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Loss of Biodiversity and Conservation Strategies: An Outlook of Indian Scenario

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ABSTRACT

This article provides a brief overview of the recent loss of biodiversity in India. By reviewing the current status of biodiversity in India, areas which need serious attention can be enumerated. There is an urgent need to monitor loss of biodiversity by analysing the situations which lead to extinction of species. It was observed in numerous case studies that major catastrophe's occurring in developing nations was attributed to loss of biodiversity. All these emphasize for a paradigm shift in the way we approach to tackle the problem. This article tries to focus on the causes which lead to loss of biodiversity in India. This was achieved by collecting all case studies and reports from scientific journals. A challenge remains, however, in using this information to provide acceptable solutions for effective conservation methods. This review will outline the biodiversity loss in India by classifying data into different categories and provides an overall picture for Indian scenario. In addition, whilst not being a comprehensive review of all the biodiversity loss in India, a number of birds, fauna and flora are included in the review. Conservation strategies adopted so far in India and strategies which have been proposed are discussed at the end.

Key words: Biodiversity, Climate change, Conservation, Extinction, India, Invasive species.

INTRODUCTION

The term biological diversity was used first by wildlife scientist and conservationist Raymond F. Dasmann in the 1968 lay book *A Different Kind of Country* advocating conservation. The term biodiversity is of relatively recent origin, becoming widespread in usage only after the American National Forum on Biodiversity in 1986 (Wilson, 1992). Scientific definitions therefore have largely followed Wilson (1992), who defines biodiversity as: *''...all hereditarily based variation at all levels of organization, from the genes within a single local population, to the species composing all or part of a local community, and finally to the communities themselves that compose the living parts of the multifarious ecosystems of the world*.'' Defining biological diversity as "*the total variability of life on earth*" (Heywood *et al*., 1995) is not conclusive to put in practice. In practice it is defined as "*number of species*." A species is, in relatively informal usage, "*a population whose members are able to interbreed freely under natural conditions*" (Wilson, 1992). Bisby *et al.* (1995) offer no fewer than eight definitions of species.

In the scientific arena most attention has focused on studying biodiversity in terms of the number of species present at a place. Defining the spatial limits of biodiversity has evolved a further group of terms; α (alpha), β (beta) and γ (gamma) diversity. This group of terms differentiates between local species richness (α diversity, the number of species at a location), the regional species pool (γ diversity, the number of different species that could be at a location) and variability between localities (β diversity) (Thompson *et al.*, 2007).

In this paper first section deals with various case studies representing loss of biodiversity in India. In next section various conservation strategies that may be adopted are reviewed for decision makers.

1. Indian biodiversity

India is a treasure chest of biodiversity which hosts a large variety of plants and has been identified as one of the eight important "*Vavilorian*" centres of origin and crop diversity. India accounts for 8% of the total global biodiversity with an estimated 49,000 species of plants of which 4900 are endemic (Kumar and Asija, 2000). The ecosystems of the Himalayas, the Khasi and Mizo hills of north eastern India, the Vindhya and Satpura ranges of northern peninsular India, and the Western Ghats contain nearly 90 percent of the country's higher plant species and are therefore of special importance to traditional medicine.

The faunal diversity comprises inter alia 2,500 fishes, 150 amphibians, 450 reptiles, 1,200 birds, 850 mammals and 68,000 insects (Alfred *et al*., 1998). Although India is designated as a mega-biodiversity area, it also has two of the world's most threatened 'hot spots', the Eastern Himalayan region and the Western Ghats. To quote Professor M.S. Swaminathan, "*both*

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are paradises of valuable genes but are inching towards the status of Paradise lost". At least 10 per cent of India's recorded wild flora and possibly more of its wild fauna are on the list of threatened species. Of the wild fauna, 80 species of mammals, 47 of birds, 15 of reptiles, three of amphibians and a large number of moths, butterflies and beetles are endangered. Out of 19 species of primates, 12 are endangered (Mittermeier *et al*., 1999).

The ecosystems of southern peninsular India including the southern Western Ghats contain more than 6000 species of higher plants including an estimated 2000 endemic species. Of these, 2500 species representing over 1000 genera and 250 families have been used in Indian systems of medicine namely Ayurveda, Unani, Siddha and Tibetan Medicine. India has coastline about 8000 km, Exclusive Economic Zone of 2.02 million km^2 and a wide range of coastal ecosystems such as estuaries, lagoons, mangroves, backwaters, salt marshes, rocky coasts, sandy stretches and coral reefs (Venkataraman, 2005).

2. LOSS OF BIODIVERSITY

Biodiversity is declining on two scales- β diversity (the difference in biodiversity between regions – species identities in more and more locations are becoming similar) and γ diversity (global biodiversity is declining), but at particular locations α diversity may be increasing due to the addition of invaders (Sax *et al*., 2002; Sax and Gaines, 2003). Sax and Gaines (2003) make clear that this phenomenon is not restricted to islands – rather, local biodiversity is increasing in many continental locations as well. Few authors documented declines in a number of components of biodiversity (Pimm *et al*., 1995; Vitousek *et al*., 1997; Sala *et al*., 2000) .The pertinent fact is that levels of extinction over the last 300 years are at least several hundred times greater than expected based on the geological record (Dirzo and Raven, 2003). Hunting by humans is believed to have been amongst the most significant factors driving the extinction of large wildlife species (Diamond, 1989). In India hunting has been recognized as major factor in historical declines of wildlife (Rangarajan, 2003). This paper will be restricted to loss of biodiversity in India.

The extinction of species caused by direct perturbation, such as broad-scale tropical forest clearance for agriculture (Sodhi *et al*., 2006) or the elimination of island populations by introduced predators (Pimm *et al*., 2006), constitutes the primary driver of biodiversity loss in the modern context (Purvis *et al*., 2000). Brook *et al*. (2008) coined a term 'extinction dynamics', they studied synergies among extinction drivers like Habitat loss, Over-exploitation, Climate change, Invasive species and Pollution. Figure 1 presents overall picture of causes.

3. LOSS OF BIODIVERSITY IN INDIA

Twenty-five biodiversity hot spots have been identified (Myers *et al*., 2000) worldwide as areas of greater biological endemism in the biosphere. Two of these are present in the Indian subcontinent, viz. the Eastern Himalayas and the Western Ghats. The threats to biodiversity

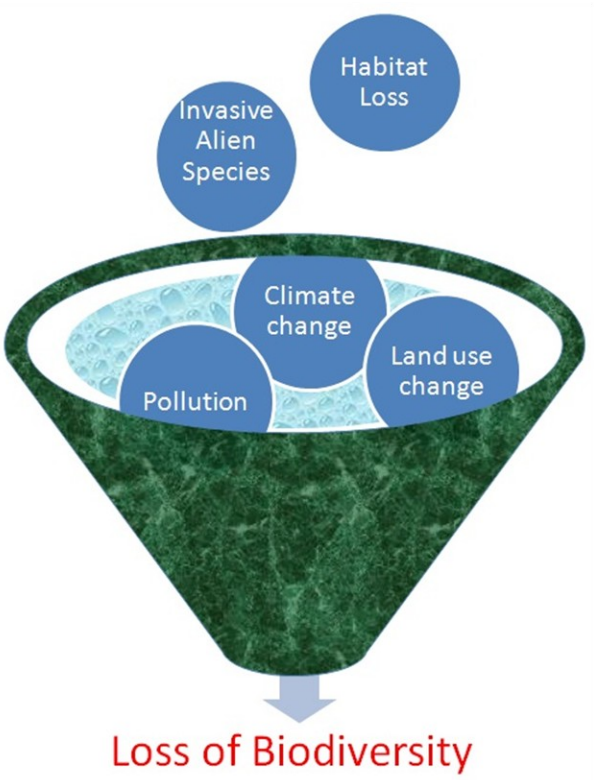

Figure1. Causes for loss of Biodiversity.

are not homogeneously distributed; the 2000 IUCN (International Union for Conservation of Nature) report (Hilton-Taylor) allows for distinguishable patterns to be discerned with regard to geography and ecological (e.g., biome) affinity, among other things. Thus a large majority of the threatened mammal species occurs in tropical countries. The top of the list is Indonesia, with 135 species, followed by India, Brazil, China, and Mexico. As a percentage of the total number of mammal species in each country, the ranking of the top countries changes, but the majority of the countries, 8 out of the top 10, are still tropical (Dirzo and Raven, 2003).

With the current level of deforestation, by year 2100 only about 10% of the land area of the Indian Himalaya will be covered by dense forest (>40% canopy cover) - a scenario in which almost a quarter of the endemic species could be wiped out, including 366 endemic vascular plant taxa and 35 endemic vertebrate taxa. In Himalaya, particularly in the sub-tropical and temperate forests (broad-leaf, coniferous and mixed), species such as tiger (Panthera Tigris) and other members of cat family (Felidae) will be highly vulnerable to extinction (Pandit *et al*., 2007). The country has lost about 40% of its mangroves and some crucial part of its wetlands (Jain, 1991).

3.1 Floral Species

India is blessed with wide variety of floral species in various biodiversity hotspots. It is estimated that there are over 7800 medicinal drug manufacturing units in India, which consume about 2000 tonnes of herbs annually (Singh, 2001). With increase in development activity, floral species have been endangered and are moving towards extinction.

Table.1. illustrates the reported endangered flora list with places where it was abundant while loss of biodiversity was observed.

3.1.1 Analysis

- The lichens exploited in India grow at rates from 5 mm/year to about 2 cm/year for the most rapidly growing leafy (foliose) or shrubby (fruticose) lichens (Upreti *et al*., 2005).Thus rapid exploitation of lichens will lead to extinction of species within no time. Commercial trade (shown in Figure 2) of floral species needs to be monitored and a sustainable approach for growth of lichens needs to be adopted. Upreti endorsed lichens to be included in the CITES (Convention of International Trade in wild species of Endangered Fauna and Flora) list.

Figure 2. Lichen materials sorted, graded, and baled at Ramnagar. Adapted from "Commercial and ethnic use of lichens in India," (Upreti *et al*., 2005).

- *Sapria himalayana* found in Indian eastern Himalayas – a biodiversity hotspot is prone to extirpation due to habitat loss through encroachments in the park area. All attempts to reintroduce or translocate the species will be in vain due to its phyto geographical limitations and host-specificity (Arunachalam *et al*., 2004).
- If we look into various causes for loss of biodiversity in flora, we can classify causes into two major categories: *Commercial use and Development activities*. Commercial use of flora is a good source of income for tribal people in remote areas of India, although knowledge on proper handling of species for such use is expected to be less in tribal people. Unscientific handling of flora for such commercial activities cannot be ignored as some of species cannot be brought back once they are extinct there by leading to loss of biodiversity and even source of income for people. Construction of reservoirs, amusement parks and various such developmental activities lead to human influx accompanied by destruction of ecosystem in which flora have adapted to live for so many years.
- Most of the endangered species reported are located in either biodiversity hotspots or places around them. Thus, need of the hour is to frame policies to monitor causes for loss of biodiversity in flora in various hotspots and encourage people to actively participate in various training programmes to handle species for commercial use. Developmental activities need to be employed only after estimation of biodiversity loss in such areas after proposed activity.

Table 1. Endangered flora, causes for loss of biodiversity and places last found.

Species Endangered	Place of interest	Causes
Rauvolfia serpentina, Terminalia chebula, Sapindus laurifolius and Jatropha curcas	Western Ghats (Kamalappa, 2003).	Destructive harvesting followed by unscientific handling.
Catuneregam spinnosa, Garcinia cambogea, Acacia pinnata, Ficus benghalensis, Zanthoxzyllum rhesta, Hemidesmus indicus, Terminalia chebula, Wrightia zeylanica, Cinnamomum verum, Bombax ceiba, Sapindus laurifolius, Alangium salvifolium and Calophyllum inophyllum	Maradavally, Shimoga district (Kamalappa, 2003).	Medicinal use and Deforestation.
Abrus precatorius, Adenanthera paronina, Aegle marmelos, Caesalpinia bonducella, Cardiospermum halicacabum, Corallocarpus epigaeus, Gloriosa superba, Andrographis paniculata	Devrayanadurga forests, Tumkur, Deccan Plateau (Kamalappa, 2003).	Destructive harvesting and Medicinal use.
Lichen genera Parmotrema, Everniastrum, and Rimelia	Ramnagar and other places in India (Upreti *et al*., 2005)	Commercial use
Arunachal Hopea Tree (*Hopea shingkeng*)	Arunachal Pradesh (CITES species database, 2011)	Construction of House Posts
Hubbardia heptaneuron	Karnataka (IUCN (SSC) E Bulletin)	Construction of the Linganamakki reservoir
Sapria himalayana	Himalayas (Myers *et al*., 2000)	Human Influx

3.2 Wild Life

India is rich in wild life biodiversity with wide variety of species across the nation through various biodiversity hotspots. But due to human influx, lack of scientific methods for handling adversaries and developmental activities lead to extinction as well as endangerment of species. There are many species that have been annihilated, unrecorded either because they were not that spectacular or because their existence remained unknown. Table 2. below illustrates the reported endangered wild life.

Table 2. Endangered wild life, causes for loss of biodiversity and places last found.

Species Endangered	Causes
Indian/ Asiatic Cheetah, Javan Rhinoceros and Sumatran Rhinoceros (Vivek Menon, 2003).	Exploitation of land and forest resources
The cheetah (*Acinonyx jubatus*) and the pink-headed duck (*Rhodonessa caryophyllacea*) (Nayyar and Sastry, 1990).	Annihilated, unrecorded
The Asiatic lion, the Bengal Tiger, and the Indian white-rumped vulture (Groombridge, 1993).	Feeding on the carrion of diclofenac-treated cattle
Asian Elephant (*Elephas maximus*) (Sukumar *et al*.,1998)	Ivory poaching
The Indian tiger (Antony Barnett, Jaipur (India) 2003).	Making of beauty products
Muntiacus putaoensis (leaf deer) (Arunachalam *et al*., 2004).	Hunting

3.2.1 Analysis

- The exploitation of land and forest resources by humans along with hunting and trapping for food have led to the extinction of many wild life species in India in recent times. Cases such as death of wild life due to feeding on treated cattle have been reported. Such reported literature on large scale is need for the hour, as India is facing crisis on assessing loss of biodiversity in a region. Wild life sensitive to ecosystem dynamics are prone to extinction with these activities, more over there is no mechanism in place to quantify the loss of species in such cases.
- Ivory poaching has been rampant in Southern India, Sukumar *et al*. (1998) have estimated that 336–388 tuskers have been poached and 3256–3334 kg of ivory harvested by poachers over the 20 year period with maximum harvest from the 10–20 year age class. Such rampant poaching has led to decline in elephant population in India, with no proper measures from government side to stop such heinous crimes.
- Poaching in India is main contributor for loss of biodiversity in any form. There used to be more than 20,000 tigers in India. Now, despite heroic efforts by conservationists to protect the last 3,000 of the great cats still roaming in remote areas, the Indian tiger is facing extinction.

3.3 Birds

Birds are considered an indicator of the good condition of the natural environment. In India Birds play important role in the traditional lifestyle and dressing habits of many tribes in the State. The tribal people use the beak of the bird as a headgear to be worn as a traditional knot on the forehead. Table 3. below illustrates the reported endangered birds. Among the endangered birds highly vulnerable species include monal pheasant (*Lophophorus impeyanus*), koklas pheasant (*Pucrasia macrolopha*), western tragopan (*Tragopan melanocephalus*), Himalayan snow cock (*Tetraogallus himalayensis*), golden eagle (*Aquila chrysaetos*), steppe eagle (*Aquila nipalensis*), black eagle (*Ictinaetus malayensis*) and bearded vulture (*Gypaetus barbatus*) (Pandit *et al*., 2007).

A recent study by the Zoological Society of London (ZSL) and Yale University (2014) has identified 100 evolutionary distinct and globally endangered (EDGE) bird species from around the world, of which 15 are from India. The 15 Indian species on the EDGE list are Bengal Florican, Forest Owlet, Red-headed Vulture, Egyptian Vulture, Jerdon's Courser, Lesser Florican, Spoon-billed Sandpiper, Sociable Lapwing, Siberian Crane, Great Indian Bustard, Greater Adjutant, White-bellied Heron, Wood Snipe, Masked Finfoot and Christmas Island Frigatebird.

While the Bengal Florican, Lesser Florican, Great Indian Bustard, Sociable Lapwing and Jerdon's Courser are under threat due to destruction of their habitat of grasslands and scrub forests, survival of the Spoon-billed Sandpiper, Siberian Crane and White-bellied Heron greatly depends on their wetland habitat. The Forest Owlet's survival too is impossible if deciduous forests in central India are destroyed as per study.

3.3.1 Analysis

- Most of the loss of biodiversity among birds is not yet reported as expected. For example, the sole stock-taking of the peacock population in India was done by WWF India in 1991. It revealed that India was left with only 50 per cent of the total peacock population that existed at the time of Partition in 1947. While the green peacock is already believed to be extinct, the peacock may soon end up on the critically endangered list. Similarly the most unfortunate crane species is the Siberian crane that was wintering in India and Iran but has gone extinct due to hunting along the route. Now the western population is nearly extinct. The eastern population breeding in East Siberia and wintering in China is endangered as the wintering grounds are threatened (Meine *et al*., 1993).
- The Vulture decline was documented by comparing results from road transects surveys of raptors across Northern and Central India in 1991–93 and 2000

Table 3. Endangered birds, causes for loss of biodiversity and places last found.

Species Endangered	Place of interest	Causes
Seychelles Parakeet (*Psittacula wardi*)	Indian Ocean islands (Kundu *et al*., 2012).	Intense persecution by farmers and coconut plant owners.
Pink-headed Duck (*Rhodonessa caryophyllacea*) and the Himalayan Quail (*Ophrysia superciliosa*) (Adams *et al*., 2003)	Not reported	Annihilated, unrecorded
Bengal Florican (*Houbaropsis bengalensis*)	Grasslands in north India and Nepal and Brahmaputra valley of Assam (Rahmani, 2001)	Reduction in grassland area, changes in habitat structure and management practices (Baral *et al*., 2003)
Great Indian Bustard (*Ardeotis nigriceps*), Jerdon's Courser (*Rhinoptilus bitorquatus*), Forest Owlet (*Heteroglaux blewitti*), White bellied (*Heron Ardea insignis*) (IUCN endangered red list)	Not reported	Not reported
Narcondam Hornbill (*Aceros narcondami*) (IUCN vulnerable species list)	Not reported	Not reported
Sarus crane	Himalayas (Meine *et al*., 1993).	Hunting
Great Indian hornbill *(Buceros bicornis*)	Arunachal Pradesh (Arunachalam *et al*., 2004).	Human traditions
Long-billed vulture (LBV: *Gyps indicus*), Slender-billed vulture (*Gyps tenuirostris*), and Oriental white-backed vulture, (OWBV: *Gyps bengalensis*)	Northern and Central India (Prakash *et al*., 2003).	Pesticides

(Prakash *et al*., 2003). Results showed annual decline rates of 33% for Oriental White-backed (OWBV) and 27% for Long-billed Vulture (LBV) respectively (Green *et al*., 2004).The estimated decline during the period 1992–2007 is 96.8 (LBV) to 99.9 (OWBV) percent (Prakash *et al*., 2007). Widespread use of the non-steroidal anti-inflammatory drug (NSAID) diclofenac to treat livestock has resulted in dramatic declines in the populations of vultures across India. Livestock carcasses provide the main food supply for vultures, and are also eaten by dogs. Dogs are the main source of rabies in humans in India, and their populations have increased substantially in parallel with the vulture decline.

- All threatened species are at risk of extinction from human activities, particularly habitat loss and degradation resulting from unsustainable and often illegal logging, wet land clearance for agriculture and exotic timber plantations.

3.4 Aquatic and Marine Biodiversity

There are few reported cases of loss of biodiversity in aquatic and marine biodiversity. Loss of biodiversity among marine species has been neglected as causes for biodiversity loss have not been established. Following are few reported cases which had significant impact on aquatic and marine biodiversity.

- Exploitation and Expansion of land, water resources are leading to rapid biodiversity loss. Geographical expansion of Coimbatore city in recent decades has led to the destruction of the Noyyal River that had once served the city's water needs. A genotoxic study by Rajaguru (2003), on the fish and earthworm in the Noyyal river basin showed extensive damage to their DNA. Similarly, the spatial growth of Kolkata has led to drastic changes in the biodiversity of the East Kolkata Wetlands in the city as well as the Sundarbans. In Goa (India), the loss of sand dunes and associated flora is near total because of ill-conceived beach beautification schemes and reclamation of sandy beach areas for recreational activities associated with tourism (Wafar et al., 2011).
- Ornamental invasive fishes have been recorded from the Chalakudy River in the Western Ghats which is a biodiversity hotspot under threat (Dahanukar, 2010). Introduced fish frequently alter the aquatic ecology by changing water quality and also cause the extinction of native fish by predation and resource competition (Pimentel, 2002). The presence of four 'habitat specialist' critically endangered species and sixteen endangered species makes this river a high priority area for implementing urgent conservation and management measures (Raghavan *et al*., 2008a).
- Introduced aquarium fish represent a major source of ecological destruction that may be locally alarming if ignored (Liang *et al*., 2006). Tilapias and the major carps are good examples of invasive food fishes. In addition to *P. reticulata,* ornamental fish such as *Osphronemus goramy*, *Xiphophorus maculatus* have been recorded from the Chalakudy River, a biodiversity hotspot in Kerala (Raghavan *et al*., 2008 a, b;

Krishna Kumar *et al*., 2009).

- Not less than 300 exotic species are traded in India (Dahanukar, 2010). There is no regulation to this trade and there is lack of data on the ecological impact of alien fish species. Some studies clearly show that there is a relationship between frequency of fish sold in aquarium stores and their introduction and establishment in freshwater habitats (Duggan *et al*., 2006). Thus threat from such unknown consequences must be analysed thoroughly by tracking route through which these invasive species are entering India. A list of such routes must be maintained and every possible way must be explored to limit the impact.
- The high population density of most countries is also a major cause of degradation of coastal habitats, especially through addition of pollutants. It has been estimated (Sen Gupta *et al*., 2001) that Indian coastal seas have been receiving $3.9 * 10^{12}$ litres of domestic sewage and $3.9 * 10^{11}$ litres of industrial sewage (taken as 10% of the former) every year. An extrapolation, using the ratio of the length of the coastline of India (6,500 km) to that of all countries (66,526 km) (Keesing et al., 2005), would suggest that a pollution load of $40 * 10^{12}$ and $4 * 10^{12}$ litres, respectively, of sewage and industrial effluents may enter coastal seas every year.

3.5 Insects and Amphibians

Generally, the life history of an organism depends upon the habitat (Begon *et al*., 1996) and the resource distribution has an important effect on ecology (Marsh *et al*., 2000). For amphibians, such data are few and knowledge of the role of habitat in determining distributions is limited. The following are some of the reported loss of biodiversity among insects and amphibians in India.

- Among the insects, butterflies occupy a vital position in ecosystems and their occurrence and diversity are considered as good indicators of the health of any given terrestrial biotope (Kunte, 2000; Thomas, 2005). As herbivorous insects, the distribution of larval and nectar host plants has a distinct impact on the status of butterfly diversity (Culin, 1997; Raju *et al*., 2004). Recent reports reveal that about 100 out of 1500 butterfly species occurring in India are on the verge of extinction (Raju and Rao, 2002). A number of colonies of butterflies have been exterminated by human activities, resulting in changes to habitats beyond the tolerance limit of the species.
- Butterflies like the *Euploea core*, *Eurema brigitta, Catopsilia Pomona*, *Danaus chrysippus*, and *Tirumala limniace* have the ability to survive in adverse biotopes and are ubiquitous. Control of the exploitation of natural biotopes for butterflies, including shrub, herb, and trees, dried and green grasses (e.g. grazing) would definitely help to maintain and increase the diversity of butterflies (Tiple *et al*., 2007). The butterfly fauna of the Western Ghats, which is one of the global biodiversity hotspots and an important conservation area, exemplifies the problems posed by current listings under the six WPA (Wild Life Protection Act) schedules (Kunte, 2000).
- Thirty-six species of anurans and six species of caecilians have been recorded in the Kudremukh National Park, central Western Ghats, India and the total amphibian species richness represents 20% of the whole Indian amphibian fauna. Among these, 20 species were distributed in both disturbed and undisturbed sites, while 22 were found only in undisturbed sites indicating they may be threatened by further habitat fragmentation (Krishnamurthy, 2003).

3.6 Mammals

Among land mammals, threatened species are concentrated in South and Southeast Asia. Other peaks of threat include the tropical Andes, Cameroonian Highlands, Albertan Rift, and Western Ghats in India, all regions combining high species richness, high endemism, and high human pressure (Sanderson *et al*., 2002). Biological traits of large mammals their inherently low densities, long life time span also render them to be vulnerable (Eisenberg, 1980; Eisenberg, 1981; Lande, 1988).

The important large mammals facing extirpation in Himalaya are black bear (*Ursus thibetanus*), musk deer *(Moschussp*.), bharal (*Pseudois schaeferi*), Himalayan tahr (*Hemitragus jemlahicus*), serow (*Capricornis sumatraensis*) and common leopard (*Uncia uncia*) (Pandit *et al*. 2007). In Kudremukha, at least 26 species of mammals were hunted, mostly with guns, at an estimated intensity of 216 hunter-days per month per village. In Nagarahole, 6 of the 9 focal species of large mammals occurred at significantly lower densities at the heavily hunted site where enforcement capabilities were poorer. Data underscore the importance of preservationist programs in the conservation of large mammals in a context of extensive local hunting (Madhusudhan *et al*., 2002).

4. CONSERVATION STRATEGIES

Most of the world's biodiversity occurs within developing countries that require donor support to build their conservation capacity (Smith *et al*., 2003). Donor support requires proper scientific quantification and areas where focus needs to be maintained in impromptu basis. The International Union for the Conservation of Nature (IUCN) maintains the Red List to assess the conservation status of species, subspecies, varieties, and even selected subpopulations on a global scale. IUCN notes that many species are threatened with extinction. At threat of extinction are 1 out of 8 birds, 1 out of 4 mammals, 1 out of 4 conifers, 1 out of 3 amphibians, 6 out of 7 marine turtles. Such lists help in understanding overall scenario but conversation strategies differ from country to country. Thus in previous section we tried to quantify the species and hotspots which need urgent attention to control the loss of biodiversity. In this section various conservation strategies which have been reported for Indian scenario are discussed.

4.1 Indian perspective

One of the key challenges for India in implementing the international commitments is to combat poverty and also economic development on sustainable basis. The first well developed regulatory framework was the UN

Conference on Human Environment held at Stockholm in 1972 (Stockholm Declaration). India, along with 113 other nations agreed on principles and an action plan to protect the environment and came under an obligation to implement these domestically. To implement these, a new authority for environmental protection known as National Council for Environmental Policy and Planning within the Department of Science and Technology was set up in 1972. This Council later evolved into Ministry of Environment and Forests (MoEF) in 1985, which today is regulating and ensuring environmental protection in India. India became the first country in the world to have provisions for the protection and improvement of its environment (Sharma, 2014).

India has recently ratified the Nagoya Protocol and formalised its commitment to it. Approach to protecting and promoting biodiversity has been guided by the belief that all three objectives of the Convention on Biological Diversity, namely, conservation, sustainable use and sharing of benefits from the utilization of genetic resources, should receive adequate and equal focus. This approach is the basis of India's Biological Diversity Act of 2002. The 2008 National Biodiversity Action Plan further identifies specific action points by various government agencies. In 2010, the country level status assessment for tigers showed an increase in their number to an estimated 1706 from an estimated 1411 in 2006. India's tiger population has significantly increased according to the 2014-15 India tiger estimation report. Recent years have seen a dramatic rise in numbers– from 1,411 in 2006 to 2,226 in 2014 (National Tiger Conservation Authority). The increase in the tiger population can be largely attributed to better management and improved protection within tiger reserves and other tiger bearing protected areas.

4.2 Strategic Plan for India

Protected areas cover up to 15.5% of the planet's land surface and are amongst the most important tool to maintain habitat integrity and species diversity (Geldmann *et al*., 2007). For habitat protection, the Geldmann *et al*., review shows that Protected Areas are an important element of conservation strategies to preserve tropical forests. India now has 448 Wildlife Sanctuaries, 102 National Parks and 18 Biosphere Reserves, covering about 5% of the total geographical area (MOEF, 2011).

The management of natural resources worldwide has largely been driven by two divergent and influential approaches: *Sustainable use* (Munro *et al*., 1991) and *Preservationism* (Kramer *et al*., 1997). The recovery of Tiger and Prey population in many wild life reserves under *Project Tiger* (Panwar, 1987) represents a successful example of Preservationist Program.

Singh *et al* (1994) suggested to stratify the country into eco regions or bio geographical zones and to sample biodiversity patterns in those zones, with particular reference to measurable environmental gradients. Ganeshaiah and Uma Shanker (1998) have proposed an integration of species distribution data and preparation of biodiversity atlases through a country-wide network of scientists. Such atlases together with habitat conservation maps can be combined to map the country's biodiversity. A combination of field sampling with remotely sensed information may permit successful extrapolation at progressively higher scales for whole landscapes (Nagendra, 1999). Ramesh *et al*. (1997) have described a vegetation-based approach for biodiversity gap analysis, and in an innovative approach, Roy and Tomar (2000) have combined data from field sampling (including biodiversity), satellite images and geographic information system to identify and map areas of particularly high biological richness on a regional scale.

India has a rich tradition of biodiversity conservation. Traditional human relationships like beliefs, faith, taboos, customs and preferences played an important role in conservation of habitats and individual species (Jain, 2000). The cultural ethos of the Indian people is amply demonstrated by such conservation efforts (Gadgil, 1991). Frequently, species selected by the local people for social significance turn out to be also of ecological significance (Ramakrishna, 1996).

CONCLUSION

The loss in biodiversity also hurts us in other ways. Our cultural identity is deeply rooted in our biological environment. Plants and animals are symbols of our world, preserved in flags, sculptures, and other images that define us and our societies. We draw inspiration just from looking at nature's beauty and power. There is need for systematic reporting and documentation of conservation projects as well as the inclusion of pressures and responses in the study design of ecological experiments. However without proper documentation and controlled conditions making this evaluation is not possible. Finally, the ultimate decision-maker for biodiversity is the individual citizen. The small choices that individuals make add up to a large impact because it is personal consumption that drives development, which in turn uses and pollutes nature. Biodiversity is essential for human survival and economic well-being and for the ecosystem function and stability. The growing awareness of importance and high rates of loss make it imperative to rapidly assess and conserve biodiversity, both at regional and global levels. Successful strategies for people's participation in preserving biodiversity are lacking. India has a rich tradition of conservation, and with growing inputs from the Government, scientists and NGOs, should provide leadership in developing appropriate methodologies and strategies for biodiversity assessment and conservation.

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