Chasing Performance of Protected Area Management in Nepal

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Abstract

Nepal represents a unique biodiversity which is associated with higher topographic variation and regional climate. The landscape 60 m above sea level reaching its maximum elevation up to 8.8 kilometers, strong monsoon system entering from south east of Nepal and westerly entering from the west contribute to considerable variety of life forms in the relatively smaller land area. The rich biodiversity not only forms the part of many ecological systems in the region but also provides varieties of ecosystem service in the region. Realizing the efficacy of conservation of biological and natural resources, the early conservation efforts were initiated in Nepal in the early 1970s when the concept of Protected Area (PAs) was in its rudimentary stage. Since then PA management achieved its greater heights in Nepal marching to include 30% land area of Nepal under PAs, which is perfectly following AICHI Target of 2030. In this communication, we have accessed the achievements and lapses in PAs management in Nepal. It is claimed the considerable increase in land areas and types of protected areas, and visible lapses in PAs management. Basically, it is very critical to pinpoint biodiversity hotspots and species endemism before setting aside protected areas for conservation. It emphasizes that it has been a high time to initiate the conservation of several small protected areas in order to complement the existing single large protected area system. Further, I recommend the equal conservation consciousness for areas outside conservation areas in Nepal with more focus on educating people for caring Mother Nature.

Keywords: *Protected area, biodiversity, conservation, ecosystem, management*

Introduction

Biodiversity in Nepal

Nepal comprises uniquely rich biodiversity due to great variation in elevation along the relatively short (150-250 km) north-south transect and associated variability in the eco-climatic conditions. Besides these local factors, the country's standing at the crossroads of two major biogeographic regions of the world (Indo-Malayan to the south and Palearctic to the north) has also contributed to high level of biodiversity in the country (Udvardy, 1975). Multiple overlapping and interacting gradients based on topography and climate are active in a heterogeneous landscape (Dewar & Richard, 2007; Slaton, 2015), such as in Nepal, which forms an incredible distribution of flora and fauna. The rich biodiversity is providing wide range of ecosystem services including subsistence to livelihood and ecosystem functioning in the region. The natural ecosystems in Nepal range from the tall grasslands, marshlands and tropical, and subtropical broadleaf forests along the Tarai and Siwalik foothills to subtropical and temperate broadleaf and conifer forests in the Middle Mountains. There are mixed and conifer forests in the High Mountains, and alpine meadows above the tree line. All of these

ecosystems, and more, are found within 300 km south-north span of Nepal and resulted primarily through the abrupt changes in geomorphology found throughout the country's land area. A total of 118 ecosystems have been identified in Nepal, including 112 forest ecosystems, four cultivation ecosystems, one water body ecosystem and one glacier/snow/rock ecosystem. Among the five physiographic zones found in Nepal, the Middle Mountains have the highest number (53) of ecosystems. The High Himal and High Mountains combined have 38 ecosystems. The Tarai and Siwalik have 14 and 12 ecosystems, respectively.

Nepal occupies only 0.1 percent of the global area, yet harbors over 3.2 percent and 1.1 percent of the world's known flora and fauna, respectively. Species diversity, particularly beta diversity, is very high in Nepal. Diversity of birds, bryophytes, mammals, and butterflies is especially high in Nepal (Kunwar et al., 2010; BCN & DNPWC, 2011; Jnyawali et al., 2011). A total of 313 flowering plants are endemic to Nepal (Tiwari et al., 2019). Nepal's biodiversity profile records 208 mammas, 867 birds, 123 reptiles, 55 (+-) amphibians, 230 freshwater fish and 651 butterfly species (Table 1). This high species diversity is also accompanied by high endemism. Increasing steadily from low to high elevations, a total of 284 flowering plants, 160 animal species, including one mammal species, one bird species and 24 herpetofauna are endemic to Nepal.

Table 1: Summary table of Nepal's biodiversity

Flora	Total Species	Global Share Percentage	Fauna	Total Species	Global share Percentage
Angiosperms	6,973 spp.	2 %	Mammals	208 spp.	4.5 %
Gymnosperms	41 spp.	3.9 %	Birds	867 spp.	9.3 %
Pteridophytes	580 spp.	4.8 %	Amphibians	55 spp.	1 %
Bryophytes	1217 spp.	5.29 %	Fish (Fresh water)	230 spp.	1%
Algae	1001 spp.	2.27 %	Moth	3,958 spp.	2.4%
Fungi	2182 spp.	0.35 %	Butterfly	651 spp.	4 %
Lichens	850 spp.	5 %	Beetles & Insects	5,052 spp.	0.06%
			Reptiles	125 spp.	1 %

Source: Rajbhandari et al., 2020

Nepal's uniquely rich biodiversity is shaped by 44.74% forest area (DFRS, 2015) with 23.39% land area under protected area system with 20 protected areas including 12 National Parks, one Wildlife Reserve, one Hunting Reserve, six Conservation Areas, and 13 Buffer Zones (DNPWC, 2018) (Table 1). As many as 35 forest types (Stainton, 1972), and 118 ecosystems (Dobremez, 1970, 1976) have been described in Nepal. Furthermore, 55 forest types have been described in Nepal by combining altitudinal belts, climatic zones, humidity types, description of plant life forms and related formations and human impact (Miehe et al., 2015). The country's forest ecosystems are categorized into 10 major groups: (i) tropical, (ii) subtropical broad-leaved, (iii) subtropical conifer, (iv) lower temperate broad-leaved, (v) lower temperate mixed broad-leaved, (vi) upper temperate broadleaved, (vii) upper temperate mixed broadleaved, (viii) temperate coniferous, (ix) subalpine, and (x) alpine scrub (Stainton, 1972). These ecosystems are of international importance both in view of the number of globally threatened wildlife and floral elements as well as the diversity of ecosystems represented within these areas (ICIMOD & MoEST, 2007).

Rangelands (grasslands, pastures, shrublands, and wetlands) form biodiversity rich area covering about 1.7 million hectares or nearly 12 percent of Nepal's land area (LRMP, 1986). Wetlands in Nepal also represents quite rich biodiversity; 25 percent of Nepal's vascular plants, including 26 endemic species of flowering plants are believed to be wholly or partly dependent on wetlands (CSUWN, 2010). Nepal now has a total 10 wetlands (a total of 60,561 ha) of international importance, which is 0.024% of the total surface of designated sites. Five, out of nine Ramsar sites in Nepal are located above 2,000 meter elevations (GoN & MoFSC, 2009; DoFD, 2012). Similarly, agro-ecological diversity in Nepal is also quite high, which is associated with diverse climatic and topographic conditions. Studies indicated a total of 1,506 species of agricultural crop and forage genetic resources from Nepal (Upadhyay & Joshi, 2003, Joshi et al; 2017), including fruit, vegetable and animal diversity. More than 200 species of vegetables are grown in the country, out of which 50 species have been commercialized and available in local and urban markets. The hills and mountains generally have higher agricultural biodiversity (both crop and animal) as compared to the lowlands (MoFSC, 2002). Mountains occupy about 83% land area in Nepal and constitutes over 84 percent of the country's protected areas, as well as about half of the country's 12 global priority ecoregions. It has been estimated that high mountains (above 3,000 m) in Nepal constitute about 34 percent of the plant and animal species, and 63 percent in the Middle Mountains (1,000-3,000 m). The higher diversity of plant species was reported from 1,500-2,500 m elevations, and about 450 species of flowering plants are also distributed in the areas that lie above 5,000 m (MoFSC, 2002; MoFSC, 2005).

Forests, rangeland, wetlands, agro-ecosystems and mountain biodiversity, all are exposed to greater threat in Nepal which differ with the location and type of ecosystems. Deforestation and forest fragmentation has greatly affected forest and grassland dependent wildlife, including bird species (BCN & DNPWC, 2011; Reddy et al., 2018)). The modern history of biodiversity conservation is relatively young in Nepal that started from early 1973 with the establishment of Chitwan National Park. With the advancement of knowledge in the values and threats to biodiversity, various tools have been adopted by Nepal and we have made substantial progress on biodiversity conservation. Hence I sought to analyze the performance of initiatives undertaken by Nepal to conserve biodiversity. Specifically I studied the expansion of protected area network, and the shifting paradigm in conservation programs in Nepal.

Materials and methods

I compiled studies published in journals, reports and books dealing with conservation of biodiversity and protected areas in Nepal (2000-2020 AD). National documents and reports published by government of Nepal were reviewed systematically. Different online database were used (ISI Web of Science, Science Direct, Scopus, and Google Scholar), with specific search terms such as 'biodiversity', 'conservation', 'protected areas', and 'Nepal' (for all terms see Table 1). The term 'Nepal' was used to limit the geographical scope of the search. The expansion of protective area network was estimated, and the major conservation efforts and their temporal trajectory was presented. I aim to document the challenges of, and changes in, protected area management and governance in Nepal over time. The particular challenges associated with balancing efforts to conserve and manage biological diversity while facilitating social and economic development of human communities are highlighted.

Results and discussion

Threats to biodiversity in Nepal

Nepal's sixth National Report to the Convention on Biological Diversity indicated that the forest ecosystem is at a high risk due to habitat loss and deforestation, human-wildlife conflict, invasion by alien species, and forest fire (NBS, 2002). According to the Millennium Ecosystem Assessment (2005), the changing climatic condition is likely to become the dominant direct driver of biodiversity loss globally by the end of this century. The Intergovernmental Panel on Climate Change estimated that 20-30 percent of species will likely be at a higher risk of extinction with temperature increases greater than 1.5°C and risks will increase with additional temperature rise (IPCC, 2007). The understanding of impacts of climate change on Nepal's biodiversity is weak, however, we have already observed some of the well-known impacts. They include: shifts in agro-ecological zones, prolonged dry spells, and higher incidences of pests and diseases due to increased temperature and rainfall variability, increased emergence and fast spread of invasive alien species (e.g. *Mikania micrantha, Parthenium hysterophorus*), increased incidence of forest fire in recent years, changes in phonological cycles of tree species, shifting of treeline in the Himalaya, and depletion of wetlands (MOE, 2010).

The threat to biodiversity in Nepal is similar to the globally observed threats. Rangelands, wetlands, agrobiodiversity and mountain biodiversity in Nepal are exposed to the higher anthropogenic pressure due to activities like overgrazing, forest fire, overfishing, use of pesticides, unplanned and unregulated rural roads, and over-exploitation of natural resources. Further, the threats posed by climate change are exacerbating ecosystem health leading to greater threat to biodiversity in Nepal. Rapid migration of people from rural to urban areas and from mountain settlements to valleys are posing great pressure to natural resources and causing mismatch to their use patterns are posing direct and indirect pressure to biodiversity. The wide range of threats to biodiversity of Nepal are summarized in Table 2.

Table 2: Main threats to Nepal's biodiversity

Direct Threats	Indirect Threats
• Encroachment/fragmentation and degradation of habitat • Poaching and illegal trade of key wild animals and plants • Unsustainable use of natural resources • Spread of invasive alien plant species • Human-wildlife conflict • Climate change (direct impacts) • Overgrazing by livestock • Fire, flood and landslide • Pollution of aquatic environments and changes in river flows • Large infrastructure development	• Human population growth • Food shortage • Inequitable access to forest benefits • Lack of economic alternatives • Cultural and religious factors that influence public behavior in ways that impact biodiversity • Climate change is having increasing impacts on people and nature, in some cases exacerbating indirect drivers of biodiversity loss

(Nepal Biodiversity Strategy, 2002)

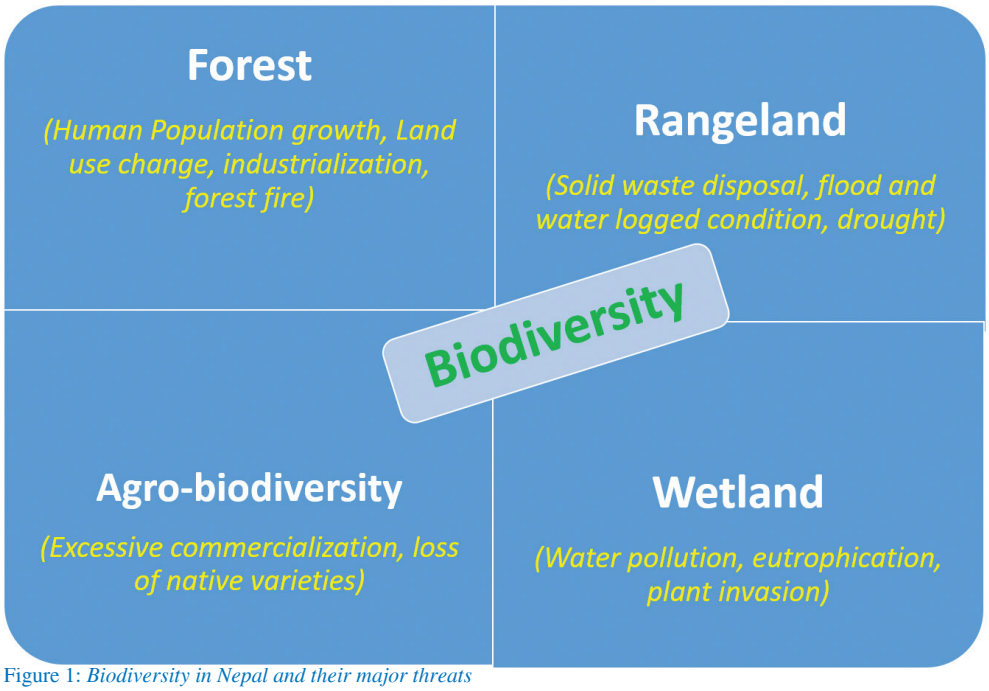

Figure 1: *Biodiversity in Nepal and their major threats*

Overexploitation and illegal exploitation of biological resources, including extraction of wood and non-wood forest products and poaching of wildlife are other major threats particularly in the Tarai and Siwalik areas, which are partly caused by weak enforcement of the law. Along with this, climate change has emerged as a major threat in many areas, although its effect on different forest ecosystems and species is not well known. Besides the above threats, poor scientific forest management; inadequate technical capacities of the district forest offices and user groups; inadequate attention to management of biodiversity in community forests; wide variations in the success of community-based forestry program across the country; poor linkage of community forestry with livelihoods and poverty alleviation; passive approaches to the management of community forests; poor relationships among stakeholders; and limited participation of women and other disadvantaged social groups are some of the key gaps and issues in forest management.

Introduction of PAs in Nepal

The modern history of protected area (PA) management in Nepal dates back to 1973 when the National Parks and Wildlife Conservation Act (1973) was promulgated and Chitwan National Park was established. In the years immediately following these key events, protected area acts and regulations were strictly applied and the role of local people in managing natural resources was neglected. However, with the passage of time, and with changes in the socio-political and economic characteristics of Nepal, management regimes have shifted towards a more liberal model which recognizes more clearly the contributions of people living and working within protected areas. Recently, landscape level conservation models including the designation of multiple use areas have been utilized in the development of management plans for protected areas. And further, to the level of trans-boundary conservation initiatives both with the neighboring countries India and China. As per the updated information from

Department of National Parks and Wildlife Conservation (DNPWC) Nepal, there are 12 National Parks, 3 Wildlife Reserves, 6 Conservation Areas, 1 Hunting Reserve and 12 Buffer Zone Areas in Nepal. And these protected area network has covered 23.39% of land area of Nepal (Figure 2, Table 3).

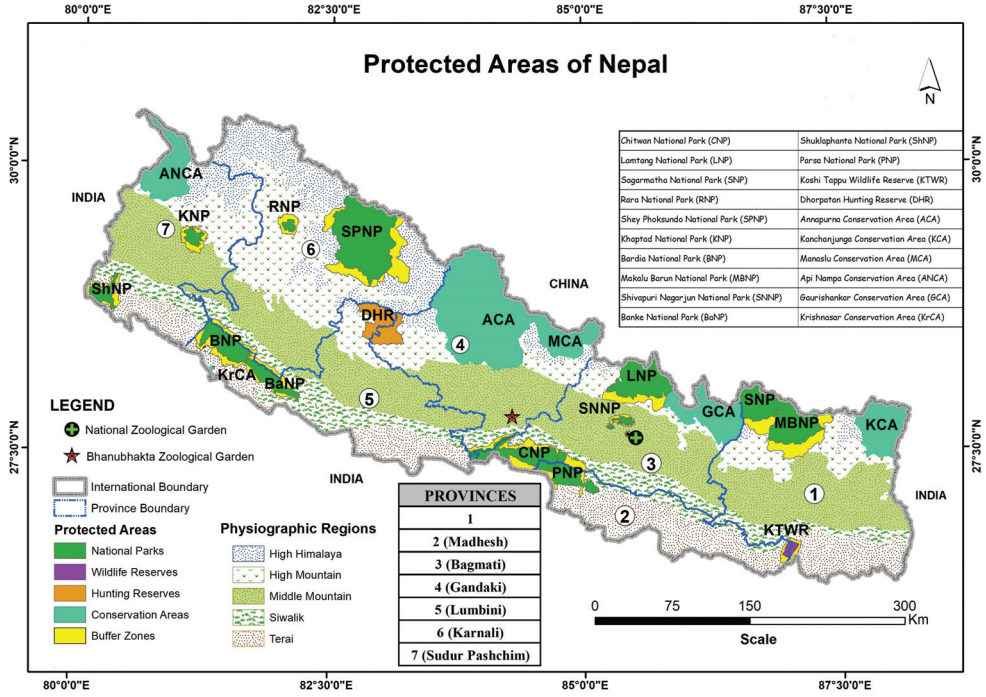

Figure 2: *Protected areas in Nepal.*

Source : DNPWC Report (2077/078)

The protected areas in Nepal are managed under four types of management modalities. The national parks, wildlife reserves and the hunting reserve are exclusively managed by DNPWC. The main focus of the national parks and wildlife reserves is conservation of flagship wild fauna, such as tiger (*Panthera tigris tigris*), rhinoceros (*Rhinocerus unicornis*), Asian elephant, snow leopard (*Panthera uncia*) and red panda (*Ailurus fulgens*) along with their habitats. Among the six conservation areas, two, Api Nampa and Blackbuck Conservation Areas, are directly managed by the DNPWC. The Annapurna, Manaslu and Gaurishankar Conservation Areas are managed by the National Trust for Nature Conservation (NTNC) under a multiple use policy. Kanchenjunga Conservation Area has been managed by a local management council since 2006 with support from the DNPWC and WWF Nepal. Buffer zones for all protected areas are managed by local buffer zone councils.

Table 3: Chronology of PA establishment in Nepal

Types	Description	Gazetted Year	Area (Km^2)	Province & Districts covered
National Park	Chitwan NP	1973	952.63	2,3,5: Chitwan, Makwanpur, Parsa, Nawalparasi

	Sagarmatha NP	1976	1148	1: Solokhumbu
	Langtang NP	1976	1710	3: Rasuwa, Nuwakot, Sindhupalchok
	Rara NP	1976	106	6: Mugu, Jumla
	Shey-Phoksundo NP	1984	3555	6: Dolpa & Mugu
	Khaptad NP	1984	225	7: Bajhang, Bajura, Doti, Accham
	Bardia NP	1988	968	5: Bardiya
	Makalu Barun NP	1991	1500	1: Sankhuwasabha
	Shivapuri Nagarjun NP	2002	159	3: Kathmandu, Sindhupalchok, Nuwakot, Dhading
	Banke NP	2010	550	5: Banke, Dang
	Shukla Phanta WR	1976	305	7: Kanchanpur
	Parsa WR	1984	627.39	3: Chitwan, Makawanpur, Parsa, Bara
Wildlife Reserve	Koshi Tappu WR	1976	175	1: Sunsari 2: Saptari
Conservation Area	Annapurna CA	1992	7629	4: Lamjung, Myagdi, Kaski, Manang, Mustang
	Kanchanjangha CA	1997	2035	1: Taplejung
	Manaslu CA	1998	1663	4: Gorkha
	Blackbuck CA	2009	16.95	5: Bardiya
	Api Nampa CA	2010	1903	7: Darchula
	Gaurishankar CA	2010	2179	3: Dolakha
Hunting Reserve	Dhorpatan Hunting Reserve	1987	1325	5: Rukum 4: Baglung, Myagdi
Buffer Zone Areas	Chitwan NP	1996	729.37	2,3,5: Chitwan, Makwanpur, Parsa, Nawalparasi
	Bardia NP	1996	507	5: Bardiya
	Langtang NP	1998	420	3: Rasuwa, Nuwakot, Sindhupalchok
	Shey -Phoksundo NP	1998	1349	1: Solokhumbu
	Makalu Barun NP	1999	830	1: Sankhuwasabha
	Sagarmatha NP	2000	275	1: Solokhumbu
	Rara NP	2006	198	6: Mugu, Jumla
	Khaptad NP	2006	216	7: Bajhang, Bajura, Achham, Doti
	Koshi Tappu WR	2004	173	1: Sunsari, 2: Saptari
	Parsa WR	2005	298	3: Chitwan, Makawanpur, Parsa, Bara
	Suklaphanta WR	2004	243.5	7: Kanchanpur
	Banke NP	2010	334	5: Banke, Dang
Total Protected Area of Nepal (km^2)			34,419.75 (23.39%)	

Source : DNPWC Report (2077/078)

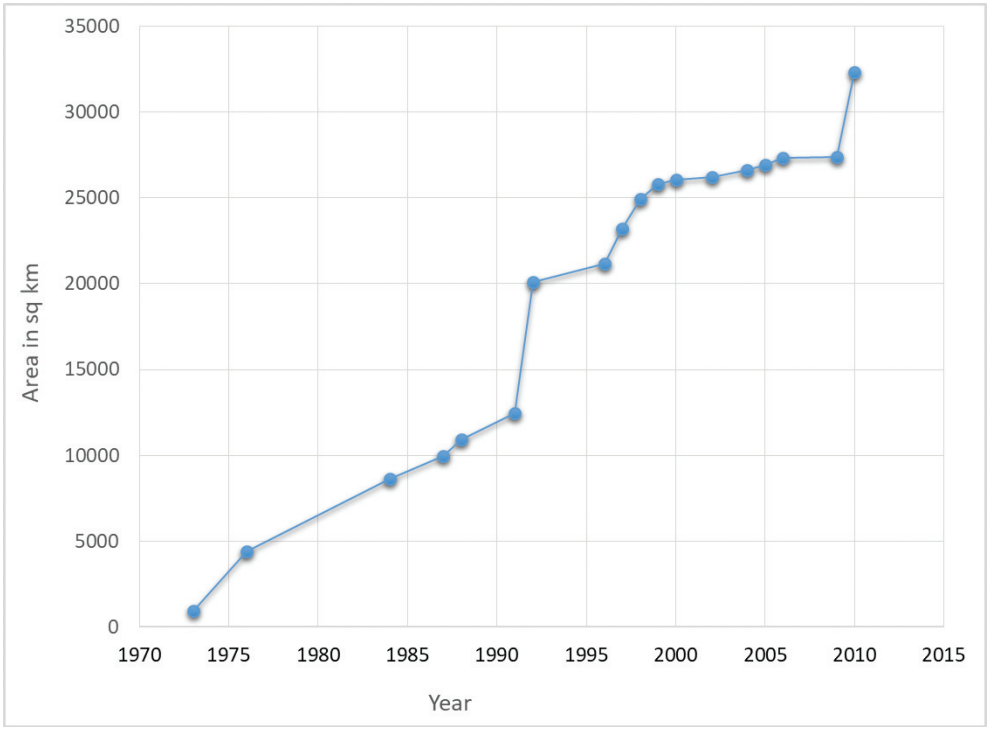

Figure 3: *Protected Area Expansion in Nepal*

Paradigm shift in conservation (global /national)

Conservation efforts for biodiversity is less than 50 years old in Nepal, and there has been a considerable shift in addressing the role of PAs in Nepal. With the beginning from very strict rules and regulation of PA management of the early 70s, the conservation programs of modern days are even managed by local people with participatory approach as well as with the landscape level to trans-boundary level. The landscape approach recognizes humans and their cultural diversity as an integral component of ecosystems and PAs as a part of a larger landscape that exists beyond the political boundary of a nation (Sherpa et al., 2003; Sharma & Chettri, 2005). The National Parks and Wildlife Conservation Act (1973) of Nepal (NPWCA) was very strict, restrictive and followed the Yellowstone model, which emphasized the protection of a pristine area and prevented people living inside the park (Heinen 1996; McNeely, 1994). During the 1970s, the government forcefully relocated villages from core areas of parks and reserves to areas outside the boundaries (Upreti, 2001). The sudden relocation of people from Rara National Park (a highland area) to the lowlands of the Banke district, probably resulted in the deaths of some people due to environmental and socio cultural stresses (Heinen & Kattel, 1992). Similarly some families were relocated from the Babai Valley of Bardia National Park during 1979-1984 (Brown, 1997). These instances have created apathy to local people to environment conservation, and such forceful extortion of people without addressing their sentiments could have far reaching consequences in protected area management in Nepal.

There is a considerable debate about the conservation impact of lowlands of Nepal where the

most fertile agricultural land is found, and about establishment of protected areas in the region. It is true that most of Nepal's land area is not suitable for agriculture due to high altitudes and steep mountain slopes (Ghimire, 1998; Thapa & Niraula, 2008), however, they could significantly contribute to conserve local biodiversity. Food security concerns associated with agriculture and protection of ecosystems and the conservation of biodiversity are competing interests especially in developing countries, and of course is appearing important challenge for conserving biodiversity. Eventually, PA management and governance is significantly affected by national and international interests and affairs, particularly in developing countries where the roles of PA in biodiversity conservation and economic development can sometimes clash (Kollmair et al., 2003; Seeland, 2000). Proposed concrete road through Chitwan National Park in Nepal was discouraged by the United Nations Educational, Scientific and Cultural Organization (UNESCO), which has responsibility for reporting and monitoring possible changes in the state of conservation of World Heritage listed sites (UNESCO, 2016). The emerging debate on construction of Nijgadh International Airport (Bara, Nepal), and the potential impact of it on biodiversity also reflects the cases of development versus conservation issues in developing country like Nepal.

Table 4 : Comparative studies of main conservation actions and management.

Era	Main Conservation Actions	Conservation Management
1970s	1. Promulgation of the National Parks and Wildlife Conservation (NPWC) Act 1973, establishment of Chitwan National Park (CNP) 2. Introduction of Restrictive approach i conservation (Yellowstone model (Heinen 1996; McNeely 1994)	• 'Command and Control' approaches: The Royal Nepalese Army, (later Nepalese Army) was deployed for park security, law enforcement and regulations • Administration carried out by park/ reserve wardens, park rangers and game scouts, under Ministry of Forests and Soil Conservation (MoFSC) • 'Fine and Fence approach' of PA management (Baral, 2005) • Increasing conflicts between park managers and local people
1980s	1. Declaration of several more protected areas including Khaptad National Park and Shey-Phoksundo National Park 2. Local people were recognized as integral to PA management, PA management approach moved from the Yellowstone model to a new, so-called Eastern model (Heinen & Kattel, 1992) 3. Amendment of the NPWC Act 1973 in 1979 granted local communities the rights to collect thatch grass and reeds from the reserves once a year (a pioneer step towards a people-centered approach	• First endorsement of the concept of striving for both conservation and development • Annapurna Conservation Area, liberalized the rights of local people; and involved them in integrated conservation and development (Nepal & Webber, 1993) • The Government handed over the authority for management of the PA to a non-government organization (NGO) • Endorsed the Integrated Conservation and Development Approach (ICDA) via ratification of the Conservation Area Regulation in 1989 (Jones, 2007)

1990s	1. Many conservation policies, rules and regulations were revised to be more pro-people and more oriented toward democracy 2. Revision of NPWCA 1973 Act in 1993 (4th amendment), included a mechanism to allow the declaration of a buffer zone around parks and reserves 3. The buffer zones includd human settlements, agricultural lands, forests, rivers and lakes to partially fulfill the requirements of local people for access to natural resources (HMGN, 1996)	• Provision of planning development activities by local people through a buffer zone management committee • Introduction of the model on the community forestry approaches in early 1980s, extremely successful and got global fame (Jones, 2007) • This strategy reduced the pressure of locals on core areas of parks and reserves (Spiteri & Nepal, 2008) and contributed to conservation (Gurung et al., 2008)
2000s	1. A shift from site-based conservation to a landscape-scale approach to conservation in Nepal 2. Introduction of the Tarai Arc Landscape (TAL) project in 2001 by the Government of Nepal with the collaboration of World Wildlife Fund (WWF, 2015) 3. This approach emphasized the roles of corridors and connectivity in biodiversity conservation	• Beginning of trans-boundary protected areas (spans the boundaries of more than one country (HMGN, 2004, then) • Handing-over of management responsibility of the Kanchenjunga Conservation Area (first PA in Nepal to be fully managed by local community) (Aryal et al., 2010)
2010s	1. Seven protected forest areas (covering 1572 km^2) to contribute to the landscape approach of conservation in Nepal (outside of PAs) 2. These areas may be utilized by local people for resources such as timber and fodder 3. Three of the seven protected forests connect PA in Nepal and India and serve as ecological corridors for iconic species (tiger, elephant, and rhinoceros) 4. Out of seven other four protected forests, one has historical and cultural significance and rest three serve as link to national parks or conservation areas (Shrestha et al., 2014)	• The management model encourages and acknowledges the participation of local communities, similar to the conservation areas managed under NPWCA 1973 and Conservation Regulation 1996

Effectiveness of PA management in Nepal

The Protected Area system (PAs) has made a significant contribution to the conservation of biodiversity by protecting 23.39% (34,419.75 km^2) of the country's total land area (DNPWC, 2018) against the Aichi Biodiversity Target 11 for the inclusion of at least 17% of terrestrial areas in effective managed and ecologically representative protected areas by 2020. The spatial distribution of PAs shows three protected areas are each entirely located in Province 1, 3, and Sudurpaschim Province; two each in Gandaki Province and Karnali Province and boundaries of rest of the protected areas are shared by two or more Provinces (Table 3). The network of PAs represents approximately 39.6% of flowering plants, 84.53% of mammals,

95.73% of birds, 70.59% of herpetofauna, and 32.5% of endemic plant species of the country (Shrestha et al., 2010).

In addition to the threats mentioned above, there are some gaps, issues and challenges in the management of biodiversity through the protected area approach. Some of these include: (i) inadequate representation of the Middle Mountain ecosystems in Nepal's protected area system; (ii) gaps in conservation of a large number of threatened plants and some animal species and in some cases (iii) conflicts among local communities, government authorities, and forest user groups. Forest biodiversity outside protected areas falls under six main types of management arrangements: (i) community, (ii) collaborative, (iii) leasehold, (iv) religious, (v) protection, and (vi) government-managed. Except for government-managed forests, there is a different level of local community involvement in the management of the forests. Leasehold forestry can be further categorized into pro-poor leasehold forestry and forests for specific purposes. Since 2002, the government has taken the initiative to manage natural forests with high biodiversity value as protection forests. Some forest patches throughout the country are under the care or management of local religious institutions. Private forests and trees grown in farmland have been contributing to the conservation of biodiversity by minimizing pressures on national forests. Forest biodiversity outside protected areas is threatened mainly by deforestation and forest degradation. Deforestation and forest degradation have been occurring through land-use conversion for agriculture, illegal settlements, infrastructure (including roads and electric transmission lines), and actions relating to the use of resources including overgrazing, unsustainable exploitation of forest products, habitat fragmentation, and uncontrolled forest fires. Invasion by alien species, such as *Mikania micrantha, Eupatorium adenophorum, Eupatorium odoratum,* and *Lantana camara* and *Parthenium hysterophorus* has emerged as a major problem, and its severity and extent is consistently increasing (Timsina et al., 2011; Shrestha, 2014).

The Nepal Tiger Genome Project has been employing a scientific and conservation-friendly method of extracting DNA of the tiger (*Panthera tigris tigris*) from non-invasively collected scat samples and to create a baseline genetic database of the species in the country. The findings are expected to facilitate a better understanding of species genetics and aid in designing effective conservation policies and strategies. The National Agriculture Genetic Resource Centre (the Gene Bank) established in 2010 at NARC has been playing a crucial role in ex-situ conservation of agricultural genetic resources. The Gene Bank has also established a tissue bank and laboratories for in-vitro culture, molecular research and seed testing. Since the creation of the Gene Bank, it has created links with community seed banks (Bhatta et al., 2012).

Lapses in PAs management

Although the protected area network has been significantly extended in Nepal, their efficacy in terms of biodiversity conservation is yet to be quantified. It seems great spatial bias in setting aside PAs in Nepal; which are disproportionately distributed in the northern highlands in comparison to the mid-hills and lowlands. Land acquisition was certainly difficult at mid-hills and lowlands in Nepal as they have highly productive lands with denser human settlements (Joppa & Pfaff, 2009). The establishment of PAs globally is often guided by socio-economic and political factors including areas that have the least conflict with competing land uses, rather than the conservation need of the prioritized areas (Venter et al., 2018; Margules & Pressey, 2000). Eventually, this results in establishing PAs in regions that

are not key areas for biodiversity conservation and this might have been the case for Nepal too. Hence, consolidating the efforts to meet the area-based targets as Aichi biodiversity target (17% area under protection by 2020) to expand the coverage of PA networks is less effective for protecting targeted biodiversity.

A recent study has highlighted that although Nepal's PA coverage (23.39% land area) is much larger than the Aichi biodiversity target, several complementary areas of endemic seed plants diversity in western Nepal, mid-hills, and lowlands of central and eastern Nepal are still lying out of the PA network (Shrestha et al., 2021). This indicates that the endemic seed plants are not adequately represented in the existing PA network, and most of these unprotected species have narrow distributional ranges, and are likely to go extinct in the future if their conservation is not properly addressed (Enquist et al., 2019). Hence, identifying the key areas of biodiversity and incorporating such areas in the PA network should be the focus of the modern day PA management.

Biodiversity in protected areas in Nepal is threatened mainly by: (i) illegal hunting and trade of important wildlife species; (ii) human-wildlife conflict; (iii) invasion by alien species of flora; and (iv) intrusion of tree species into grasslands. Furthermore, encroachment of forest areas for cultivation and settlement is a threat in some areas. The threat of illegal hunting is particularly severe for some vertebrates driven in particular by demand for wildlife parts and products in the international market. Rhinoceros (*Rhinocerus unicornis*), tiger, musk deer (*Moschus moschiferus*), pangolin (*Manis spp.*), red panda (*Ailurus fulgens*), common leopard (*Panthera pardus*), Himalayan black bear (*Ursus thibetanus*) and some bird species are especially at higher risk from poaching.

Effective enforcement of the law is a major challenge while addressing conservation threats in Nepal, both inside and outside protected areas. Human-wildlife conflict relates to crop raids and livestock depredation, property damage; and human injury and casualty by wild animals, which is common in and around most of the protected areas. Wildlife involved in crop raiding include herbivores like Asian elephant (*Elephas maximus*), rhinoceros (*Rhinocerus unicornis*), wild water buffalo (*Bubalus arnee*), Himalayan black bear (Ursus thibetanus), spotted deer (*Axis axis*) etc. And, animals involved in livestock depredation include tiger, snow leopard (*Panthera uncia*), common leopard, Himalayan black bear and wolf (*Canis lupus*) and the animal involved in property (houses, grain-stores, cash crops) damage is elephant. Similarly, Asian elephant, rhinoceros, tiger, common leopard, Himalayan black bear, sloth bear (*Milursus ursinus*), wild water buffalo and wild boar are mainly responsible for human injury and casualty. The government of Nepal is trying to resolve the problem through a system of awareness and relief with the provisions mentioned under the Wildlife Damage Relief Guideline, 2011, yet there are many challenges (Bajiyama, 2012). Similarly, invasion and rapid expansion of alien plant species, such as *Mikania micrantha, Ageretina adenophora, Parthenium hysterophorus, Lantana camara* and many more plant species (30<) has emerged as a major threat to protected areas and other forests located in the Tarai, Siwalik and Middle Mountain zones in recent years in Nepal. Hence, species management plans (both conservation and control) have to made not only for animals but also for plant species in Nepal both inside and outside in the PAs.

Conclusion

Nepal has made a significance progress on the PA management during the course of half

century of nature conservation initiatives. Conservation programs of 'Command and Control Approach of 1070s have been progressively transformed towards more participatory and public oriented conservation in Nepal. Both government and non-government organizations have recognized the key role that local communities play in biodiversity conservation. Recent development towards landscape level and trans-boundary level conservation initiatives would certainly make a significant achievement in conservation and the PA management. Biodiversity conservation in Nepal aims to strengthen governance in natural resource management, improve livelihoods of forest dependent communities, and improve local stewardship in conserving natural resources. This includes promoting meaningful participation and equitable benefit sharing for poor and marginalized groups, and for women. However, more is yet to be done with focus efforts in areas critical for biodiversity including biological corridors, catchments and refugia, working to link protected areas through corridors to meet the ecological requirements of focal species.

Over the past few years, Nepal has experienced enormous challenges in conserving the country's biodiversity, from the mountains to the Tarai. Globally, significant wildlife species such as Bengal tiger, greater one-horned rhinoceros, Asian elephant, gharial, Gangetic river dolphin and giant hornbill in Terai Arc Landscape (TAL) and snow leopard, red panda and musk deer in the Chitwan-Annapurna Landscape (CHAL) are under threat. Species-specific regional conservation strategies have also been devised for key animal species and few plant species. Key areas of biodiversity, areas of higher species endemism and important biological corridors have to recognized as mentioned by Shrestha et al. (2021), and should be incorporated in the PAs in Nepal, so that the PAs will be more inclusive. Conservation agencies have attempted to tackle challenges such as land use conflict, poaching and smuggling of wildlife parts and illegal harvesting of highly valued medicinal herbs through regulation, but these efforts are not always successful. We recommend a holistic conflict resolution approach which recognizes and resolves the different needs of all stakeholders. Species representation targets are the most relevant measure for investigating whether protected areas contribute an effective conservation response to intense human pressure (Jones et al. 2018), and climate change (Hannah et al., 2007), the current protected areas have not been designated globally for efficient (or even complete) representation of species (Hannah et al., 2007). Hence, there is a global need for effective additional protected areas in the light of anticipated species range shifts caused by climate change (Hannah et al., 2007), and this applies to Nepal too as there have been many reports on upslope shift of trees in sub-alpine treelines. Since Nepal is already able to include considerable proportion of are under PAs, we have to focus on extending PA network to include key area of biodiversity and species endemism to improve the efficacy of conservation initiatives. We should extend wide coverage of habitats along altitudinal gradients and climatic zones found within the PAs in Nepal that would definitely assist in-situ conservation of biodiversity (Chaudhary, 1998, Chaudhary et al., 2016) as well as species adaptation in the pace of rapidly changing climate.

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