*Asian Journal of Conservation Biology*, December 2014. Vol. 3 No. 2, pp. 105–114 AJCB: RP0001 ISSN 2278-7666 ©*TCRP* 2014

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

## M.N.V. Anil1,\*, Kanchan Kumari1 and S. R. Wate1

*1CSIR-National Environmental Engineering Research Institute,*

*Nehru Marg, Nagpur - 440020, Maharashtra, India*

(Accepted December 15, 2014)

# ABSTRACT

**This article provides a brief overview of the recent loss of biodiversity in India. By reviewing the cur- rent 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 re- mains, 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 catego- ries 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* advocat- ing 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 biodiver- sity 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 them- selves 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 condi- tions*” (Wilson, 1992). Bisby *et al.* (1995) offer no fewer than eight definitions of species.

In the scientific arena most attention has fo- cused 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

*\*Corresponding Author’s E-mail:* [*mnvanil@yahoo.com*](mailto:mnvanil@yahoo.com)105

diversity, the number of species at a location), the re- gional species pool (γ diversity, the number of different species that could be at a location) and variability be- tween 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.

## 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). Al- though 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*

*are paradises of valuable genes but are inching towards the status of Paradise lost*”. At least 10 per cent of In- dia'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, butter- flies 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 represent- ing 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 km2 and a wide range of coastal ecosystems such as estuaries, lagoons, mangroves, backwaters, salt marshes, rocky coasts, sandy stretches and coral reefs (Venkataraman, 2005).

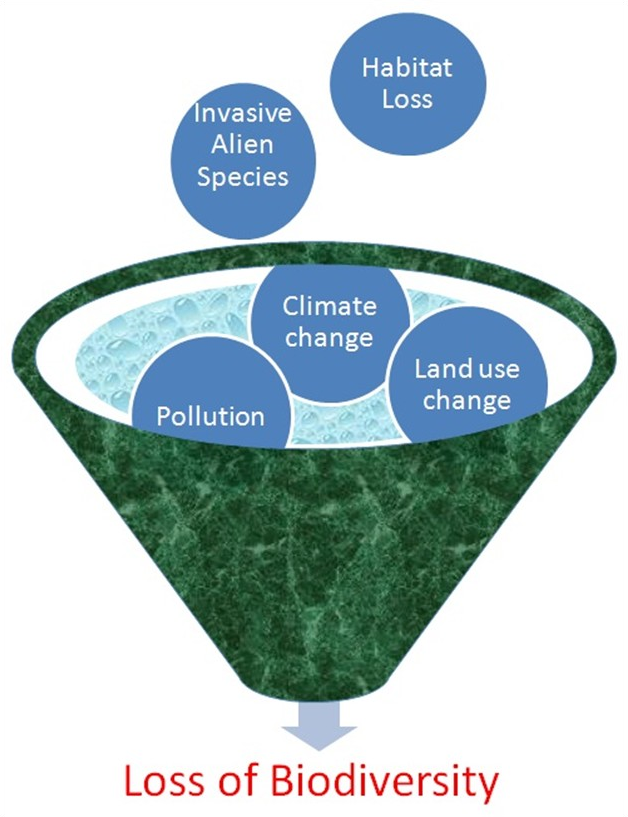
## LOSS OF BIODIVERSITY

Biodiversity is declining on two scales- β diversity (the difference in biodiversity between regions – species identities in more and more locations are becoming simi- lar) 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, lo- cal biodiversity is increasing in many continental loca- tions 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 perti- nent fact is that levels of extinction over the last 300 years are at least several hundred times greater than ex- pected based on the geological record (Dirzo and Raven, 2003). Hunting by humans is believed to have been amongst the most significant factors driving the extinc- tion 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 per- turbation, 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.

## LOSS OF BIODIVERSITY IN INDIA

Twenty-five biodiversity hot spots have been identified (Myers *et al*., 2000) worldwide as areas of greater bio- logical endemism in the biosphere. Two of these are pre- sent in the Indian subcontinent, viz. the Eastern Himala- yas 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 major- ity of the threatened mammal species occurs in tropical countries. The top of the list is Indonesia, with 135 spe- cies, 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 Hi- malaya will be covered by dense forest (>40% canopy cover) - a scenario in which almost a quarter of the en- demic species could be wiped out, including 366 en- demic 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 ex- tinction (Pandit *et al*., 2007). The country has lost about 40% of its mangroves and some crucial part of its wet- lands (Jain, 1991).

## 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 In- dia, which consume about 2000 tonnes of herbs annually (Singh, 2001). With increase in development activity, floral species have been endangered and are moving to- wards extinction.

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

## 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. Com- mercial 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 Interna- tional 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 Himala- yas – 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 geo- graphical limitations and host-specificity (Arunachalam *et al*., 2004).
* If we look into various causes for loss of biodiver- sity in flora, we can classify causes into two major categories: *Commercial use and Development ac- tivities*. 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 can- not 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 activi- ties need to be employed only after estimation of biodiversity loss in such areas after proposed activ- ity.

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

|  |  |  |
| --- | --- | --- |
| **Species Endangered** | **Place of interest** | **Causes** |
| *Rauvolfia serpentina, Terminalia chebula, Sapindus lauri- folius and Jatropha curcas* | Western Ghats (Kamalappa, 2003). | Destructive harvest-  ing followed by un- scientific handling. |
| *Catuneregam spinnosa, Garcinia cambogea, Acacia pin- nata, Ficus benghalensis, Zanthoxzyllum rhesta, Hemides- mus indicus, Terminalia chebula, Wrightia zeylanica, Cin- namomum 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 harvest- ing 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 reser- voir |
| *Sapria himalayana* | Himalayas (Myers *et al*., 2000) | Human Influx |

## 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 annihi- lated, unrecorded either because they were not that spec- tacular or because their existence remained unknown. Table 2. below illustrates the reported endangered wild life.

**Table 2.** Endangered wild life, causes for loss of biodi- versity and places last found.

* Poaching in India is main contributor for loss of biodi- versity in any form. There used to be more than 20,000 tigers in India. Now, despite heroic efforts by conser- vationists to protect the last 3,000 of the great cats still roaming in remote areas, the Indian tiger is facing ex- tinction.

## 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 en-

dangered birds. Among the endangered birds highly vul-

|  |  |
| --- | --- |
| **Species Endangered** | **Causes** |
| Indian/ Asiatic Cheetah, Javan Rhinoceros and Sumatran Rhi- noceros (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, unre- corded |
| The Asiatic lion, the Bengal Ti- ger, and the Indian white- rumped vulture (Groombridge, 1993). | Feeding on the carrion of di- clofenac-treated cattle |
| Asian Elephant (*Elephas maxi- mus*) (Sukumar *et al*.,1998) | Ivory poaching |
| The Indian tiger (Antony Bar- nett, Jaipur (India) 2003). | Making of beauty products |
| *Muntiacus putaoensis* (leaf deer) (Arunachalam *et al*., 2004). | Hunting |

nerable species include monal pheasant (*Lophophorus impeyanus*), koklas pheasant (*Pucrasia macrolopha*), western tragopan (*Tragopan melanocephalus*), Himala- yan 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 evo- lutionary 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 In- dian 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 habi- tat of grasslands and scrub forests, survival of the Spoon- billed Sandpiper, Siberian Crane and White-bellied Heron greatly depends on their wetland habitat. The For-

est Owlet's survival too is impossible if deciduous forests

in central India are destroyed as per study.

## 3.2.1 Analysis

* The exploitation of land and forest resources by hu- mans 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 re- ported 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 popu- lation in India, with no proper measures from govern- ment side to stop such heinous crimes.

## 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 farm- ers and coconut plant owners. |
| Pink-headed Duck (*Rhodonessa caryophy*  *llacea*) 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 hu- mans in India, and their populations have increased sub- stantially in parallel with the vulture decline.

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

## 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 Ra- jaguru (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 be- cause of ill-conceived beach beautification schemes and reclamation of sandy beach areas for recreational activi- ties 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 ecol- ogy by changing water quality and also cause the ex- tinction of native fish by predation and resource com- petition (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 man- agement 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 biodiver- sity 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 establish- ment 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, espe- cially through addition of pollutants. It has been esti- mated (Sen Gupta *et al*., 2001) that Indian coastal seas have been receiving 3.9 \* 1012 litres of domestic sew- age and 3.9 \* 1011 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 \* 1012 and 4 \* 1012 litres, respectively, of sewage and industrial effluents may enter coastal seas every year.

## Insects and Amphibians

Generally, the life history of an organism depends upon the habitat (Begon *et al*., 1996) and the resource distribu- tion 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 lim- ited. The following are some of the reported loss of bio- diversity 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 lar- val 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 hu- man 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 natu- ral 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 biodi- versity hotspots and an important conservation area, exemplifies the problems posed by current listings under the six WPA (Wild Life Protection Act) sched- ules (Kunte, 2000).
* Thirty-six species of anurans and six species of caecili- ans have been recorded in the Kudremukh National Park, central Western Ghats, India and the total am- phibian 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 indicat- ing they may be threatened by further habitat fragmen- tation (Krishnamurthy, 2003).

## Mammals

Among land mammals, threatened species are concen- trated in South and Southeast Asia. Other peaks of threat include the tropical Andes, Cameroonian Highlands, Al- bertan Rift, and Western Ghats in India, all regions com- bining 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 suma- traensis*) and common leopard (*Uncia uncia*) (Pandit *et al.* 2007). In Kudremukha, at least 26 species of mam- mals were hunted, mostly with guns, at an estimated in- tensity of 216 hunter-days per month per village. In Na- garahole, 6 of the 9 focal species of large mammals oc- curred at significantly lower densities at the heavily hunted site where enforcement capabilities were poorer. Data underscore the importance of preservationist pro- grams in the conservation of large mammals in a context of extensive local hunting (Madhusudhan *et al*., 2002).

## CONSERVATION STRATEGIES

Most of the world’s biodiversity occurs within develop- ing 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 ex- tinction are 1 out of 8 birds, 1 out of 4 mammals, 1 out of

1. conifers, 1 out of 3 amphibians, 6 out of 7 marine tur- tles. 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.

## 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 to- day 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 pro- tecting and promoting biodiversity has been guided by the belief that all three objectives of the Con- vention on Biological Diversity, namely, conservation, sustainable use and sharing of benefits from the utiliza- tion of genetic resources, should receive adequate and equal focus. This approach is the basis of In- dia’s Biological Diversity Act of 2002. The 2008 National Biodiversity Action Plan further identifies specific action points by various government agen- cies. 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 popu- lation 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 in- crease in the tiger population can be largely attributed to better management and improved protection within tiger reserves and other tiger bearing protected areas.

## 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 main- tain habitat integrity and species diversity (Geldmann *et al*., 2007). For habitat protection, the Geldmann *et al*., review shows that Protected Areas are an important ele- ment of conservation strategies to preserve tropical for- ests. India now has 448 Wildlife Sanctuaries, 102 Na- tional Parks and 18 Biosphere Reserves, covering about 5% of the total geographical area (MOEF, 2011).

The management of natural resources world- wide has largely been driven by two divergent and influ- ential 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 success- ful 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 particu- lar 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 pro- gressively 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 com- bined 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 conser- vation. 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 envi- ronment. Plants and animals are symbols of our world, preserved in flags, sculptures, and other images that de- fine 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 re- sponses 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 indi- vidual citizen. The small choices that individuals make add up to a large impact because it is personal consump- tion that drives development, which in turn uses and pol- lutes 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 pre- serving biodiversity are lacking. India has a rich tradition of conservation, and with growing inputs from the Gov- ernment, scientists and NGOs, should provide leadership in developing appropriate methodologies and strategies for biodiversity assessment and conservation.

# REFERENCES

Adams, M. P., Cooper, J. H. and Collar, N. J. 2003, Ex- tinct and endangered (E and E') birds: a proposed list for collection catalogues. Bulletin-British Orni- thologist Club, 123, 338-354.

Alfred, J.R.B. 1998. Faunal Diversity in India: An Over- view: In Faunal Diversity in India, i-viii, 1-495 ENVIS Centre, Zoological Survey of India, Cal- cutta.

Antony, B. West’s love of talc threatens India’s Tigers 2003 <http://www.guardian.com/uk/2003/jun/22/>

world.antonybarnett. Cited 7 November 2014.

Arunachalam, A., Adhikari, D., Sarmah, R. Majumder,

M. and Khan, M. L. 2004. Population and conser- vation of Sapria himalayana Griffith in Namdapha national park Arunachal Pradesh In- dia. Biodiversity and Conservation: 13(13) 2391- 2397.

Arunachalam, A., Sarmah, R., Adhikari, D., Majumder,

M. and Khan, M. L. 2004. Anthropogenic threats and biodiversity conservation in Namdapha nature reserve in the Indian Eastern Himalayas. Current Science, 87(4), 447-454.

Baral, N., Timilsina, N and Tamang, B. 2003. Status of Bengal Florican *Houbaropsis bengalensis* in Ne- pal .Forktail: 51-56.

Begon, M., Harper, J.L. and Townsend C.R. 1996. Ecology: Individuals Populations and Communi- ties. Oxford UK: Blackwell Scientific Publica- tions: 945 pp.

Bisby, F. A., Coddington, J. and Thorpe J. P. 1995. Characterization of biodiversity. Global biodiver- sity assessment. 162, 14624-14627.

Brook, Barry W., Navjot S. Sodhi, and Corey Bradshaw JA. 2008. Synergies among extinction drivers un- der global change. Trends in ecology and evolu- tion 23, no. 8: 453-460.

Culin, J.D.1997.Relationship of butterfly visitation with nectar qualities and flower colour in butterfly bush, Buddleia davidii. News Lepid. Soc, 39**,** 35- 38.

Dahanukar, Neelesh, ed. 2010. Invasive ornamental fish: a potential threat to aquatic biodiversity in peninsular India. Journal of Threatened Taxa 2, no. 2, 700-704.

Dasmann, R.F**.** 1968 A Different Kind of Country. Mac- Millan Company, New York, ISBN 0-02-072810- 7.

Diamond, Jared. 1989. Overview of recent extinc- tions, Conservation for the twenty-first century, 37

-41.

Dirzo, Rodolfo and Peter H. R. 2003. Global state of biodiversity and loss. Annual Review of Environ- ment and Resources.28, no. 1, 137-167.

Duggan, I.C., Corinne A.M. Rixon, and Hugh J. Mac Isaac. 2006. Popularity and propagate pressure: determinants of introduction and establishment of aquarium fish. Biological invasions 8, no. 2, 377-

382.

Eisenberg, J.F. 1980. The density and biomass of tropi- cal mammals. Conservation biology: an evolution- ary-ecological perspective, 35-55.

Eisenberg, J.F. 1981. Mammalian radiations*,* University of Chicago Press

Gadgil, M. 1991. Conserving India's biodiversity: the societal context. Evolutionary Trends in Plants, 5 (1), 38.

Ganeshaiah, K.N. and Uma Shanker, R. 1998. Contours of conservation-a national agenda for mapping biodiversity. Current Science*,* 75(3) 292-298.

Geldmann, J., Barnes, M., Coad, L. and Craigie, I.D. et al. 2013. Effectiveness of terrestrial protected ar- eas in reducing habitat loss and population de- clines. Biological Conservation, 161, 230-238.

Green, R., Newton, I., Shulz, S. and Cunningham, A.A. et al. 2004. Diclofenac poisoning as a cause of vulture population declines across the Indian subcontinent. Journal of Applied Ecology, 41 793–800.

Groombridge**,** B. 1994.The 1994 IUCN Red List of threatened Animals. IUCN Gland Switzerland and Cambridge.

Heywood, Vernon Hilton. 1995. Global biodiversity as- sessment. Cambridge University Press.

Jain, S.K. 1991. Dictionary of Indian Folk Medicine and Ethno botany. Deep Publication, New Delhi

Jain, S.K. 2000. Human aspects of plant diver- sity. Economic Botany*, 54*(4) 459-470.

Kamalappa and Ramakrishnappa. 2003. Impact of culti- vation and gathering of medicinal plants on biodi- versity. Food and Agricultural Organisation of United Nations Corporate Document repository, ISBN 9251049173.

Keesing, J. and Irvine, T. 2005. Coastal biodiversity in the Indian Ocean: The known unknown and un- knowable. IJMS, 34: 11–26**.**

Kramer, R., Schaik, C.V. and Johnson, J. 1997. Last stand: protected areas and the defence of tropical biodiversity*,* Oxford University Press

Krishna Kumar, K.R., Raghavan, G. and Prasad, A. et al. 2009. When pets become pests – exotic aquarium fishes and biological invasions in Kerala India. Cur- rent Science*,* 97: 474-476

Krishnamurthy, S.V. 2003. Amphibian assemblages in undisturbed and disturbed areas of Kudremukha National Park central Western Ghats India. Environ- mental Conservation*,* 30(03) 274-282.

Kumar, Updesh, and Mahender J. A. 2000. Biodiversity: Principles and Conservation. Agrobios.

Kundu, S. and Jones, C.G. et al. 2012. The evolution of the Indian Ocean parrots (*Psittaciformes*): Extinc- tion adaptive radiation and eustacy Molecular phy- logenetics and evolution*,* 62(1) 296-305

Kunte, K. 2000. A life scope of butterflies of peninsular India −University Press, Hyderabad

Lande, R. 1988 Genetics and demography in biological conservation Science (Washington*)* 2414872:1455- 1460

Liang, S.H., Chuang, L.C. and Chang, M.H. 2006. The pet trade as a source of invasive fish in Tai- wan. Taiwania*,* 51(2): 93-98

Madhusudhan, M. D. and Karanth, K. U**.** 2002. Local hunting and the conservation of large mammals in India. Ambio*,* 49-54

Marsh, D.M., Rand, A.S. and Ryan, M.J. 2000. Effects of inter-pond distances on the breeding ecology of tungara frogs. Oecologia, 122: 505–513

Meine, C., George W. and Archibald. 1996. The Cranes: Status Survey and Conservation Action Plan, IUCN. Mittermeier, Russell A., Norman Myers, Cristina Goettsch Mittermeier, and Patricio Robles Gil.

1999. Hotspots*:* Earth's biologically richest and most endangered terrestrial eco regions. CE- MEX,SA, Aggrupation Sierra Madre*, SC*.

MoEF .1999.National Policy and Macro level Action Strategy on Biodiversity, Ministry of Environment and Forests, Govt of India, New Delhi.

Munro, D.A. and Holdgate, M. W. 1991. Caring for the earth*:* a strategy for sustainable living*.* International Union for the Conservation of Nature and Natural Resources (IUCN).

Myers, Norman, Russell A. Mittermeier, Cristina G. Mit- termeier, Gustavo AB Da Fonseca, and Jennifer Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403, no. 6772, pp: 853-858**.**

Nagendra, H. and Gadgil, M. 1999. Biodiversity assess- ment at multiple scales: Linking remotely sensed data with field information. Proceedings of the National Academy of Sciences*, 96*(16) 9154-9158

Nayar, M.P. 1996. Hotspots of endemic plants of In- dia Nepal and Bhutan *(*Tropical Botanical Garden and Research Institute Thiruvanthapuram, India)

Pandit, M. K., Navjot S. Sodhi, Lian Pin Koh, Arun Bhaskar, and Barry W. Brook. 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity and Conservation 16, no. 1, 153-163.

Panwar, H.S. 1987. Project Tiger: the reserves the tigers and their future Tigers of the world: The biology bio politics management and conservation of an endangered species New Jersey: Noyes Publica- tions 110**-**117

Pimentel, D. 2002. Biological Invasions: economic and environmental costs of alien plant animal and mi- crobe species. (2002), CRC Press, London, 384pp

Pimm, Stuart L., Gareth J. Russell, John L. Gittleman, and Thomas M. Brooks. 1995. The future of biodi- versity. Science-AAAS-Weekly Paper Edition 269, no. 5222, 347-349.

Pimm, Stuart, Peter Raven, Alan Peterson, Çağan H. Şekercioğlu, and Paul R. Ehrlich. 2006. Human impacts on the rates of recent, present, and future bird extinctions. Proceedings of the National Acad- emy of Sciences 103, no. 29, 10941-10946.

Prakash, V. et al. 2007. Recent changes in populations of resident Gyps vultures in India. Journal of the Bombay Natural History Society, 104, 129–135.

Prakash, V., Pain, D.J. and Cunningham, A.A. et al. 2003.Catastrophic collapse of Indian white-backed *Gyps bengalensis* and long-billed *Gyps indicus* vulture population. Biological conservation, 109 381–390

Purvis, Andy, Kate E. Jones, and Georgina M. Mace. 2000. Extinction. Bio Essays 22, no. 12, 1123-

1133.

Raghavan, R.G., Prasad, P.H., Anvar-Ali, B. and Pereira. 2008a. Exotic fish species in a global biodiversity hotspot: observations from River Chalakudy part of Western Ghats Kerala India. Biological Inva- sions*,* 10: 37-40

Raghavan, R.G., Prasad, P.H., Anvar-Ali, B. and Pereira. 2008b. Fish fauna of Chalakudy River part of Western Ghats biodiversity hotspot Kerala India: patterns of distribution threats and conservation needs. Biodiversity Conservation*,* 17: 3119-3131.

Rahmani, A.R. 2001. Status of Bengal Flori- can *Houbaropsis bengalensis* in UttarPradesh, India. Unpublished report. Bombay, India: Bombay Natural History Society .

Rajaguru, P., S. Suba, M. Palanivel, and K. Kalaiselvi. 2003. Genotoxicity of a polluted river system meas- ured using the alkaline comet assay on fish and earthworm tissues. Environmental and Molecular Mutagenesis 41, no. 2, 85-91.

Raju, A.J.S. and Rao, S.P. 2002. A case study on the de- cline of butterfly colonies in degraded habitats of Visakhapatnam. In Bull Andhra University Res Forum, **(**Vol 7 pp 57-59**).**

Raju, A.J.S., Bhattacharya, A. and Rao, S.P**.** 2004. Nec- tar host plants of some butterfly species at Visakha- patnam. Science and Culture*. 70*(5/6)187-190

Ramakrishnan, P.S. 1996. Conserving the sacred: from species to landscapes. Nature and resources*, 32*(1) 11-19

Ramesh, B.R., Menon, S. and Bawa, K.S. 1997. A vege- tation based approach to biodiversity gap analysis in the Agastyamalai region Western Ghats India. Ambi*o, 26*(8) 529-536

Rangaraju, Mahesh.1998. The Raj and the natural world: The war against 'dangerous beasts' in colonial In- dia. Studies in history 14, no. 2, 265-299.

Roy, P.S. and Tomar, S. 2000. Biodiversity characteriza- tion at landscape level using geospatial modelling technique. Biological conservation*, 95*(1) 95-109

Sala, Osvaldo E., F. Stuart Chapin, Juan J. Armesto, Eric Berlow, Janine Bloomfield, Rodolfo Dirzo, Elisa- beth Huber-Sanwald et al. 2000. Global biodiver- sity scenarios for the year 2100 science 287, no. 5459 1770-1774.

Sanderson, E.W., Jaiteh, M. and Levy, M.A. et al. 2002. The Human Footprint and the Last of the Wild The human footprint is a global map of human influence on the land surface which suggests that human be- ings are stewards of nature whether we like it or not. Bio Science, *52*(10) 891-904

Sax, D. F., and Steven D. Gaines. 2003. Species diver- sity: from global decreases to local in- creases. Trends in Ecology and Evolution 18, no. 11, 561-566.

Sax, D. F., Gaines, S. D., and Brown, J. H. 2002. Species invasions exceed extinctions on islands worldwide: a comparative study of plants and birds. The American Naturalist, *160*(6), 766-783.

Sen Gupta, R. and Qasim, S.Z. 2001. Health of the Indian Ocean. The Indian Ocean: A perspective *1*, 327- 371.

Sharma, A. 2014. Multilateral Environmental Agree- ments and India. Employment news, VOL. XXXVIII NO .51, 22- 28 March, pp 1 and 72.

Singh, H.P. 2001. National perspective on development of medicinal and aromatic plants. Technical report Agri Watch. [www.agriwatch.com.](http://www.agriwatch.com/) Cited 18 January 2014.

Singh, J.S., Raghubanshi, A.S. and Varshney, C.K. 1994. Integrated biodiversity research for India. Current Science, 66(2)109-112.

Smith, R., Muir, R.D., Walpole, M.J., Balmford, A. and Leader-Williams, N. 2003. Governance and the loss of biodiversity. Nature*, 426* (6962) 67-70.

Sodhi, Navjot S., and Barry W. Brook. 2006. Southeast Asian biodiversity in crisis. Cambridge University Press.

Sukumar, R., Ramakrishnan U. and Santosh, J.A. 1998. Impact of poaching on an Asian elephant popula- tion in Periyar, southern India: a model of demog- raphy and tusk harvest. Animal Conservation, *1* (4), 281-291.

Thomas, J.A. 2005. Monitoring change in the abun- dance and distribution of insects using butterflies and other indicator groups. Philosophical Trans- actions of the Royal Society B: Biological Sci- ences 360 (1454) 339-357.

Thompson, Ross, and Brian M. Starzomski. 2007. What does biodiversity actually do? A review for man- agers and policy makers. Biodiversity and Conser- vation 16, no. 5, 1359-1378.

Tiple A.D., Khurad, A.M. and Dennis, R.L. 2007. But- terfly diversity in relation to a human-impact gra- dient on an Indian university campus", Nota Lepi- dopterologica*,* 301: 179

Upreti, D.K., Divakar, P.K. and Nayaka, S. 2005. Com- mercial and ethnic use of lichens in India. Economic botany, *59*(3) 269-273.

Venkataraman, K., and Wafar. M. V. M. 2005. Coastal and marine biodiversity of India. Indian journal of marine sciences, 34, no. 1, 57-75pp.

Vitousek, Peter M., Harold A. Mooney, Jane Lubchenco, and Jerry M. Melillo. 1997. Human domination of Earth's ecosystems. Science 277, no. 5325, 494-499.

Vivek Menon. 2003. A field guide to Indian mammals. Dorling Kindersley Delhi, ISBN 0-14-302998- Volume 2 San Diego: Academic Press 697–713.

Wafar, M., Venkataraman, K. and Ingole.et al. 2011. State of knowledge of coastal and marine biodiversity of Indian Ocean countries. PloS one 6(1) e14613.

Wilson, E.O. 1992.The Diversity of Life. Cambridge MA: Belknap press, 424 pp.