India needs a National Biodiversity Conservation Board

T. N. Khoshoo

India's stakes in biodiversity are very high not only because it is a country rich in biodiversity but, out of the twelve centres, it is also a very important centre of origin of agri-biodiversity. Furthermore, the country as a whole is predominantly biomass-based with largely bio-industrial pattern of development in an unusually large number of villages, where over 76% of its population lives. The country is also a signatory to the Biodiversity Convention (1992), but such a decision was taken without any serious consultation with the scientific community. This has resulted in India landing itself into a situation where policy on biodiversity has overtaken the underlying science and technology. A major issue is how well scientific and technical knowledge can be harnessed into public policy. This paper summarizes India's strengths and weaknesses in this area and urges that the Government of India appoint a small scientifically and technically sound National Biodiversity Conservation Board. This would not only enable to prepare a cadre of conservation biologists, but also help to generate products and give the requisite bargaining power to the country in the international arena during negotiations.

In common parlance, biodiversity may be defined as species richness (plants, animals and microorganisms) in a given habitat be it on land, in fresh water or sea, or as parasites or symbionts. Biodiversity is critical to the very health and stability of the biosphere and renewability of biomass, soil, water and air, together with oxygen, carbon, nitrogen and phosphorous cycles. Thus biodiversity renders free recycling and purification services together with natural pest control.

A subset of biodiversity is *genetic diversity* which occurs in the form of interbreeding *populations* of a given species. Populations of different plants, animals and microorganisms in a given habitat, existing as an interacting system, are known as *communities*. An aggregate of communities occurring as an interacting system in a given ecological niche makes an *ecosystem*. Different ecosystems in an ecological region occurring as an interacting system constitute a *biogeographical province*. All biogeographical provinces in a major ecological zone constitute a *realm*, and all realms on the surface of the earth together constitute the *biosphere*—the living mantle around the world occurring on land, in fresh water and in sea. Biodiversity is also the source of all living materials used as food, shelter, clothing, biomass energy, medicaments, etc. and host of other raw materials used in bioindustrial development. These along with metallic and non-metallic minerals constitute the basic wealth of any country. Ultimately, economy and ecology of a country depend on the health of these resources.

There is increasing pressure on natural habitats due to growing human population and enhanced pace of socio-economic development. This has led to the degradation of parts of earth's biosphere, and has resulted in loss of biodiversity and agricultural productivity. Such losses of species *are for ever* and affect not only plants, animals and microorganisms in nature together with those under cultivation/domestication and used in industry, but also those whose value has yet to be ascertained.

The evolutionary history of earth is replete with examples of both extinction of old and origin of new species taking place simultaneously. Infact, geological times have witnessed five major episodes of extinction because of the cataclysmic events, but today's accelerated rate of extinction episodes can be traced only to the influence of human race. Therefore, steps need to be taken to halt such species losses. There is also a need of a well-conceived and dynamic programme of biodiversity estimation, conservation and sustainable utilization.

The over-all estimation of the extent of biodiversity in the form of plant cover and forests in different habitats (including deserts, water bodies, coastal areas, etc.) would come under the purview of Department of Space and Forest Survey of India (MoEF), particularly the former because theirs would be a third party evaluation thus more credible. Periodic (say 5-yearly) reports from these bodies are needed to monitor all habitats for the extent of biodiversity. These data would be useful to take up work on ecorestoration of degraded habitats. Such surveys may also help in calculating the overall quantity of biomass, i.e. all living matter plant, animal and microorganism come under its purview.

The entire *in situ* conservation falls within the mandate of the Ministry of Environment and Forests (MoEF) together with some aspects of *ex situ* conservation, like conservation of complete organisms being attempted in field gene banks in botanic gardens, arboreta, zoos, zoological parks and aquaria (Figure 1). However, use of modern technologies in conservation of organism parts, falls primarily under S&T departments like Department of Agricultural Research and Education (DARE), Indian Council of Forestry Research and Education (ICFRE), and secondarily under Department of Biotechnology (DBT), Department of Scientific and Industrial Research (DSIR) and Department of Science and Technology (DST). These include biological banks for seeds, pollen, sperms, eggs, embryos, tissues, microorganisms and genes (in the form of DNA). A well-managed network of such banks of parts of plants and animals, and microorganisms already exists in the ICAR. This Council has national bureaus on soil and land use, and plant, mammalian, avian, fish and microorganism genetic resources. Some of the bureaus have very large holdings in *ex situ* form. In addition, a large number of collections exist in the Institutes working on crop plants (e.g. wheat, rice, maize, sorghum, potato, tuber crops, sugar cane, cotton, jute, ground nut, gram, soya bean, edible oil crops, pulses, mango,

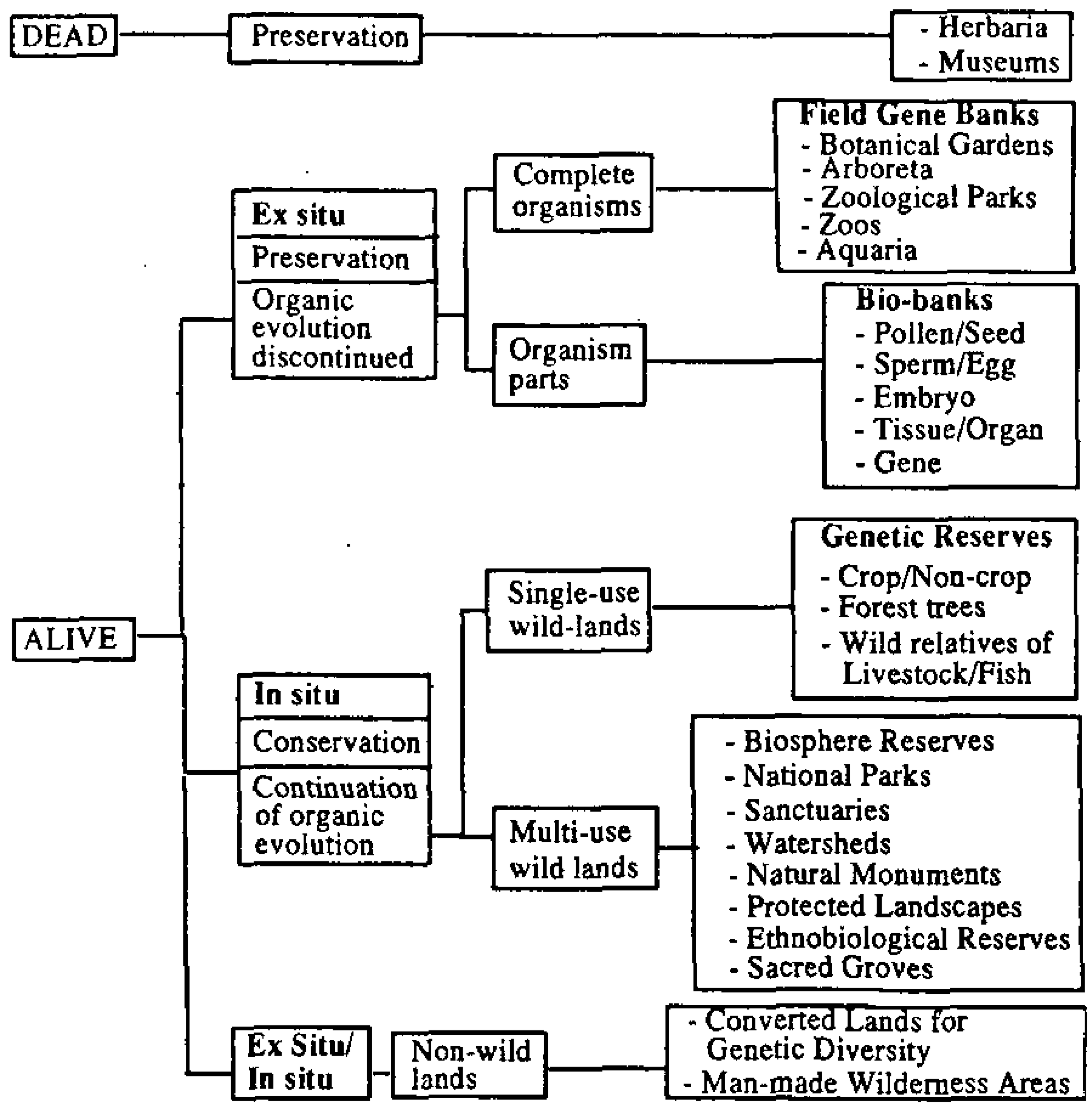

Figure 1. Options of conservation.

citrus, cashew, banana, grape, tobacco, medicinal and aromatic plants, spices, plantation and horticultural crops, mushrooms, orchids and other flowers, etc.). Among animals large collections exist in the case of cattle, buffalo, pig, sheep, goat, poultry, camel, mithun, yak, fish (freshwater and marine), aquaculture, lac, etc. In these Institutes there is also basic S&T infrastructure and capability, together with long-term funding available for this purpose. Additions/replenishments have to be made carefully and should also include all the important endangered and rare species; and ancestral and other related species, land races and primitive cultivars of agricultural crops and domesticated animals for purposes of breeding better types. A network of such banks has to be organized to save the relevant materials under threat of endangerment or extinction. This network should act as Native Germplasm Saver Societies of old and discarded varieties.

Biodiversity in India

The Botanical and Zoological Surveys of the country have estimated that as of today India's biodiversity constitutes 126,188 species[1]. These cover all the five kingdoms, namely *Monera*, *Protista*, *Fungi*, *Animalia* and *Plantae*. According to the World Conservation Monitoring Centre[2], 1,604,000 species have been described at the global level. Thus India accounts for 8% of the global biodiversity existing in only 2.4% land area of the world.

The country has a coastline of over 7516 km long, a sizeable exclusive economic zone (2.15 million km^2) and a large shelf area (0.13 million km^2). EEZ is about two-third of the area of main land. Marine areas are by and large still to be systematically charted for biodiversity. There is an abundance of seaweeds, crustaceans, molluscs, corals, fish, reptiles and mammals.

Biodiversity exists at three major levels: *genetic diversity*, *species diversity* and *ecosystem diversity*. *In situ* conservation at the species and ecosystem levels of diversity fall under the purview of MoEF. The first level (genetic diversity) involves the actual utilization and is the concern of DARE, DBT, ICFRE and to a small extent, of DSIR and DST. Thus from genes to ecosystems, there is indeed a continuum[3].

Of late, there has been increasing preference and demand for biodegradable products obtained from different forms of biodiversity. Excessive demand for such products would surely lead to biodepletion of natural biota. There is not only an urgent need for the bioenrichment of the depleted species, but also for evolving strategies that would prevent bio-impoverishment in natural habitats. MoEF is principally responsible for this and has to harness professional expertise across the whole spectrum for this purpose. Unfortunately, this has not happened so far because these are very few science and technology-based ecorestoration programmes.

Biogeographical provinces

Udvardy[4] recognized eight realms in the biosphere of the earth. These have been discerned based on a holistic approach. Each realm is infact a complex of related Biogeographical Provinces which number 193. India falls in two realms, with a total of 12 Biogeographical Provinces[5], which are listed below:

- Palaearctic realm: Tibetan (Ladakh), Himalayan Highlands.
- Indo-Malayan realm: Malabar Rain Forest, Bengalian Rain Forest, Indus–Ganges Monsoon Forest, Assam–Burman Monsoon Forest, Mahanadian, Coromandel, Deccan Thorn Forest, Thar Desert, Laccadive Islands, and Andaman and Nicobar Islands.

The foregoing 12 Biogeographical Provinces have six broad ecosystem types[5]. These are: Tropical Humid Forest, Tropical Dry or Deciduous Forest (including Monsoon Forest or Woodlands), Warm Deserts and Semi-deserts, Cold Winter (Continental) Deserts, Mixed Mountain and Highland System (with complex zonation) and Mixed Island Systems. This classification does not take into account the marine ecosystems and the interface between land and sea, and freshwater and sea. Such interfaces are also rich in biodiversity.

Rodgers and Panwar[6] have done a detailed exercise, taking into account all the previous classifications including that of Meher-Homji[7]. According to them, the country can be divided into 10 Biogeographical Zones and 25 Biotic Provinces. These are: Trans-Himalayan (Ladakh); Himalayan (North-West, West, Central and East Himalaya); Desert (Kutch and Thar); Semi-desert (Punjab and Gujarat–Rajwara); Western Ghats (Malabar Coast and Western Ghat Mountain); Deccan Peninsula (Deccan Plateau South, Central, Eastern, Chhota-Nagpur and Central Highlands); Gangetic Plains (Upper Gangetic and Lower Gangetic

Plains); North-East India (Brahmaputra valley and Assam hills); Islands (Andaman, Nicobar, Lakshadweep Islands) and Coasts (West Coast and East Coast).

These authors[6] have taken into account 'land-planning regions of India, largely on geomorphological considerations'. The underlying rationale has been the mega animal part of India's wildlife, rather than the sum total of India's biodiversity. They feel 'some species are characteristic or indicators of certain habitats (e.g. pheasants in temperate Himalayan communities); other species (such as tiger) are dominant member of communities. Ensuring the long-term survival of such animals means that the communities and habitats are also protected'. However, they feel that, for such purposes, 'in general, animals are used more often than plants, mammals are used more than other animal groups, and larger species are used more than smaller ones'.

The report has also brought out that in 1987, there were 54 national parks and 372 sanctuaries with a total area of 109,652 km^2 or 3.3% of the area of the country. After their review and identification of new sites, they recommended that the country should have 148 national parks and 503 sanctuaries which totals to 151,342 km^2 or 4.6% of the country's total area.

The report of Rodgers and Panwar[6] is indeed an excellent effort but takes a traditional view of wildlife. However, today wildlife is regarded as a part of overall biodiversity so as to make the former more holistic. It must encompass the whole gamut of plants, animals and micro-organisms. This change is necessary, because the traditional concept of wildlife is rather restricted in outlook. This laudable report is now a decade old and MoEF has yet to take a decision on the recommendations and publish the report for wider circulation and use.

Hotspots in India

Among the 18 hotspots in the world[8] two are in India. These are two disjunct areas: Eastern Himalaya and Western Ghats. Their floral wealth is particularly rich so is their endemism not only in flowering plants but also in reptiles, amphibians and swallow-tailed butterflies. Western Ghats have endemic mammals as well.

Apart from the two foregoing mega 'hotspots', 26 endemic centres have been identified by Nayar[9]. These are: Karakoram and Ladakh of Kashmir Himalaya; Kumaon–Garhwal Himalaya; Siwaliks; Terai; Sikkim Himalaya; Arunachal Pradesh; Lushai Hills; Tura–Khasi Hills; Aravallis; Chhota-Nagpur Plateau; Panchmarhi–Satpura Range; Simplipal and Jeypore Hills of Orissa; Bastar and Koraput Hills; Vizagpatnam Hills and Araku Valley; Tirupati–Cuddappa Hills; Marathwada Hills; Saurashtra Kutch; Mahabaleshwar–Khandala Ranges of W. Ghats; Agumbe–Phonda Ranges of W. Ghats; Ratnagiri and Kolaba Ranges; Nilgiris, Silent Valley and Wynad; Anamalais of W. Ghats; Palni–Yercaud; Kalakad and Agastyamalai Hills of W. Ghats; Andaman Island; and Great Nicobar Island.

The northeastern region is the home of some botanical rarities. One of these is *Sapria himalayana* which is a parasitic angiosperm and has been sighted only twice since 1836. The flowers are about 35 cm across and buds are about the size of a grape fruit. Besides this, Sahni[10] has enumerated several such vanishing taxa. The region is meeting ground of Indo-Malayan and Indo-Chinese biogeographical realms as well as Himalayan and Peninsular Indian elements. It may be recalled that it was here that the Peninsular plate struck against Asian land mass, after it broke off from Gondwanaland. It is, therefore, not surprising that the northeastern India is the region where a large number of primitive angiosperm families are also found. These are: *Magnoliaceae, Degeneriaceae, Himantandraceae, Eupomatiaceae, Winteraceae, Trochodendraceae, Tetracentraceae* and *Lardizalbaleaceae*. The primitive genera are: *Alnus, Aspidocarya, Betula, Decaisnea, Euptelea, Exbucklandia, Haematocarpus, Holboellia, Houttuynia, Magnolia, Mangelietia, Pycnarrhena* and *Tetracentron*[11]. Takhtajan[12] was led to believe that this region along with contiguous regions is the cradle of flowering plants. Furthermore, Janaki Ammal's[13] outstanding cytogeographic work has shown that northeast India, together with contiguous region of Chinese provinces of Yunnan and Schezwan, is a very active centre of organic evolution. This has now been confirmed by studies in South East China where an altogether new large mammal (*Muntiacus gongshanensis*) and four new genera (*Xizangia, Sinoleontopodium, Sindoxa* and *Tetradoxa*) of flowering plants have been discovered[14]. Such is the biological riches of NE India and the adjoining SE China. This region needs special attention.

Although the two areas (North Eastern Himalaya and Western Ghats) are today disjointed having their own characteristic flora and fauna, the following species are common to both[15,16]: *Ternstroemia japonica, Rhododendron arboreum, Hypericum hookerianum, Thalictrum javanicum, Cotoneaster buxifolia, Parnassia wightiana, Lonicera ligustrina, Gaultheria fragrantissima, Symplocos lauriana*, Himalayan and Nilgiri Tahr, Nilgiri Pine Marten, laughing thrush (associated with genus *Rubus*), great pied hornbill, frogmouths, fairy blue bird, lizard hawk and rufous bellied hawk-eagle. The probable explanation for the presence of common species between the two disjunct regions is an indication of their being Pleistocene relicts. According to this view, during Pleistocene glaciation, temperate flora and fauna moved south. On retreat of the glaciation, temperate relicts were left at higher altitudes of the southern mountains and continuous distribution between northeast and southwest India was lost after the Pleistocene glaciation. This is the most plausible explanation[7].

According to Hora[17], there is also resemblance in fish fauna between the two disjunct areas. However, he advanced Satpura Hypothesis, which envisaged movement of Assam flora and fauna through Satpura System to Western Ghats. Whatever be the explanation, the fact remains that the northeast and southwest floras and faunas have some degree of commonality. The common species listed above need detailed genetic study including genetic fingerprinting to establish the relationship between the two groups of disjunct biota in space and time.

In the Indian subcontinent, five sites have been recognized internationally that are not only rich but are also priority sites for data sheet treatment[2]. These are: Agastyamalai Hills, Nallamalais, Nilgiri Hills, Namdapha, and Nanda Devi. Agastyamalai and Nilgiri Hills can be categorized as distinct floristic provinces, often covering a very wide area. Together these constitute a centre of plant diversity and/or endemism covering the whole region. For conservation to be effective, a network of smaller reserves needs to be established because it may be impracticable to protect the entire area. Namdapha and Nanda Devi are discrete geographical areas needing conservation.

Endemism and extinction

The most reliable work on endemism in flowering plants of India has been done by Chatterjee[18]. Most of the subsequent work has depended on this detailed study. According to him, there are 6850 endemic species in India out of which 3165 (about 50%) occur in the Himalaya. Among the largest genera in India are *Impatiens* and *Primula* with a high degree of endemism. The former has 189 species, about 112 of which grow in the Himalayan belt, while 77 species in Western Ghats, with only one species (*I. balsamina*) common to the two disjunct regions. *Primula* has 162 species out of which 148 are endemic[18]. Endemic birds are found in western Himalaya, Indus valley, Western Ghats, eastern Himalaya, Nepal, Bhutan, Bangladesh, Assam Plains and Tirap Frontier with Burma[2]. In higher vertebrates, the country has 12% endemism in mammals, 7% in birds, 40% in reptiles and 53% in amphibia. Andaman and Nicobar has 93% (75 out of 81 species) richness in endemic land snails. Overall, India has 90 species of mammals, 110 species of birds, 158 species of reptiles and 110 species of amphibians endemic in the Indian region[2,19].

Data on threatened species may be relatively more reliable. It appears about 1336 species of flowering plants, 39 species of mammals, 72 species of birds, 17 species of reptiles, 3 species of amphibian and 2 species of fish are threatened.

Though no professional studies have been made on the extinction of biota in India, the following species appear to have become extinct in India. These have not been sited for a long time[2].

- *Rhodonessa caryophyllacea* (Pink Headed Duck) around 1935 possible cause has been over-hunting.
- *Athene bleinitti* (Forest owlet) around 1914.
- *Ophrysia superciliosa* (Himalayan Mountain Quail) cause was over-hunting. According to Salim Ali it was last sighted in 1876. There is however, a recent unconfirmed report of its sighting in Uttarkhand.
- *Rhinoceros sondaicus* (lesser one-horned rhino) extinct in India but occurs in Java.
- *Acinonyx jubatus venaticus* (Cheetah) extinct in India in 1939, but occurs in Central and Southern Africa and perhaps also in parts of Middle East.
- *Isoetes dixitii* (Isoetaceae) from Maharashtra. Extinct in 1868.
- *Isoetes sampathkumarnii* from Karnataka.
- *Lastreopsis wattii* (Aspediaceae) from Manipur.
- *Ophiorhiza brunonis* (Rubiaceae) from Karnataka and Kerala.
- *Ophiorhiza caudata* from Kerala.
- *Ophiorhiza radicans* from Kerala and Sri Lanka.
- *Wendlandia augustifolia* (Rubiaceae) from Tamil Nadu.
- *Trochetia parviflora* (Sterculiaceae) from Meghalaya.
- *Sterculia khasiana* (Sterculiaceae) from Meghalaya.
- *Eragrostis rottleri* and *E. rangacharli* (Graminae) from Tamil Nadu.
- *Hubbardia hepataneuron* (Graminae) from Karnataka.
- *Dipcadi concanense* and *D. reidii* (Liliaceae).
- *Urginea polyphylla* (Liliaceae).
- *Corypha taliera* (Palmae).
- *Hedychium marginatum* (Zingeberaceae) from Nagaland.
- *Calanthe whiteana* (Orchidaceae) from Sikkim.
- *Prasophyllum colemaniae* (Orchidaceae) from Meghalaya.

Although the loss of foregoing 24 species has come to light, there may be many more species which have become extinct. A systematic study has to be initiated by BSI and ZSI involving the university system.

Centre of origin and diversity

All crop plants and domesticated animals can be traced to their wild ancestors. They have arisen both through inadvertent and deliberate selection by human being. The degree of dependence of these plants and animals on human being is directly proportional to the extent and nature of transformation that has taken place from the wild to the cultivated/domesticated condition. The crop plant genetic resources of the world can be assigned to specific centres of diversity as originally identified by Vavilov[20].

Vavilov identified these on the basis of varietal diversity, homologous variation, endemism, dominant allele frequencies and disease resistance. The centres are located in different continents. These have also been referred to as Germplasm Treasures (for details see Khoshoo[5]).

While Vavilov's[20] basic conclusions have stood the test of time, there have been small differences about the number and location of centres of diversity. There is today a general unanimity about 12 centres of diversity[21]. India is one very important centre having contributed to world agriculture at least 167 plant species[5,21]. Within the overall mega Indian Centre of Diversity as recognized by Vavilov, there are at least nine subcentres of diversity, where wild relatives of cultivated plants still occur[22].

One indeed marvels at the intuitive power of our very remote ancestors to have picked up these plants from the wild, and selected these unconsciously and consciously so as to make them far different and highly productive compared to the ancestral stock. Some of these are being cultivated world wide, e.g. rice, sugarcane, cucumber, egg plant, banana, citrus, ginger, etc. Among animals, the three important animals (chicken, cattle and pig) supporting world animal husbandry, chicken (*Gallus gallus*: jungle fowl) is India's contribution. The cultigens and domesticated types both in plants and animals have been crafted meticulously and are different from the ancestral species. Like cultural and developmental diversity, agri-biodiversity is also a part of the creative diversity of human being. All these diversities are mutually supportive and reinforcing.

There are secondary centres of genetic diversity which are environmentally different from the primary centres, where the crops were developed further by human ingenuity. Thus India is a secondary centre of diversification for several species which are very old introductions (may be even pre-Columbian) into the country. Such crops are grain amaranths, maize, red pepper, soybean, potato, oil palm, etc. Similarly, the Indian breeds of exotic and domestic animals like horse, pony, sheep, goat, cattle, etc. are always in demand particularly for their disease resistance and hardy traits. The reason is that these animals are the result of hardiness, adaptation to heat, parasitic stresses, and availability of roughage with low nutritive value and, therefore, these are in demand for breeding purposes in Australia, USA and Latin America.

National Biodiversity Conservation Board (NBCB)

By their very nature, most Indians are

peace-loving and vegetarian, and believe in non-violence which is enshrined deep into their psyche. Thus conservation is basically a part of Indian ethic. It is, therefore, not unexpected that in the historical past, India had a tradition of giving highest attention to wildlife. In the recent times, the country had a powerful Indian Board for Wildlife (IBWL) headed by the then Prime Minister of India, Indira Gandhi. This continued up to her assassination. After her, the Board has met *only once*. What it means is abundantly clear!

There is, however, no doubt that the concept behind IBWL has outlived its utility because there is a need to widen its scope and make it holistic. Even the World Wildlife Fund, from which many rich Indians have been drawing inspiration, was compelled to change its name to World Wide Fund for Nature by shear circumstances of new and vastly extended knowledge on biodiversity. However, for the sake of continuity and convenience, they continued to have the same acronym: WWF. Theoretically, wildlife means all undomesticated plants and animals, but in practice it was restricted to large mammals, big cats in particular. This was so on account of a feeling that these animals were top of the food chain. The underlying rationale was: if big animals are conserved, *ipso facto* others below them are also conserved. This may not be correct under all circumstances and can, therefore, be a fallacious argument. In India due to the outstanding work of the late Salim Ali, birds have been studied very intimately. There has also been outstanding work done on algae, fungi, liverworts, mosses, ferns, gymnosperms besides angiosperms. The same is true of different groups under the animal kingdom. All this work is scattered and needs to be organized into a modern database.

Today, the concept of wildlife has widened considerably. It includes all biodiversity as a dynamic and interacting system, of which even the local human beings are also an integral part. It is not merely the number of microorganism, plants and animals, but the most important point is the interconnectedness, interrelatedness and interdependence of plants, animals (human beings included) and microorganisms existing as a system. There is also a very definite connection between biodiversity and cultural diversity, together with social, economic, historical, religious and philosophical dimensions. Such a relationship is mutually reinforcing (Khoshoo, unpublished). Biodiversity is now looked upon as a major renewable resource and hence an important Earth Capital. If we take away biodiversity from the Earth, human beings cannot exist. Conversely, if we were to take away human beings from the surface of earth, biodiversity (except agri-biodiversity which has been created and crafted by human beings) will continue to exist, may be even flourish. Human race must realize this.

This country has done nothing worthwhile, although we made tall claims after signing the Biodiversity Convention at Rio in 1992 and thereafter. It may also be pointed out that biodiversity is not to be mistaken for mere animal welfare and such other populist measures, but there is whole range or scientific, technological, social, economic, ethical, moral and political disciplines involved in it.

Furthermore, throughout rural India, there are innumerable microenterprises at the village level using local biodiversity. The products from the same find their way to cities and even in international market. These are exotic and often exquisite items and are in demand. There have been very few dependable studies on such enterprises. There is need to document and analyse these with a *'cradle to grave'* approach. With a little innovation, such studies can be linked not only provincially, but also nationally and some even globally. Sufficient attention has not been paid to these aspects except for the outstanding studies of K. S. Bawa and his colleagues. Their work has attracted world attention. As a whole this area is indeed uncharted and if work is done professionally, it would also give us an inkling about the economic value of the products obtained from our biodiversity. Regrettably, Indian biologists have not played their part well. The vacuum thus caused has been filled by a host of non-biologists. The professional biologist of the country must now take a lead lest the whole area of biodiversity should fall in wrong hands.

Another dimension is that there is considerable illicit trade in wild animal parts and plants, e.g. tiger bones, claws, skin of tiger and other cats, rhino horns, butterflies, orchids, herbal drugs and aromatic plants, sandalwood, etc. It is clear that animal and/or plant producing countries are in developing world in South America, Meso-America, Africa and South East Asia, but ultimate destination of the traffic in biodiversity is USA, Canada, West Europe, Japan, Middle East and China[23]. On paper, India is neither a producing nor a receiving country, but considerable illicit trading in biodiversity comes to light once in a while.

Techniques like DNA fingerprinting can be used to identify such threatened and rare species. This technology has become very important because it enables unequivocal identification of the concerned species. Not only do target species need fingerprinting but also their adulterants. In addition, the diversity within the species needs to be charted and related to their chemical profile particularly in the identification of high-yielding strains of the concerned phytochemicals from drug and aromatic plants. Work on genetic fingerprinting has to be intensified and fingerprints obtained on most cultivated/domesticated and wild biota (human diversity included). All this information has to be collected in the form of a proper database and related to the uses of different cultivars, ecotypes, chemotypes, etc. Such information together with species-specific and even gene-metabolite linked probes will also be of help in standardization of bio-pharmaceuticals and biodiversity-linked intellectual property rights, etc. For some critical species (endangered species like lion and tiger), such a technique will also give us an idea of the extent and nature of genetic variation so as to decide an effective strategy for its conservation based on principles of population genetics and breeding biology.

These sophisticated techniques need to be applied on a systematic basis to genetically, economically and trade-related biodiversity. Such a sophisticated database is going to be also critical to biodiversity conservation and utilization. Besides, it will have tremendous social, economic, ethical, and legal implications.

The foregoing aspects of biodiversity have to be accompanied by teaching and training in Conservation Biology: a new multidisciplinary subject which is becoming increasingly critical to the conservation and sustainable utilization of biodiversity particularly in developing countries. Advanced teaching and training in this discipline has to be started in some chosen conventional and agricultural universities and Wildlife Institutes so as to generate a cadre of well-trained and knowledgeable conservation biologists.

An important and an integral component of Conservation Biology will be a proper economic valuation of India's biodiversity. In fact it is a part of larger problem of proper economic evaluation of different forms of the Earth's capital (air, water, soil, minerals, etc.). Biodiversity has an indirect and a direct value. Indirect value pertains to the overall biological productivity of an ecosystem, fresh air and water, soil, regulation of climate, and ecotourism for shear greenery and fresh air and clean water and good viewing of wild animals and plants in their natural habitats. The direct value pertains to the level of community use of timber and whole range of non-wood forest products, genetic resources of crops and domestic animals and their ancestral and other related species. Putting a price tag on our biodiversity will make its loss more understandable because it would be in fiscal terms. At present economic value of wild biodiversity (be it a medicinal or aromatic or fruit plant or whatever) is the cost of travel to collect the same, and no more. Those who make products, make the real money. However, it is the end-user and nature at large who pay the real cost.

Policy decisions regarding biodiversity have to be taken realistically, based on actual facts. Therefore, there is need to consolidate information and put it in the form of a major database commensurate with the biodiversity wealth of India.

Being predominantly a biomass-based country with largely bioindustrial pattern of development, India's stakes in biodiversity are indeed very high. Our performance in this area has been far from ideal. This is true even in its legal and political dimensions. At any rate, it is not commensurate with the extent and nature of bio-wealth that India owns. There are reasons for this. The result has been that biodiversity which is India's strength has been progressively going by default even when internationally biodiversity has assumed considerable importance. It is high time that Government and scientific and economic communities and responsible social scientists think about it very seriously. The least that can be done is to organize a competent and responsible organization so as to give proper importance and treatment to this wealth for the good of the country.

The information on biodiversity is very dispersed and needs to be consolidated so that the country can reap rich harvests from this important wealth. There is, therefore, a very urgent need of having a comprehensive and a professional National Biodiversity Conservation Board (NBCB) which can look at various aspects of biodiversity, ranging from environmental, to biological (including agricultural), social, economic, ethical and other related dimensions. The three broad functions (Figure 2) are the establishment of database(s), and management and utilization of India's biodiversity. The National Database(s) will store data on all the five kingdoms. Other equally important databases would deal with agricultural and industrial biodiversity. Here information of wild and human-created and crafted useful microorganisms, domesticated animals and cultivated plants together with their ancestors and related species and other relevant dimensions will be stored. It is indeed gratifying to note that this country already has a chain of very prestigious national bureaus of plant and animal genetic resources under the aegis of ICAR.

Indian Council of Forestry Research and Education (ICFRE) must take up the responsibility of conservation of forest tree germplasm, both under *in situ* and *ex situ* conditions in a meaningful manner[15,24]. Forest tree germplasm and lack of proper forest tree genetics and breeding programmes have been major lacunae in forestry research and development. This is why our wood productivity is indeed dismal, being the lowest in the world[24].

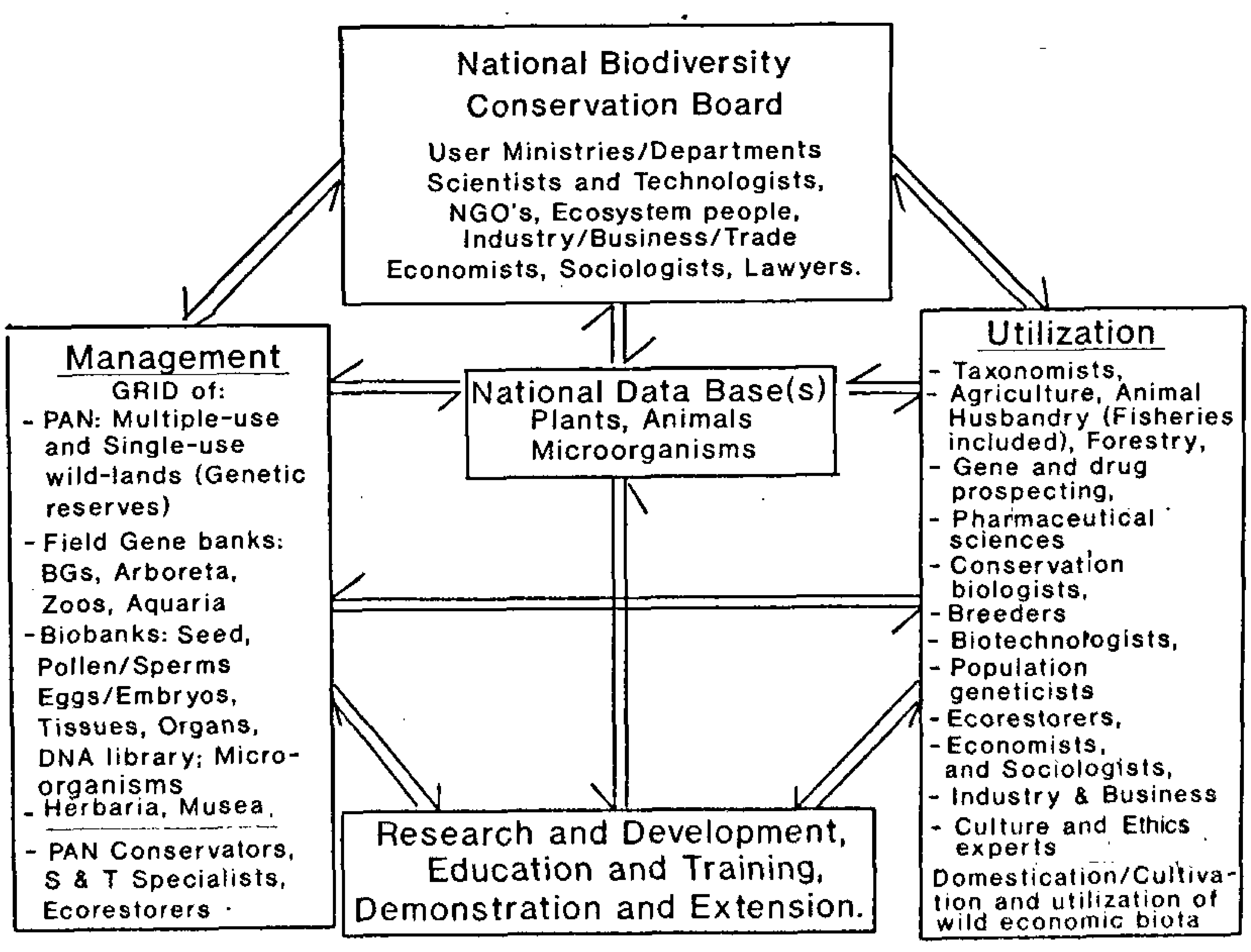

Figure 2. Broad functions of the National Biodiversity Conservation Board.

It may also be pointed out that the Ministries/Departments/Organizations involved with NBCB would be Environment and Forestry, Agriculture, Industries, Commerce and their relevant Departments (DARE, DBT, DSIR, DST), ICFRE and those dealing with commodities like tea, coffee, jute, cotton, silk, tasar, rubber, cashew, coconut, arecanut, phytochemicals, biopharmaceuticals, biocosmetics, bioinsecticides, biopesticides, biofertilizer, etc. The total membership of the NBCB should under no circumstances exceed nine otherwise it will be only a talking body.

Of late, there has been a realization in the industrial countries that local technical knowledge of the indigenous people in the developing countries is not mere collection of myths and voodoos, but distilled knowledge accumulated over millennia. Such knowledge is based on large scale trial and error and intensive observation. Regrettably, this knowledge is regarded as 'ownerless' and is taken for granted as *Common Heritage*. There is now major effort by industrial countries to own all such 'ownerless' knowledge and resources. After its updating and refining, in industrial countries through the application of relevant upstream S&T, this knowledge would be regarded as *innovation* and *intellectual attainment* and would become patentable. It would then be rewarded and awarded as private property and become available to only those who can pay the high price. All this has led to renewed emphasis on ethnobiology, ethno-medicine and ethno-pharmacology. This aspect of biodiversity has also opened up new vistas in ecology, biology, economics, micro-enterprises, anthropology, linguistics (particularly local languages), community development, conservation, etc.

In view of the foregoing, *the time has come that the country must declare biological diversity a National resource, its conservation and sustainable utilization a National goal and National priority.* The functions of NBCB have been worked out[15] and need to be refined further. These need to be periodically looked at indepth and updated. An illustrative list of functions is given below:

- Formulate a National Policy on conservation and utilization of India's biodiversity and agribiodiversity together with a time-bound plan of action.
- Inventorize India's biodiversity.
- Establish minimal database(s).
- Review existing PAN (Protected Areas Network), identify gaps and draw criteria for identification of new protected areas.
- Examine tenurial security of PAN to ensure conservation in perpetuity.
- Prepare plans for management of PAN, ensuring stake and involvement of people.
- Support PAN with adequate number of genetic reserves, botanical and zoological gardens, arboreta and aquaria, and biological banks of organism parts including DNA.
- Draw plans for ecorestoration of degraded habitats.
- Draw plans for *ex situ* conservation together with rehabilitation of endangered species (e.g. tiger, rhino, lion, pheasants, butterflies, wild medicinal and other economic plants, etc.) based on genetic-evolutionary considerations.
- Draw criteria for endangerment of species leading to extinction together with causes for the same and suggest remedial measures.
- Draw conservation and sustainable utilization plans regarding hitherto neglected areas like marine biodiversity, forest tree genetic resources and microorganisms.
- Following principles of population and evolutionary biology and genetics and breeding, domesticate wherever necessary, wild biota that are in demand in trade, e.g. medicinal and aromatic plants, ornamentals, butterflies, fish, fur animals, botanical and zoological rarities and teaching materials.
- Draw plans for meaningful involvement of local people in conservation effort and in community biodiversity programmes.
- Establish centres for research and development, teaching and training and demonstration and extension in conservation biology, ecorestoration of habitats; economic value of ecosystems, species and genes; trade in biodiversity, particularly in endangered species; microenterprises at the village level; and indigenous people and their local technical knowledge.
- Build a cadre of PAN conservators and S&T specialists.
- Establish centre(s) of study for legal and policy aspects relating to conservation and utilization of biodiversity.
- Guarantee financial support.

Finally, it may pointed out that in its wider context, the poor and struggling developing countries of the world in tropical/subtropical belt are particularly rich in biodiversity, but are very poor in its utilization using modern science and technology. There are definite reasons for this[25]. There is also an immediate need for an indepth discussion for forging ahead an alliance between all or most biodiversity-rich but technology-poor developing countries so as to deal with biodiversity-poor but technology very rich industrial countries in an effective and a gainful manner[26].

If this is not done, the onslaught of concealed compulsions from industrial countries will keep developing countries (rich in biodiversity and local technical knowledge) in *permanent bondage*. Therefore, the most urgent need is to professionalize and technicalize the whole area of biodiversity, if not the whole area of environment.

Indian Bioresources Council

Over the years there have been suggestions made from India and abroad regarding organizing inter-ministerial and an all-encompassing Indian Bioresources Council (IBC). Bioresources as a whole are indeed very critical for the development of India, because, as pointed out earlier, this country is essentially a biomass-based and predominantly rural country, where the pattern of development has to be bio-industrial rather than purely industrial. There are already several Councils under Government of India dealing with bioresources (including human being), e.g. Indian Council of Agricultural Research, Council of Scientific and Industrial Research, Indian Council of Medical Research, Indian Council of Social Sciences Research, etc. In addition, there are Councils on Ayurveda, Unani, Siddha systems of medicine. The basic raw material for all these councils is biodiversity of sorts (including human). These councils have rendered yeoman service. Having IBC over these, would therefore, be adding a layer of administrative hassles. It would be counter-productive. However, a NBCB will be more pointed and focused organization to oversee in entirety conservation and utilization of the principal bioresource, i.e. biodiversity.

Note added in proof: An important publication on Hotspots of Endemic Plants by M. P. Nayar has been just published by the Tropical Botanic Garden and Research Institute. This is an update on Chatterjee's (1939) paper referred to in the text.

1. Khoshoo, T. N., *Curr. Sci.*, 1995, **69**, 14–17.
2. WCMC, *Global Biodiversity*, Chapman Hall, London, 1992.
3. Solbrig, O., *From Genes to Ecosystems*, IUBS-SCOPE-UNESCO Workshop, Paris, 1991.
4. Udvardy, M. D. F., Occasional Paper IUCN, Gland, 1975.
5. Khoshoo, T. N., *Indian Biosphere and Geosphere*, Har-Anand Publications, New Delhi, 1991, pp. 178–233.
6. Rodgers, W. A. and Panwar, H. S., *Planning a Wildlife Protected Area Network*, Wildlife Institute of India, Dehra Dun, 1988, vols I & II.
7. Meher-Homji, V. M., *Sci. Cult.*, 1972, **38**, 8–12.
8. Myers, N., *The Environmentalist*, 1988, **8**, 1–20 and 1990, **10**, 243–256.
9. Nayar, M. P., *In situ Conservation of Wild Flora Resources*, WWF-India, 1989.
10. Sahni, K. C., 1982, vide ref. 15.
11. Malhotra, C. L. and Hajra, P. K., *Bull. Bot. Surv. India*, 1977, **19**, 61–63.
12. Takhtajan, A., *Bull. Bot. Surv. India*, 1969, **19**, 145–155.
13. Janaki Ammal, E. K., 1950–1954, vide ref. 15.
14. De-yuan, H. and Zheng-yu, L., *Biodiversity and its Conservation and Management in Hindukush Himalayan Region*, ICIMOD Kathmandu, 1995.
15. Khoshoo, T. N., G.B. Pant Memorial Lecture II, G.B.P-Himalayan Institute for Environment and Development, Almora, 1992.
16. Ali, S., *The Himalaya: Aspects of Change*, Oxford University Press, Delhi, 1981, pp. 16–31.
17. Hora, S. L., *Curr. Sci.*, 1950, **19**, 364–370.
18. Chatterjee, D., *J. R. Asiatic Soc. Bengal*, 1939, **5**, 19–67.
19. Mackinnon, J. and Mackinnon, K., *Review of the Protected Area System in Indo-Malayan Realm*, IUCN, Gland.
20. Vavilov, N. I., *Chron. Bot.*, 1951, **13**, 1–364.
21. Zeven, A. S. and de Wet, J. M. J., *Dictionary of Cultivated Plants and their Regions of Diversity*, Centre for Agricultural Publishing and Documentation, Wageningen, 1982.
22. Arora, R. K. and Pandey, M., *Wild Edible Plants of India*, NBPGR, New Delhi, 1996.
23. UNESCO, *Environmental Education Dossiers*, 1994, No. 12.
24. Khoshoo, T. N., *Curr. Sci.*, 1996, **70**, 205–214.
25. Khoshoo, T. N., in *Science and Technology*, Prism Books, Bangalore, 1996, pp. 215–275.
26. Khoshoo, T. N., *Curr. Sci.*, 1994, **67**, 577–582; *Ambio*, 1995, **24**, 251–533.

ACKNOWLEDGEMENTS. The paper represents contribution number 45 of research programme in Conservation of Biodiversity and the Environment jointly co-ordinated by TERI and University of Massachusetts at Boston. The programme is supported by the McArthur Foundation.

T. N. Khoshoo is at Tata Energy Research Institute, Darbari Seth Block, Habitat Place, Lodi Road, New Delhi 110 003, India.

Indian cycads cry for protection

E. J. H. Corner who was professor of Tropical Botany in the Botany School, University of Cambridge has aptly said, 'But the forests which show how trees were made are dying, they are vanishing nowhere faster than from the alluvial plains where the vestiges of the last creative phase of plant life that prepared the way for the modern world may survive.... Before machines the forest is defenceless. Human progress is clearing it with gathering speed to plant crops for quick returns'. It is, therefore, necessary to conserve the plant cover of tropical forests, and therein specially the cycads, need to be conserved. Being relics of a bygone age they are handicapped by their slow growth, relatively short stature, disadvantageous dioecism, sex ratio problems including less frequent coning of female individuals, frequently non-synchronous production of male and female cones, their inefficient pollination mechanisms, shedding of seeds with immature embryos and a long period of about 10 years required by seedlings to attain puberty for producing reproductive parts. Accordingly in various native countries of cycads, except India, there is public and governmental awareness about the need of conserving cycads against human interference.

My visits to Beaulieu-sur-Mer in southern France in 1987, to Australia in 1990 and my recent visit to China in May 1996 to attend the International Conferences on Cycad Biology have convinced me that other countries are far ahead of India in the conservation of cycads. The Cycad Societies of USA, South Africa and China and the Palm and Cycad Societies of Australia and New Zealand have played a vital role in creating such awareness about protecting their cycads *in situ* (in the areas of their occurrence) and *ex situ* (under cultivation in gardens, parks and in private collections).

In situ conservation

As a result of this awareness all native countries have started protecting their natural populations of diverse cycads in protected areas. In China alone there are about 20 or more natural population reserves where cutting of any parts of cycads or even the collection of fallen seeds is prohibited. Australia and Central America have also taken steps to protect their rare cycads. South Africa in particular has already enacted legislation to protect its cycad populations and to punish the guilty with fine and imprisonment. India, on the other hand, cannot claim even a single Cycad Reserve anywhere in the country, perhaps, because we are over-emphasizing biotechnology, agricultural production and applied sciences.

Ex situ conservation

Despite the limitations of cultivated collections of cycads, lasting conservation is offered to cycads, by various botanical gardens of the world. Some of these are situated in temperate or cold temperate countries (where the climate is not favourable for growth of cycads in the open), e.g. in the Royal Botanic Gardens at Kew in UK, the St. Petersburg (Leningrad) Botanical Garden of Russia and the Glasnevin Botanical Garden of Ireland and they all have stupendous collections of the cycads of the world. Many South African Botanical Gardens,