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# On the Road to Sustainability? A Review of a Half-Century of Biodiversity Conservation Successes in Nepal and Some Thoughts on Future Needs

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## Abstract

We review the history, over the past half-century, of biodiversity conservation legislation and programs in Nepal. We especially consider how they have evolved in light of some earlier concerns resulting from, for example, the strict “fines and fences” conservation approaches first implemented in the 1970s, to pressing issues that emerged over time such as park-people and wildlife-human conflicts, poaching and illegal wildlife trade. We also consider how the implementation of international conservation agreements and demographic and political changes have affected conservation programs in Nepal. We finish by discussing conservation in the context of sustainable development and conclude with some thoughts on future research and managerial needs in a rapidly-changing world.

**Keywords:** biodiversity, conservation, Nepal, protected areas, sustainable development

## 1. Introduction

Nepal is a poor land-locked, mountainous country of 147,181 sq. km in area and approximately 30 million residents. Mountainous regions in general, given their climatic diversity, tend to be high in species diversity and endemism (e.g. [1]). Nepal is located at the boundary of the Palearctic and Indo-Malayan zoogeographic provinces at relatively low subtropical latitudes with elevations ranging from ca. 100 m above mean sea level (asl) to the world’s highest peaks. For those reasons, it boasts very high species diversity, many centers of adaptive radiation and high degrees of endemism and animals [2–6]. Nepal is recognized as being very important for biodiversity within the Asia-Pacific region [7, 8] and it boasts several Global 200 Ecoregions, two endemic bird areas, and it’s a global biodiversity hotspot (e.g. [9, 10]).

Here we explore the history of conservation programs in Nepal and how they have expanded over the past half century with the objective of asking how sustainable such programs are likely to be into the future. Our review relies on a detailed

literature review, interviews over many years with government officers and fellow academics and, collectively, among us, over 80 years of studying biodiversity and conservation programs in the country. We focus on many conservation programs that have shown promise (e.g. [11–14]) and we consider some taxon-specific conservation successes and concerns (e.g. [15, 16]). We pose this review in the context of sustaining biodiversity in an uncertain world given rapid climate change and its likely affects (e.g. [17, 18]) and we finish with some thoughts about future research and management needs.

## **2. Meager beginnings**

Much of the early history of conservation programs in Nepal has been covered in depth elsewhere (e.g. [19]). Here we give a brief background. The country was largely closed to the rest of the world until the 1950s; it was still mostly forested and underdeveloped at that time and had large wildlife populations and extensive habitat. Among the first major international projects, beginning in the 1950s, was that of the United States Agency for International Development (USAID), in conjunction with the World Health Organization (WHO), to eradicate the virulent strain of malaria endemic to the lowland (terai) region along Nepal's southern border with India. With malaria eradication, the government began moving large numbers of land-poor mountain farmers to the terai and rapid rates of deforestation and poaching ensued.

With the events described above, the successful ascent of Sagarmatha (Mr. Everest) in 1957 [20], and growing numbers of westerners visiting in the 1960s, it was apparent that the Nepal had potential as a major tourist destination and that rampant deforestation and poaching in the 1950s and 1960s were not sustainable [21, 22]. Economic development and conservation were both major concerns of King Mahendra during this time and large areas of the terai had started to undergo faunal collapse of large mammals due to these pressures [23]. In response, the king formed the rhino patrol in the central terai, in what is now part of Chitwan National Park [24]. The government then requested the first of several large projects over the years to study and promote conservation beginning in the late 1960s under the United Nations Development Program (UNDP). That first project identified important wildlife populations, proposed the first areas to be protected (some of which had been royal hunting reserves) and made many recommendations to the government about necessary legislation and staffing for conservation.

### **2.1 The seventies: modern conservation implemented**

Based on recommendations from that UN project, by 1973, the Department of National Parks and Wildlife Conservation (DNPWC) was formed (from an office within the Forest Department) as a separate entity within the Ministry of Forests and Soil Conservation, and the first protected area (PA; Chitwan National Park) was formed [25–27]. That year also saw the passage of the National Parks and Wildlife Conservation Act (the Act) that recognized four types of protected areas (PAs): national parks (NPs), wildlife reserves (WRs), strict nature reserves (SNRs) and hunting reserves (HRs). The first three correspond to International Union for the Conservation of Nature (IUCN) Protected Area Categories II, IV and Ia, respectively, while HRs do not meet IUCN standards [28]. No separate SNRs were designated because the DNPWC decided they would be impractical to enforce.

The act also published a list of protected species and hunting regulations for others. Many Nepali nationals were also sent abroad during the 1970s and 1980s,

under a number of bi- and multi-lateral international projects, to pursue professional degrees in conservation. Growing numbers of foreign nationals also pursued wildlife research in Nepal from those years to the present. This was greatly helped by the Smithsonian Institution's funding of Nepal's first permanent field site in Chitwan NP to study tigers and their prey [21, 29, 30]. That facility still exists and is now managed by the Nepal Trust for Nature Conservation (below).

Along with many other developing countries [31–35], Nepal at first adopted a strict “fences and fines” conservation model and, by the end of the 1970s, it was apparent that this led to various types of park-people conflicts [36, 37]. While living in the vicinity of PAs can have measureable economic benefits (e.g. [38]) crop loss [39] is common around PAs as wildlife populations recover, and core PAs in Nepal were off limits to activities, such as fodder and thatch grass collection, upon which rural villagers had previously depended [40, 41]. Attacks by wildlife on humans, including fatalities, have also been of growing concern from the 1970s to the present [42–44].

In one particularly disastrous decision, villagers whose families had lived in the area for centuries were removed from Rara NP (ca. 3000 m asl) to the western terai, and many succumbed to malaria (e.g. [45]). With these events, the DNPWC began changing some rules by, for example, allowing private inholdings in the other Himalayan PAs such as Sagarmatha and Langtang NPs, and allowing thatch grass removal for periods of time during the dry season in the terai PAs (e.g. [46, 47]). The former policy also had the advantage of allowing private homeowners to rent rooms to trekkers for the growing tourist markets and thus (presumably) to allow locals direct economic benefits from tourism [48–51].

## **2.2 Expanding and experimenting: the eighties and nineties**

The 1980s saw immense growth in the conservation sector of Nepal [19]. Several major international non-governmental organizations (INGOs), as well many of national-level NGOs, in support of conservation efforts began during this period and into the 1990s, and the PA system approximately doubled in area. INGOs such as the World Wildlife Fund (WWF), The Mountain Institute (TMI), the International Union for the Conservation of Nature (IUCN) and the Integrated Center for International Mountain Development (ICIMOD) all opened offices in Kathmandu during the decade of the 1980s. ICIMOD is a regional organization that includes eight Himalayan countries as members. It was founded under the UN's Education, Scientific and Cultural Organization (UNESCO) Man and Biosphere Program. The Nepal Trust for Nature Conservation, (NTNC) also began during this period. They all have since expanded greatly both in scope and funding within Nepal.

Many other national and local NGOs opened in the 1980s and 1990s as a result of democratization and attempts to decentralize power [52]. Civil society in all sectors expanded greatly during this period and the phenomenon shed light on many pressing issues. For example, the NGO Wildlife Conservation Nepal (WCN) focuses mostly on illegal wildlife trade and has been instrumental in breaking up several criminal organizations [53]. Several local NGOs focus on researching the potential for cultivating and marketing medicinal and aromatic plants (MAPS; [54]), a very important economic activity in the region (e.g., [55, 56]), and still others have formed around, for example, bird conservation (e.g. [57]). These efforts have had the effect of greatly increasing awareness of conservation in Nepal and attracting more funding for conservation efforts at multiple scales.

It was also during this period that Nepal became Party to the Convention on International Trade in Endangered Species of Wild Fauna and Florida (CITES), the convention on Wetlands of International Importance (Ramsar; [58]) and the World Heritage Convention (WHC), all of which positioned the country at the forefront

of global conservation [59, 60]. Koshi Tappu WR became Nepal's first wetland of international importance under the Ramsar convention [47]; the country has since listed seven more sites (e.g. [58]) and developed a wetlands policy to promote sustainable uses, in part due to the high ecosystem values associated with wetlands [61]. Sagarmatha and Chitwan NPs are world heritage natural sites and Nepal has many other potential WHC natural sites not yet listed including several of its other Himalayan PAs. Nepal is rich in WHC cultural sites such as the ancient temple complexes in Kathmandu Valley and Lumbini, the birthplace of the founder of Buddhism. The WHC can be especially important in promoting natural and cultural tourism, and the tourism sector has grown greatly over the years within Nepal (e.g. [62–64]).

The 1980s and 1990s (to the present) saw the passage of legislation within the PA and forestry sectors to allow for greater decentralization and democratization of natural resource use and governance, thus empowering local communities. Amendments were passed that allowed for the development of conservation areas (CAs) as a new type of PA recognized in law, as well as buffer zones (BZs) around NPs and WRs [19]. CAs are not as strictly protected as NPs or WRs, but are set aside with the intention of providing some additional protections for biodiversity, while empowering local communities to make decisions about sustainable use of local resources. Nepal's CAs correspond to IUCN Category VI [28] and much of recent expansion of the PA system has been through designating CAs in the Himalayas (**Table 1**).

In many ways, the rights and general rules granted under CA and BZ legislation reflected the earlier movement toward community forestry first implemented by the forest department and Nepal-Australia forestry project in a few districts in the mountains, which then spread to the rest of the country (e.g. [65]). They allow for some degree of local community ownership via permitting user groups to exclude outsiders and decide harvest regimes for local needs [66]. The BZ and CA laws also allow for revenues generated from tourist entry fees to be used by local communities for development projects. While government agencies maintain the power to approve plans, the regulations go a long way toward community-based conservation. They also require female and minority representation on user committees but that has proven difficult to attain in the highly socially- and gender-stratified society of Nepal (e.g. [67–69]).

The 1990s also saw the beginnings of transboundary conservation efforts between Nepal and India and Nepal and China (e.g. [19]). To date, a series of bi- and multilateral meetings have taken place in Kathmandu on these issues despite China and India's mutual hostilities over their international borders, and a number of reserves have been established in both countries that abut or come close to Nepali PAs. They include the massive Qomalanga Reserve in Tibet that borders six of Nepal Himalayan PAs, to Indian reserves that border several of Nepal's terai NPs and form additional habitat and connectivity for wildlife populations [70]. While co-management has not been achieved through these efforts, the three countries recognize that nature does not conform to political borders and coordination of efforts is needed.

### **2.3 Into the twenty-first century**

By the mid 1990s, Nepal became party to the convention on biological diversity and spent several years developing a biodiversity action plan [71]. This commitment partly led to the development of national policy and, later, legislation for the study and domestic propagation of medicinal and aromatic plants (MAPs) as part of its non-timber forest products policy (NTFPs, [54]). Value addition could be of great potential importance because Nepal has been a supplier of raw materials to the Ayurvedic medicinal industry based in India for centuries. Via CBD and the NTFP policies under implementation, the country is now positioning itself to be

Name	Date	Area	BZ area
a. National parks			
Chitwan NP	1973	932	360
Sagarmatha (Mt. Everest) NP	1976	1148	443
Langtang NP	1976	1710	660
Rara NP	1976	106	41
Shivapuri NP*	1976	159	61
Suklaphanta NP*	1976	305	118
Khaptad NP	1984	225	87
Parsa NP*	1984	637	246
Shey-Phoksundo NP	1984	3555	1373
Makalu-Barun NP	1992	1500	580
Banke NP	2010	550	210
b. Conservation areas			
Annapurna CA	1985	7629	
Blackbuck CA	1997	16	
Kanchenjunga CA	1997	2035	
Manaslu CA	1998	1642	
Api Nampa CA	2010	1903	
Gaurishankar CA	2010	2179	
c. Reserves			
Koshi Tappu WR	1976	175	68
Dhorpatan HR	1987	1325	
Totals		27,731	4247
Grand total		31,978	

The abbreviations are: NP, national parks; CA, conservation area; HR, hunting reserve and WR, wildlife reserve. Most of the older parks have been increased in area and only current (2019) areas are given. The core areas of all PAs include about 19% of the land area of Nepal. With buffer zones (BZ), the figure increases to about 22% of Nepal. Note that some NPs (\*) were originally designated as WRs and later upgraded.

**Table 1.**  
 The names, establishment dates and areas (sq. km) of PAs of Nepal, with their buffer zone areas where appropriate.

a producer of some medicines and a domestic cultivator of some species of MAPS to produce greater supplies for growing markets and to improve rural livelihoods through biodiversity conservation and use, a major goal of CBD. This has shown great promise for conservation of rare MAPs in other regions as well (e.g. [72]).

These efforts show great promise and have garnered a good deal of NGO interest and support. Although CITES (above) has been difficult to implement for many reasons worldwide (e.g. [73]), and Nepal has faced some difficult wildlife poaching and smuggling issues for several decades (e.g. [74, 75]), the passage of comprehensive national legislation to implement the convention has proven important in raising awareness of wildlife trafficking and shows some potential for reducing poaching threats [53]. Both the NTFP and wildlife trade policies are now national laws that attempt to address these pressing issues. Both require the formulation and regular meetings of national-level cross-sectoral advisory groups that include high government officials to oversee implementation.

Political instability is common in developing countries (e.g. [76, 77]) and, from 1996 to 2006, the Maoist insurgency was impacting all aspects of society in Nepal including the conservation sector [78]. Despite major setbacks, the government continued to implement conservation conventions via expanding WHC and Ramsar designations within the country, developing sustainable use policies for BZs and CAs, and drafting the wildlife trade, wetland and NTFP policies. Regulations were also adopted for better PA management planning [79]. These all had the effect of furthering sustainability locally and further advertising Nepal's vast cultural and natural heritage to its growing tourist sector. These efforts made visiting Nepal more commonplace after several years of decreased tourist arrivals during the insurgency. They also improved financial resources for conservation via tourist entries into PAs and foreign projects to promote those policies.

Both WHC and Ramsar (above) maintain trust funds to help developing countries with projects in furtherance of those conventions. They thus present opportunities but also imposed costs in the form of the need to develop national legislation and policies to further those efforts. Throughout the prior period, Nepal relied on its international treaty legislation to implement any number of global agreements to which it was party, and it took at least another decade or more for the country to develop national implementing or enabling legislation [53]. The result was poor compliance. For example, The DNPWC was designated the management authority for CITES, but had no jurisdiction outside of PAs. The department of forests was the secondary management authority for most of the country (i.e. outside PAs) but had no law enforcement unit to implement wildlife legislation. While Ramsar is perhaps easier to implement, the lack of enabling legislation, and the Maoist insurgency, postponed adding more Nepali sites to the international list for years. These issues have, thankfully, been addressed through the drafting of national enabling legislation, but much research remains to be done in terms of improved transparency and efficiency of implementing agencies and laws.

#### **2.4 More recently...**

Nepal began its first wildlife translocations in the 1980s by moving rhinos from the large population in Chitwan NP to Bardia NP, where the species had been extirpated [24]. This program was successful in that the Bardia population expanded well into the 1990s, and more animals were moved in that decade as well. The Chitwan population also continued to grow. But the Maoist insurgency had the effect of loosening law enforcement within PAs and many animals in both NPs were poached. Both populations have been recovering since.

Given the initial success of the rhino translocation, the fact that the insurgency is over, and the fact that all of Nepal's terai reserves have undergone some degree of faunal collapse of large mammal species [23], more translocations have been planned or attempted. Wild buffalo were proposed for reintroduction many times previously (e.g. [16]) and funds were garnered from the United States government for this purpose in 2014 [80]. Buffalo were moved from the large population in Koshi Tappu WR to Chitwan NP in 2017, as were swamp deer from Suklaphanta NP to Chitwan NP. To date, the buffalo translocation appears to have been a success but the swamp deer translocation does not. In the latter case, most of the translocated animals have died. Research is ongoing into these attempts and large populations of buffalo in Koshi Tappu and swamp deer in Suklaphanta remain, so more projects could be carried out if the situations warrant such.

By the early 2000s, it was well known that snow leopards had recolonized Sagarmatha NP after a long absence [81]. This, and several other observations in Himalayan PAs (e.g. records of brown bears in Manaslu CA and argali sheep

in Annapurna CA), led some researchers to hypothesize that the Maoist insurgency, negative as it was for terai wildlife, may have been perversely positive for Himalayan wildlife. The persistence of large mammals world-wide is considered to be a measure of ecosystem health (e.g. [82]) and, during the insurgency, many mountain inhabitants sold livestock and moved elsewhere, especially to Kathmandu valley and other urban areas, to escape its effects. The dearth of tourism for several consecutive years in the Himalayas may also have had the effect of reducing many other types of disturbances at high elevations (e.g. [83]). For these reasons, several researchers have explored possibilities for reintroductions of mountain ungulates in places where they have been extirpated as well (e.g. [84]).

Lastly, environmental and ecological economics began as academic disciplines in the 1980s and have greatly expanded. They are important for policy makers to understand the values of biodiversity at species, community and ecosystem levels in national economies. Research in Nepal has ranged from using contingent valuation [85] to assess the value of vultures [68, 69], using travel cost methods to explore the values of wetlands [86], to assessing possibilities for, and economics of, implementing REDD (reducing emissions from deforestation and degradation, [87]). Various findings have shown that fees foreign tourists are willing to pay for entry permits into PAs are frequently higher than what governments charge (e.g. [88, 89]). Differential fees are the norm for residents versus foreign nationals in many places, but such studies show that governments could be getting higher revenues in the most famous and visited PAs, which could be then used to shore them up and/or supplement management needs elsewhere.

### 3. Discussion: future research needs

The Bruntland report [90] defined sustainable development as: “development that meets the needs of the present without compromising the ability of future generations to meet their needs.” Phrased in more modern terms, it can be considered: “economic development that is conducted without depleting natural resources” (from Dictionary.com). In either case, many have questioned whether sustainable development can be achieved without stabilizing human populations and some consider that we are grossly overpopulated now, and beyond hope without massive population reductions (e.g. [91, 92]). We cannot address such global problems with our look at one sector of society in one country. Suffice it is to say that, like most developing countries of Asia and Latin America (but not Africa) Nepal’s birthrate has declined greatly over the past three decades but it is still somewhat above the replacement rate. But here we can only focus on the topic at hand by asking how well Nepal has done in its conservation efforts, and where to go from henceforth.

We contend that, by most measures, Nepal has done very well in adopting modern conservation programs in a comparatively rather short time period. Core areas within the PA system now cover over 18% of the country’s land area and, with buffer zones, the figure increases to over 20% (**Table 1**). With the implementation of community forestry, forest cover has increased across much of the country although biomass reduction is typical in nationalized forests outside PAs (e.g. [70, 93, 94]). More research is needed to determine how this affects plant and animal community composition and long-term forest health. On the managerial front, more coordination is needed between policies that involve MAPs harvest and those that involve community forests, CAs and BZs, where some extraction of common NTFPs is permitted (e.g. fodder, pole wood, fuel wood, etc.). While some efforts are underway, we contend that more needs to be done, especially given the physiographic variation of Nepal, and thus the differences in ecosystem productivity and composition due



to altitudinal change on north-south axes and annual rain and snowfall averages on east-west and north-south axes (e.g. [95]). Progress has been made with partnerships between the department of plant resources and various NGOs and INGOs, as well as the forest department and various INGOs, but coordination between these related sectors has not. Ranabhat et al. [96] also made an argument in favor of policy coherence in Nepal's forestry sector and between forestry and other sectors.

While the PA system is now quite large, there are many latent issues that have been raised. Obvious successes have been that vast expanses of the major Himalayan peaks and valleys have been protected, most of Nepal's terai reserves were expanded in area and upgraded to NP status, and strides have been made in recognizing international reserves with both India and China. While gaps exist in these efforts (e.g. [97]) all represent advances and many wildlife populations have demonstrably increased despite growing human populations. But ecosystems and habitats in the middle hills of the country are under-represented in the PA system (e.g. [98–100]) and this remains a concern. The middle hills traditionally were the most populated rural parts of Nepal due to the difficulty of farming at high elevations or living year-round in the terai before malaria eradication. For these reasons, many species endemic to the middle hills are under greater threats than elsewhere in Nepal (e.g. [101]). Much more research is needed on wild populations in the middle hills outside PAs, and surveys should be undertaken to locate potential PAs in that region. Due to the abundance of private landholdings, any new PAs in the middle hills would necessarily be small. However, given what we now know about the diversity of small mammals, butterflies and plants in those areas, viable populations of many species of concern could likely be conserved within relatively small reserves (e.g. [2, 5, 15]).

With regard to climate change, in terms of research, mitigation and/or adaptation, Nepal presents huge potential concerns as well as opportunities, given its physiographic variability. There is great concern, for example, about impacts on Himalayan glaciers that have already begun and upon which millions of people throughout large portions of South Asia depend for potable water [18] to potential impacts on forests and freshwater wetlands due to changes in local and regional precipitation patterns [102]. Studies on assisted colonization are underway in many places and, given the vast biodiversity that Nepal harbors, there is no limit to other studies that could be done in-country. But this remains controversial (e.g. [17]) and some suggest that we should let nature take its course given that humans tend to focus only on species that are economically important or esthetically pleasing. Perhaps a more fruitful approach would be to move only species into well-protected habitat from which they were previously extirpated, as opposed to where they never occurred, which is what the DNPWC has done with rhino and buffalo, and attempted with swamp deer.

For the myriad of other species that may or may not thrive in places outside their known geographic ranges as climates change, perhaps the most efficacious route would be to develop more potential north-south corridors for movement between PAs at different elevations. While this has been explored in the past, little progress has been made. Once again, this would require detailed surveys throughout forested areas of the middle hills to determine where core PAs could be established, albeit small in area as discussed above, and where and how they could be connected by corridors where feasible, or act as stepping stone reserves to enhance natural dispersal across elevations. A good deal of cross-sectorial coordination would be needed to eventuate these possibilities, but it would also need to begin with more-focused research.

There also remains a great deal of research to be done on policy and economics of conservation in Nepal. Studies on the ways in which community-level user groups work (or do not) within community forestry, BZ and CA organizations, for example, have led to some generalizations that may improve implementation over time

(e.g. [68, 69]). But more studies are needed given the high socio-cultural diversity inherent to Nepal (e.g. [103]) and differences in economies and levels of development in different part of the country. There is vast potential for more ecological and environmental economics research in Nepal as well; studies are now underway that look explicitly at the values of forests, wetlands and some important species in the national economy and more efforts should be encouraged along these lines. The importance of the PA system to the tourism sector cannot be understated and this is another area with great research potential. The need for more infrastructure as tourist markets increase has been apparent in some places (e.g. [104]) as has the need for more and better-trained manpower and programs designed to train them [105]. Tourism brings money, money generates jobs, and more or better employment opportunities cause people to move, thereby increasing population densities around highly-visited PAs (e.g. [106]). Long-term sustainability is in question if more tourism leads to environmental degradation. Much more socio-economic research is needed on these topics, as well as on the issue of willingness-to-pay for entry fees that may lead to, for example, charging lower fees to encourage entries to little-visited PAs and higher fees to discourage excess entries elsewhere (e.g. [107, 108]).

There is no question that a global-scale human-induced mass extinction is underway and has been for quite some time (e.g. [109, 110]). There is also no question that the rate of extinction has increased greatly as human populations expanded from about 2 to about 7.5 billion over the past 100 years. In that time, Nepal's population is thought to have increased from several million to 30 million now, yet records are made regularly for species thought previously not to occur in the country (e.g. [111]) and the press regularly publishes articles on species newly discovered in Nepal and the Himalayan region (e.g. *The Times of India*, 11 February, 2017; *The Daily Telegraph*, 23 December, 2018). This is encouraging, as is the extent of the PA system, its rapid growth and the fact that much international conservation law is under implementation, enabling legislation has been drafted, and regulations have resulted from them that encourage sustainable resource use. The decrease in Nepal's population growth rate, the expansion of community-based conservation and the MAPs and wetland policies under implementation in recent decades, are all very encouraging. The amount of NGO and INGO involvement is also encouraging and has proven very effective for conservation. In addition, many wildlife populations are known to be increasing and forest cover has demonstrably increased across much of the country.

#### **4. Conclusions**

Does the formal conservation sector in Nepal meet standards of sustainable development via either of the definitions offered above? We contend that it does, with several caveats. For different countries, places and times, there are may be many roads to sustainable development. With regard to the conservation sector of Nepal, we argue that it is on one such road. The country has made far too many efforts and has had far too many successes to deny the obvious. But will and can it continue? The answer to that question lies outside the scope or purview of any one nation. But, we would also argue, with more research and the development and the implementation of more programs to solve difficult problems—such as likely consequences of global warming—Nepal has, at the very least, arguably set up an important and highly functional PA system, and a vastly-broader conservation sector, that is likely to be resilient in the face of change. Although much remains to be done, we are encouraged about the future of biodiversity conservation in Nepal in the rapidly-changing world of the Anthropocene.

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