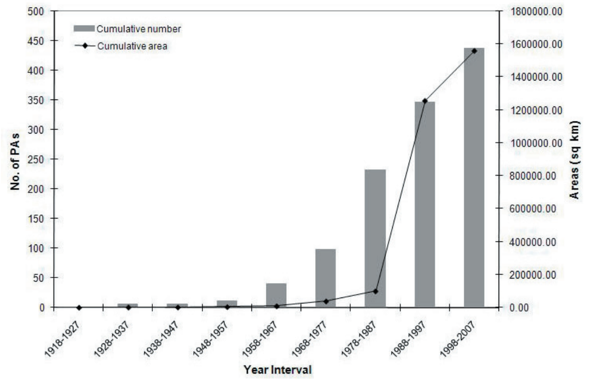

Figure 2 Trend in number and area coverage of protected areas from 1918–2007 in the HKH

of the total area, including recently established larger conservation reserves (Table 1).

The first PA in the HKH was the Pidaung Wildlife Sanctuary (1918), in the state of Kachin in Myanmar. There were 12 PAs in the region up to 1957, increasing to 98 in 1977 and to 346 in 1997. Considering the trend in establishment of PAs within the HKH, significant growth has been witnessed in the last three decades (Figure 2), corresponding to other global-scale trends (Chape *et al.* 2005; Kollmair *et al.* 2005; Naughton-Treves *et al.* 2005). Total coverage continued to increase significantly, from 3973 km^2 in 1957 to more than 1.2 million km^2 by 1997. In 2007, coverage exceeded 1.6 million km^2. The extent of PA spatial coverage significantly increased from 1970 to 2007, similar to global-scale coverage (Chape *et al.* 2005; Kollmair *et al.* 2005; Naughton-Treves *et al.* 2005). Interestingly, the proportion of terrestrial area covered by PAs in the HKH is much higher (39%) than in Central America (26%) (Chape *et al.* 2005). Such growth in the numbers and areas of PAs is a significant achievement on the part of the HKH countries towards fulfilling their global commitment to conservation.

The PAs in the HKH differ in size, ranging from the smallest, Bagmara Pitcher Plant Sanctuary in India (0.02 km^2), to the largest, Hai Zi Mountain Nature Reserve (494,076 km^2), in Sichuan, China.

Among the recorded 488 PAs in the HKH, most (27%) are less than 50 km^2 in area, and 20% are between 101–250 km^2. PAs from 251–500 km^2 account for 14% of the total, and only 5% are larger than 5000 km^2 (Figure 3). Most (68%) PAs in the HKH are small (< 500 km^2) and scattered.

Protected area management categories

Analysing PAs in terms of their IUCN management category, the majority in the HKH belong to Category V (39%), followed by Category IV (29%) (Figure 4), which are basically 'protected landscapes for conservation and recreation' and 'habitat species management areas', respectively. These PAs are less strictly managed, and human activities are generally allowed. Of the 488 PAs in the HKH, only 0.6% are managed as Category I, 'strict nature reserve' or 'wilderness area', in which no human intervention is permitted except for scientific monitoring: two nature reserves in China (Mo Tuo Nature Reserve and Shen Zha Nature Reserve) and one in Bhutan (Toorsa Strict Nature Reserve). In China, the Heqing Zhao Xia Ming Sheng Nature Reserve (8 km^2) is the only Category III PA, 'protection of natural monuments'.

If the area of PAs is considered in relation to the IUCN management categories (Figure 4), Category V has the highest coverage (41%, about 0.6 million km^2), Category VI has 36%, and Category I has the least coverage, only 0.08%. Analysis of the establishment of PAs with reference to the IUCN categories (Figure 5) showed that the number of PAs under Category V significantly increased in the last 40 years, reaching the highest point in the last decade. A similar increasing trend was observed for Category IV, until the 1970s, after which the number of Category IV PAs declined. For all other categories, establishment of PAs has also been increasing, but with relatively little variation compared to Categories IV and V. Thus the analysis of PAs in the HKH shows a weak shift away from strictly managed PA systems, as also observed by Zimmerer *et al.* (2004).

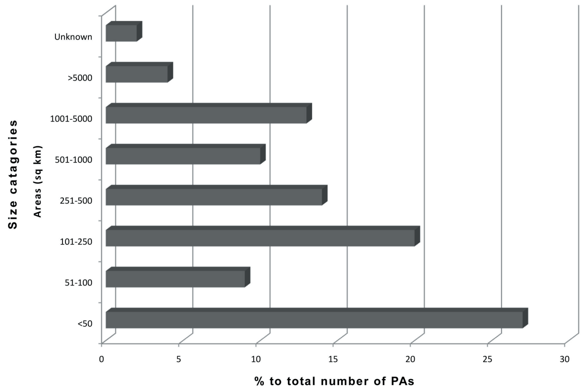

Figure 3 Distribution pattern of protected areas in different size range (in sq km) in the HKH

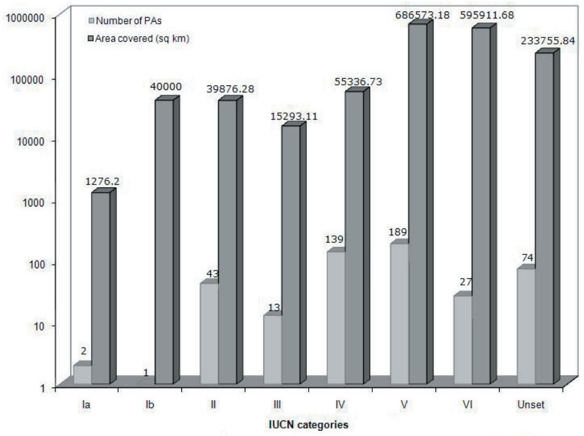

Figure 4 Number and protected area coverage under different IUCN management categories in the HKH

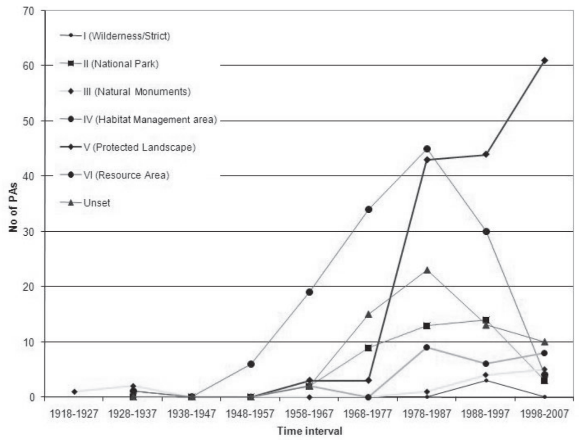

Figure 5 Trend in the establishment of different IUCN categories of protected areas from 1918–2007 in the HKH

Important bird areas: distribution and extent

There are 1106 IBAs (Birdlife International 2007) in the eight member countries of the HKH, covering about 1.1 million km^2, of which around 30% (330) are within the HKH *per se*, covering 11% (467,627 km^2) of the total area (Table 2). The majority of IBAs are within the four global biodiversity hotspots in the HKH (Figure 6). However, 73% of the total IBAs in terms of area, and 57% in terms of number, are outside existing PA networks. China has the largest area outside its PA network, with more than 0.29 million km^2 of IBAs outside the PA network. Pakistan, on the other hand, has the largest area of IBAs (88%) within PAs (Table 2). It is arguable whether IBAs, which are regarded as key biodiversity areas (Eken *et al.* 2004; Langhammer *et al.* 2007), should be a conservation priority as, while they contain a rich biodiversity of birds, the biodiversity of other species is not necessarily so great.

Table 2 Number and area coverage of Important Bird Areas (IBA) in the HKH region

Country	*Total number of IBAs in each countries*	*Total area covered by IBAs in each country (km^2)*	*Total number of IBAs within HKH*	*Total area covered by IBAs within HKH (km^2)*	*Total number of IBAs outside PAs in HKH*	*Total area of IBAs outside PAs (km^2)*
Afghanistan	17	40931	13	9431	8	7370
Bangladesh	19	5395	6	796	3	241
Bhutan	23	12133	23	12133	15	2765
China	445	796623	75	326204	59	294869
India	465	164118	141	56258	65	22286
Myanmar	55	54364	22	18158	15	7387
Nepal	27	26119	27	26119	12	3860
Pakistan	55	46701	23	18528	9	2161
Total	**1106**	**1146384**	**330**	**467627**	**189**	**340939**

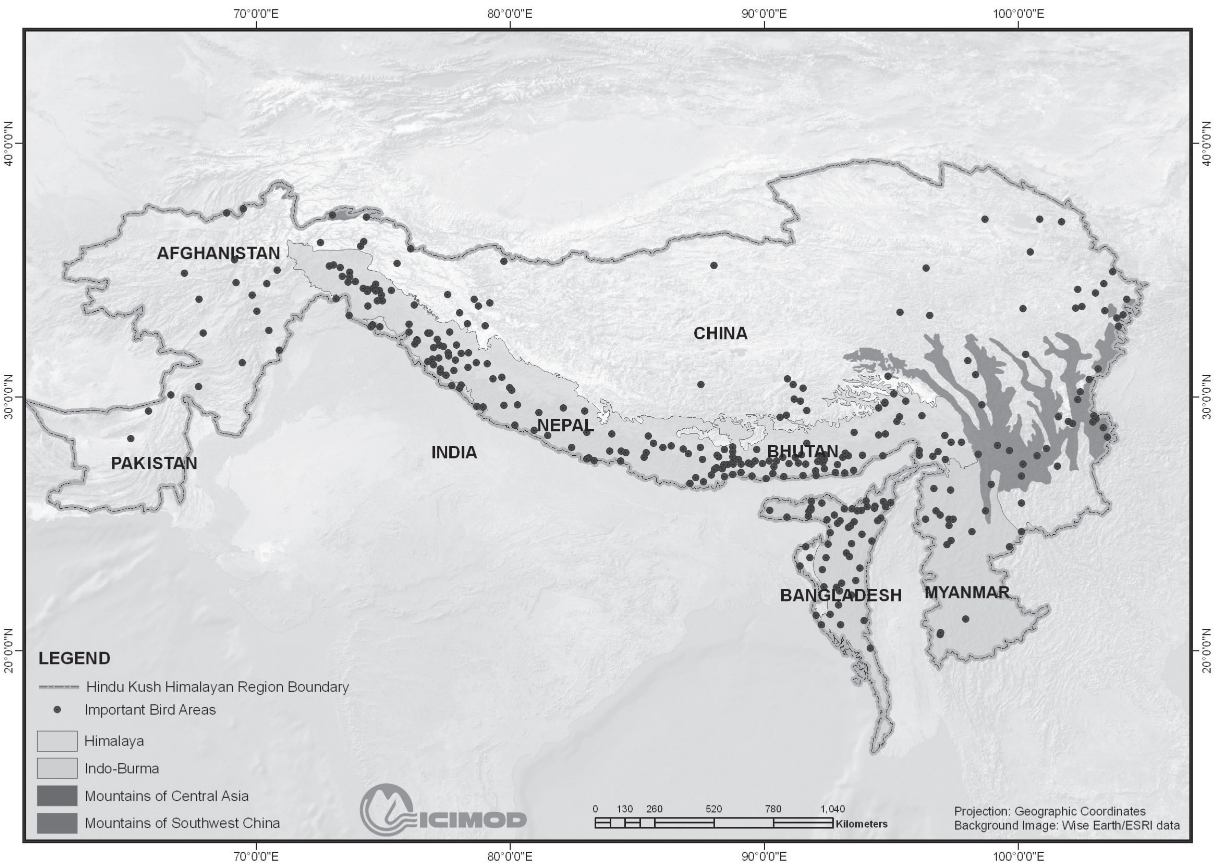

Figure 6 Distribution of global biodiversity hotspots and important bird areas in the HKH

Biodiversity hotspots, Global 200 Ecoregions: extent of PA coverage

Looking at global biodiversity hotspots and Global 200 Ecoregion coverage within the HKH, GIS Arc-view data reveal that 32% of the HKH is covered by parts of the four global biodiversity hotspots: the Himalaya hotspot (15%), the Indo-Burma hotspot (11%), the mountains of southwest China (6%), and the mountains of Central Asia (< 1%) (Table 3, Figure 6). Of the 488 PAs in the HKH, 194 (39%) fall within the four global biodiversity hotspots, the highest number (111) being in the Himalaya hotspot. However, when considering area coverage, 80% of the mountains of southwest China, 30% of the mountains of Central Asia, 22% of the Himalaya hotspot, and 0.9% of Indo-Burma hotspot are within PAs. In other words, on average, 25% of the area of the global biodiversity hotspots falling within the HKH is within PA networks, leaving a very significant area unprotected.

The HKH contains 14 of the world's highest mountain peaks, including Everest/Sagarmatha/Qomolangma, Kangchenjunga, and the highest peaks of the Karakoram. The majority of these mountain ecosystems are protected within PAs. Within the region, there are many critical habitats and ecoregions of global importance. Among the 60 ecoregion types found within the HKH, 30 are critical and represent 12 of the Global 200 Ecoregions (Olson *et al.* 2001; Olson and Dinerstein 2002) (Table 4, Figure 1, Annex 1). Our analysis indicates that 71% (345) of the total number of PAs in the HKH and 40% of the region's PA coverage are within the 12 Global 200 Ecoregions. Among the 12 Global 200 Ecoregions, the largest area within the HKH is in the Eastern Himalayan alpine meadow (75%), followed by the Tibetan Plateau steppe (56%), the Eastern Himalayan broadleaf and conifer forests (26%), the Hengduan Shan conifer forest (22%), and the Middle Asian montane woodland and steppe (19%). However, two of the 12 ecoregions, the Kayah-Karen/Tenasserim moist forest and the Indo-China dry forest, are not represented in the existing PA networks (Table 4).

DISCUSSION

Biodiversity conservation in mountain regions through the establishment of PAs is central to the modern conservation paradigm. In the recent past, there has been a tremendous increase in the number and coverage of PAs in mountain regions (Kollmair *et al.* 2005). Enormous progress in terms of PA coverage in the HKH is evidence of the commitment shown by the countries of the HKH with respect to delineating biologically significant areas for conservation. Thirty-two per cent (32%) of the HKH region is covered by parts of the four global biodiversity hotspots; however, only 25% of these hotspots are within PAs. This indicates that more conservation initiatives are necessary to bridge this 75% gap. In addition, there are 12 critically important ecoregions (Global 200 Ecoregions) in the HKH, covering 62% of its geographical area, and 40% of this area is within the PA network, which is quite significant (Wikramanayake *et al.* 2002). However, it is also important to determine whether such conservation initiatives address the Global Conservation Targets 2010 (Balmford *et al.* 2005). The region is also facing challenges in terms of rapid deforestation and development activities (Bawa *et al.* 2004; FAO 2007; Pandit *et al.* 2007). These development activities could widen the gap between conservation and development agendas, presenting more challenges than ever before.

Trend and management aspects

PAs in the HKH show similar trends in terms of number and extent of coverage as at the global scale (Chape *et al.* 2005; Kollmair *et al.* 2005; Naughton-Treves *et al.* 2005). There has been considerable progress in the number and extent of PAs established from the 1980s till the 2000s. This appears to be the result of the process of globalisation, as explained by Zimmerer *et al.* (2004), Büscher and Whande (2007), Rodriguez *et al.* (2007) and Wilson *et al.* (2007). These studies argue that trends in biodiversity conservation and PA management are, in large part, determined by an array of international environmental agreements, global political and economic developments, and strong advocacy by prominent global conservation organisations and multilateral and bilateral funding institutions supported by the United Nations (UNEP and UNESCO) and, in particular, by UNESCO's Man and the Biosphere Program (MAB). In the HKH region, this has been supplemented by global (UNDP 2003; Hamilton and McMillan 2004; Secretariat of the CBD 2004a, 2004b) and national (Anonymous 2002;

Table 3 Number and area coverage of PAs within the global biodiversity hotspots in the HKH

Biodiversity hotspot within HKH	*Total hotspot area (km^2)*	*Total hotspot area falling within HKH (km^2)*	*% to the total area of HKH*	*No of PAs falling in each hotspots within HKH*	*% to total number of PA in HKH*	*PA area coverage in each hotspots within HKH (km^2)*	*% PA area coverage with respect to the hotspot area in HKH (%)*
Himalaya	741706	658549	15.4	111	22.7	145842	22.15
Indo-Burma	2373057	456711	10.7	25	5.1	4204	0.92
Mountains of southwest China	262446	245472	5.7	57	11.7	194505	79.24
Mountains of Central Asia	863362	2267	0.1	1	0.2	679	29.96
Total	**4240751**	**1362999**	**31.8**	**194**	**39.8**	**345230**	**25.33**

Table 4 Number and area coverage of PAs within the Global 200 Ecoregions in the HKH

Ecoregions Global 200 Ecoregion	*Area coverage by Global 200 ecoregions in HKH (km^2)*	*Area coverage by each Global 200 ecoregions within HKH (%)*	*Total number of PAs in each ecoregion in HKH*	*PA coverage within Global 200 ecoregions of the HKH (km^2)*	*PA coverage with respect Global 200 ecoregions within HKH (%)*
Northern Indo-China Sub-tropical Moist Forest	266843.1	6.2	70	7414.4	2.8
Kayah-Karen/Tenasserim Moist Forest	22997.6	0.5	0	0.0	0.0
Naga-Manipur Chin Hills Moist Forests	201013.2	4.7	30	13568.5	6.8
Indo-China Dry Forest	13.3	0.0	0	0.0	0.0
Eastern Himalayan Broadleaf and Conifer Forests	161544.1	3.8	37	43124.3	26.7
Western Himalayan Temperate Forests	85979.1	2.0	37	10173.3	11.8
Southwest China Temperate Forest	6208.2	0.1	1	640.0	10.3
Hengduan Shan Conifer Forest	245446	5.7	48	55072.9	22.4
Terai-Duar Savannas and Grassland	26531.1	0.6	4	935.2	3.5
Tibetan Plateau Steppe	1522161.3	35.5	113	851974.7	56.0
Middle Asian Montane Woodland and Steppe	3613.5	0.1	1	679.4	18.8
Eastern Himalayan Alpine Meadow	121184.9	2.8	13	90482.9	74.7
Total	**2663535.4**	**62.1**	**354**	**1074065.6**	**40.3**

Annex 1 A list of ecoregions including those falling within the Global 200. Ecoregions (in **bold**)

CODE	*Ecoregion*	*Area (km²)*
1	Afghan mountains semi-desert	13413.7
2	Badghyz and Karabil semi-desert	46402.7
3	Baluchistan xeric woodlands	240560.2
4	Brahmaputra Valley semi-evergreen forests	4651.1
5	Central Afghan mountains xeric woodlands	83273.6
6	**Central Indochina dry forests**	13.3
7	**Central Tibetan Plateau alpine steppe**	629473.1
8	**Chin Hills-Arakan Yoma montane forests**	26381.4
9	**Daba Mountains evergreen forests**	194.4
10	East Afghan montane conifer forests	19651.4
11	**Eastern Himalayan alpine shrub and meadows**	121184.9
12	**Eastern Himalayan broadleaf forests**	81286.8
13	**Eastern Himalayan subalpine conifer forests**	27478.2
14	Ghorat-Hazarajat alpine meadow	62515.4
15	**Gissaro-Alai open woodlands**	3613.5
16	Guizhou Plateau broadleaf and mixed forests	101.8
17	**Hengduan Mountains alpine coniferous forests**	99418.5
18	Himalayan subtropical broadleaf forests	32902.8
19	Himalayan subtropical pine forests	73632.0
20	**Hindu Kush alpine meadow**	28259.2
21	Irrawaddy dry forests	356.2
22	Irrawaddy freshwater swamp forests	753.6
23	Irrawaddy moist deciduous forests	14751.8
24	**Karakoram-West Tibetan Plateau alpine steppe**	135245.9
25	**Kayah-Karen montane rain forests**	22997.6
26	Kuh Rud and Eastern Iran montane woodlands	2063.0
27	Lower Gangetic Plains moist deciduous forests	17385.1
28	**Meghalaya subtropical forests**	28580.4
29	**Mizoram-Manipur-Kachin rain forests**	99556.2
30	Myanmar coastal mangroves	5101.9
31	Myanmar coastal rain forests	23632.7
32	North Tibetan Plateau-Kunlun Mountains alpine desert	176938.9
33	**Northeast India-Myanmar pine forests**	9556.2
34	**Northeastern Himalayan subalpine conifer forests**	46277.3
35	**Northern Indochina subtropical moist forests**	173488.8
36	**Northern Triangle subtropical forests**	46495.3
37	**Northern Triangle temperate forests**	6501.8
38	Northwestern Himalayan alpine shrub and meadows	49404.1
39	Northwestern thorn scrub forests	32307.7
40	**Nujiang Langcang Gorge alpine conifer and mixed**	82807.4
41	Pamir alpine desert and tundra	4997.2
42	Paropamisus xeric woodlands	90544.6
43	Qaidam Basin semi-desert	165645.2
44	Qilian Mountains conifer forests	13069.5
45	Qilian Mountains subalpine meadows	39492.9
46	**Qin Ling Mountains deciduous forests**	6013.8
47	**Qionglai-Minshan conifer forests**	63220.1
48	Registan-North Pakistan sandy desert	70334.8
49	Rock and Ice	88963.5
50	**Southeast Tibet shrublands and meadows**	425853.2
51	Sulaiman range alpine meadows	21651.2
52	Taklimakan desert	790.5
53	**Terai-Duar savanna and grassland**	26531.1
54	**Tibetan Plateau alpine shrublands and meadows**	272131.2
55	Upper Gangetic Plains moist deciduous forests	4274.8
56	Western Himalayan alpine shrub and meadows	70162.5
57	**Western Himalayan broadleaf forests**	55147.8
58	**Western Himalayan subalpine conifer forests**	30831.3
59	**Yarlung Tsangpo arid steppe**	59457.9
60	**Yunnan Plateau subtropical evergreen forests**	93354.3

HMGN/MFSC 2002, 2005; Xu and Melick 2007) approaches that specifically emphasise the establishment of new PAs in the mountains. The advocacy role played by mountain representatives in global initiatives further strengthened the recognition of mountains as key areas for conservation (WWF and ICIMOD 2001; Sharma and Acharya 2004; Sharma *et al.* 2007).

In this evolving scenario, PA management is considered in the context of integrated development, in which resource conservation is undertaken together with sustainable livelihood development for local communities who are directly dependent on natural resources (Balasinorwala *et al.* 2004; Borrini-Feyerabend *et al.* 2004). As indicated in Figures 4 and 5, comparatively larger areas (about 41%) have been assigned to PAs in Category V, and are predominantly protected landscapes and recreational natural areas, which have significantly increased since the late 1980s. This indicates a paradigm shift towards more people-oriented and people-centred management of PAs. In China, many PAs have been re-categorised as Category V (areas protected mainly for conservation and recreation) with the objective of safeguarding the traditional interactions between parks and indigenous people (Xu and Melick 2007). Similarly, in Nepal, collaborative forest management between the park authorities and local communities in buffer areas outside PAs, as well as the landscape approach to conservation, stand out as successful measures for conservation (Bajracharya *et al.* 2005; Gurung 2005). Twenty-five years ago, PAs were considered the domain of ecologists, foresters and the occasional land-use planner for research and to understand the dynamics of ecosystems. Now, they are being defined as the arena of a wide range of stakeholders with broad missions, and even as a way of achieving the Millennium Development Goals (UNDP 2003).

Effectiveness of PAs in achieving conservation targets

PA coverage was endorsed by CoP7 of the CBD as an indicator for immediate testing in relation to the adopted target of significantly reducing the rate of biodiversity loss by 2010. Additionally, CoP7 set a target that 'at least 10% of each of the world's ecological regions [should be] effectively conserved' (Secretariat of the CBD 2004a). PAs are also indicators of success in achieving Millennium Development Goal 7 (ensuring environmental sustainability), Target 9 (integrating the principles of sustainable development into country policies and programmes and reversing the loss of environmental resources), and Indicator 26 (land area protected to maintain biological diversity). The HKH countries have made significant progress, compared to the global target, in creating a PA network with 39% coverage. However, these PAs are scattered throughout the region, with no connectivity between them, making each PA a 'conservation island'.

Many conservationists have raised serious concerns about the effectiveness of PAs in achieving global conservation goals (Gaston 2000; Chape *et al.* 2005; Rodrigues *et al.* 2004; Zimmerer *et al.* 2004). These authors point out that the percentage of the area protected in a given country or biome is not a strong indicator of actual conservation needs or effective action, as such indicators overlook the fact that biodiversity is unevenly distributed. This is illustrated by the case of Myanmar, where 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 lack of economic opportunities, interdisciplinarity in conservation actions, institutional development, skilled human resources, and lack of large scale conservation actions are hindering conservation globally.

In addition, Locke and Dearden (2005) and Naughton-Treves *et al.* (2005) have expressed concern at the use of the new categories of PA, such as Categories V and VI, as indicators of the paradigm shift in conservation (Phillips 2003). Lock and Dearden (2005) strongly argue that the management of PAs under Categories V and VI will devalue and undermine the creation of strictly protected nature reserves, which provide protection, in a real sense, to wild biodiversity. They contend that the recent trend towards people-centred PAs is not in line with the objectives of conservation, and advocate the recognition of Categories I–IV as appropriate for the strict protection of wild biodiversity and the reclassification of other categories, such as culturally-modified landscapes (Category V) and managed resource areas (Category VI) as sustainable development areas. Doing so would better serve both the protection of wild biodiversity and human development needs in humanised landscapes where sustainable development could be practised. These developments have highlighted two critical issues that are now the subject of debate within the conservation community: the effectiveness of existing PAs for biodiversity conservation; and the effectiveness of the newly classified PA Categories V–VI in achieving conservation goals. In both cases, little can be predicted, as there are large knowledge gaps on species distribution and management effectiveness due to a lack of convincing monitoring and assessment mechanisms and holistic indicators (Butchart *et al.* 2004; Balmford *et al.* 2005).

Perceived conservation gaps in the HKH region

In recent years, there have been many regional efforts on biodiversity documentation and gap analysis in the HKH (Wikramanayake *et al.* 1998; WWF and ICIMOD 2001; Allnutt *et al.* 2005; CEPF 2005, 2007; Chettri *et al.* 2008), but coverage across the region has not been uniform (Sarkar 2007). Species distribution, diversity patterns (alpha and beta diversity) and the population status of the majority of globally significant species, such as snow leopard, red panda, wild ass, takin, etc., are still poorly documented (Wikramanayake *et al.* 1998, 2002). Most of the information available is on the larger vertebrates that are easily observed and inventoried (Myers *et al.* 2000; Eken *et al.* 2004; Mittermeier *et al.* 2004; CEPF 2005, 2007), and the criteria used mainly refer to threatened and endemic species (Myers *et al.* 2000; Butchart *et al.* 2004). The smaller mammals, reptiles, amphibians and fish, have been overshadowed, and the most abundant taxonomic group, insects, has been virtually ignored. Further research on these information gap species and taxa, especially those outside the PA network, could provide insight into the conservation significance of the region (Mishra *et al.* 2004; Pawar *et al.* 2006; Sarkar 2007). PAs in the HKH, especially in the higher altitude areas, such as the Tibetan Plateau and Eastern Indian Himalayas, are facing more challenges due to rises in human population and human-induced threats (Cardillo *et al.* 2006; Cincotta *et al.* 2000; Myers *et al.* 2000; Jha and Bawa 2006). Many of these remote areas are key elements of the global biodiversity hotspots and Global 200 Ecoregions and are critical in terms of biodiversity conservation. In spite of the significant progress in PA coverage within the critical ecoregions and hotspots, there are still many potential areas with high biodiversity that have a low profile, mainly due to poor documentation and prioritisation (Rawal and Dhar 2001). For example, recent surveys (Mishra *et al.* 2004, Pawar *et al.* 2006, 2007) revealed that many of the important wildlife habitats in the northeastern Indian states of the eastern Himalayas are still outside the present PA network. CEPF (2005, 2007), with inputs from conservation experts, has identified many priority areas and species from the region as conservation targets and has recommended that corridors be established to link broader landscapes for effective conservation. Recently, Langhammer *et al.* (2007), using the Key Biodiversity Areas approach, reflected on the conservation gaps, and concluded that many of the key biodiversity components are still outside existing PA networks and suggested the need for a comprehensive conservation strategy to address such gaps.

In the HKH, land-use and land-cover change have important implications for the development of indicators to measure the effectiveness of PAs in terms of conservation (Chape *et al.* 2005; Balmford *et al.* 2005). However, such indicators are virtually non-existent for most of the PAs in the HKH. In addition, recent scientific opinion, led by the Intergovernmental Panel on Climate Change (IPCC), states that global climate change is taking place; it is inevitable and will have practical ramifications for local ecosystems (IPCC 2007). The mountain systems of the world are expected to be warmer in the twenty-first century, although to differing extents, and predictions about the extinction of species in the region are alarming (Schwartz *et al.* 2006). If climate change continues as globally projected, it will have significant impacts on biodiversity (Parmesan and Yohe 2003; Thomas *et al.* 2004; Malcolm *et al.* 2006). However, in the HKH context, these concerns are anecdotal. No serious efforts have been made so far to understand the impacts of climate change on biodiversity, especially on species with a narrow home range, such as the one-horned rhinoceros.

Future prospects and opportunities

During the last two decades, either as mechanisms or as conservation targets themselves, a series of new perspectives based on ecoregions, biodiversity hotspots, key biodiversity areas and landscapes have evolved to accomplish various conservation objectives. These perspectives have emerged as a result of changing perceptions in ecology, which have stimulated scientists to think in broader terms to include economic and socio-cultural perspectives. The increasing realisation of the importance of large-scale patterns and disturbances has encouraged scientists to recognise that long-term conservation and all types of targets require the explicit recognition of landscape heterogeneity in conservation activities and a focus on each activity at the appropriate scale (Noss 1983; Redford *et al.* 2003). The philosophy exemplified by these conservation approaches is that human beings are necessary components of bio-cultural landscapes (Brunckhorst 2000; Balmford *et al.* 2005). Many conservationists and land managers now include targets such as ecological processes and landscape patterns as a new dimension to conservation practice.

The HKH region contains many globally significant landscapes such as the Kangchenjunga-Singhalila Complex, Bhutan Biological Conservation Complex and North Bank Landscape, which are home to numerous species of global importance (CEPF 2005, 2007). Some of the species have a wide habitat, ranging across political borders, and others are confined to a limited geographical area. For example, only 3.5% of the Terai Duars savanna and grassland falling within the HKH is under formal PA management. This area is home to many charismatic species such as the one-horned rhinoceros, Asiatic elephant and the Royal Bengal tiger (*Panthera tigris*). Thus, existing PAs have so far not been able to cover all the critical habitats in the region, and these species cannot be conserved within the boundaries of a single PA due to their contiguous and extensive habitat ranges (Wikramanayake *et al.* 1998; Chettri *et al.* 2007). The establishment of continuous habitats as transboundary PAs would further enhance ongoing conservation initiatives in the region and ensure the continued supply of ecosystem services by this diverse and rich landscape (Sharma and Chettri 2005). However, to bring such areas into PA networks requires bilateral or regional cooperation (Secretariat of the CBD 2004b; Bennett and Mulongoy 2006; Sharma *et al.* 2007). Hence, it is important for all HKH countries to employ an ecosystem approach with matrix (protected and non-protected areas) management through regional cooperation and to close the current gaps in conservation.

CONCLUSION

The HKH is an important repository of biodiversity and home to many globally significant species. The conservation initiatives taken by the eight regional member countries represent significant progress towards achieving global conservation targets. The PAs in the HKH vary in management objectives, ranging from strict nature reserves and wilderness areas with minimal interaction with local people, to community-managed areas where people play an important role in conservation. However, substantial efforts are needed to fill the gaps in our knowledge of species distribution, population status and the management effectiveness of existing PAs, critical ecoregions and hotspots. Research is needed to produce a complete gap analysis on the state and trends of biodiversity in the HKH. Emphasis should also be given to identifying and using effective indicators, both ecological and socio-economic. The ecosystem approach and transboundary PA management have been important in taking conservation beyond PAs and beyond political borders in the HKH region. In some cases, national and regional collaborations are emerging to make this concept a reality; for example cooperation between Bhutan, India and Nepal in Kangchenjunga landscape (Sharma *et al.* 2007). Such collaborations will, in due course, help to achieve the ultimate aim of establishing an effectively managed, ecologically representative PA system with associated buffer zones and conservation corridors. Such initiatives could contribute to checking the rate of biodiversity loss. Meanwhile, to further strengthen the PA network in the HKH and to fill the knowledge gaps, the following recommendations are made:

i) Develop a comprehensive knowledge base on the extent of coverage for species of both narrow and wide habitats range, and for endemic species in the HKH, including endemic flora, species of special concern, and less studied species groups such as insects, smaller mammals and lower plants.

ii) Create inventories of beta diversity and meta-populations of species occurring within PAs and landscapes in the HKH, and particularly for PAs in Pakistan, Afghanistan, Myanmar and China, as little information is available for PAs in these HKH countries.

iii) Develop comprehensive indicators to assess the effectiveness of PAs and their conservation targets.

iv) Ensure the protection of key elements of distinct ecoregions, the Kayah-Karen/Tenasserim moist forest and the Indo-China dry forest because, at present, none of the PAs in the HKH cover the biodiversity elements contained in these ecoregions.

v) Include the 73% of unprotected IBA sites in the HKH within key biodiversity areas, complemented by more research on other forms of biodiversity in these sites, and develop a framework to include them in PA systems, either by formally notifying them as PAs or by incorporating them within existing PAs.

vi) Increase connectivity between PAs by establishing conservation corridors to provide a contiguous habitat for the protection of species with larger habitat requirements, and promote adaptive measures to tackle environmental stresses due to climate change and other anthropogenic influences.

ACKNOWLEDGEMENTS

We express our gratitude to the Director General, International Centre for Integrated Mountain Development (ICIMOD), for his inspiration in reaching out to a larger audience and for providing the required facilities. We also thank the related departments and individuals from ICIMOD's eight regional member countries in the Hindu Kush-Himalayan region for their support in data updates, including Birdlife International, Conservation International, IUCN and WWF for providing access to their datasets. The contribution of two anonymous reviewers to an earlier version of this manuscript and critical review by Dr Michael Kollmair (ICIMOD) enabled us to bring new thoughts and insights to this paper. Financial support from the MacArthur Foundation to conduct this analysis as part of the Transboundary Biodiversity Management initiative in the Eastern Himalayas is highly appreciated.

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