EXTRACTS FROM

THE REPORT OF THE COMMITTEE ON IDENTIFYING PARAMETERS FOR DESIGNATING ECOLOGICALLY SENSITIVE AREAS IN INDIA

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PREFACE

The very act of constitution of this Committee to Identify Parameters for Designating Ecologically Sensitive Areas in the Country is yet another reflection of the deep and abiding concern that the Government of India has consistently expressed regarding the rapid deterioration of the environment, both nationally and internationally. India has been a pioneer in the area of integrating the needs of development with the desire to protect the environment. Since the Fourth Five Year Plan of the country in the early 1970's, sustainable development has been a key feature of the development strategy of the nation. This was long before the term, or even the concept, had become popular in international discourse. Indeed, much of the issues reflected in Agenda 21 of the Rio Declaration find reflection in several of India's Five Year Plans. As a consequence of this concern, India has been an active and enthusiastic supporter of all international efforts at protecting the environment and encouraging sustainable development. It is a signatory to every major convention on environmental protection, including, most particularly, the Convention on Bio-diversity, which has special significance for the work of this Committee. In pursuance of the goals and objectives that have been laid down in these international conventions, India has taken upon itself to introduce such legislation and guidelines as are necessary.

The ecological security of this country is paramount and can brook no compromise.

Pronab Sen
Chairman

Concepts, Approach and Recommendations

Introduction

The deliberations of this Committee were consistently guided by the assumption that the ecologically sensitive areas identified by the parameters by the Committee would receive protection under the Environment (Protection) Act, 1986 (EPA). This awareness had two major implications. First, a balance had to be struck between the protection of ecologically sensitive areas and the needs of national development, particularly in the context of a country like India with low levels of income and high levels of poverty. Therefore, the parameters had to be selected and defined in such a manner that they represented only the critical elements of ecological preservation and did not impinge unduly on the process of development and efforts at eradication of poverty. Second, it was clearly recognised that in view of the pressing demands on land and land-use patterns, areas designed as ecologically sensitive would become issues for litigation. Therefore, the parameters evolved by the committee and the modes of application would have to be framed in such a manner that they could stand scrutiny in the courts of law.

Definition of Ecological Sensitivity

The Committee has defined ecological sensitivity or fragility as follows:

> ***Ecological sensitivity is defined as the imminent possibility of:***
> ***(a) Permanent and irreparable loss of extant life forms from the world; or***
> ***(b) Significant damage to the natural processes of evolution and speciation.***

Conservation of bio-diversity would have to cover not only species which are presently threatened and protection of eco-systems which have demonstrated qualities of high evolutionary activity, but also characteristics whose ecological impact can be so widespread that there is no reasonable method of predicting the consequences on present and future progress of bio-diversity.

The Committee has identified thirteen principal parameters of ecological sensitivity falling into three broad categories of ecological significance. The first of these categories is species related, and defines the characteristics of species which are or may become threatened with extinction. The second category relates to eco-systems. Some of these derive their importance from being essential to the survival of the first category, while the rest are critical for maintaining the range and pace of evolution and speciation. The third category includes geo-morphological conditions

which are known to have substantial effect on eco-systems at large. The list of these primary parameters or criteria is given below:

Primary Criteria

Species based

1. Endemism
2. Rarity
3. Endangered species
4. Centres of evolution of domesticated species

Ecosystem based

5. Wildlife Corridors
6. Specialised ecosystems
7. Special breeding site/area
8. Areas with intrinsically low resilience
9. Sacred groves
10. Frontier Forests

Geo-morphological feature based

11. Uninhabited Islands in the sea
12. Steep Slopes
13. Origins of Rivers

In the opinion of the Committee, areas which meet even one of the above primary criteria deserve to be protected without any additional factor or consideration being brought in.

In addition to these primary criteria, the Committee has also identified seven auxiliary criteria, which though less compelling than the primary criteria, nevertheless require consideration in view of our insufficient state of knowledge and ecological understanding.

Auxiliary Criteria

Species based

1. Areas or centres of less known food plants

Ecosystem based

2. Wetlands
3. Grasslands

Geo-morphological features based

4. Upper Catchment areas
5. Not so Steep Slopes
6. High Rainfall Areas
7. Other uninhabited Islands

Issues in Identification and Protection

This possibility places an onus on the Government for moving proactively in identifying and protecting areas expeditiously as possible. A convenient starting point would be to consider such areas which are already known to be either ecologically important or under ecological stress. Examples of such areas are:

1. National Parks and Sanctuaries
2. Tiger Reserves
3. Protected and Reserve Forests
4. Biosphere Reserves
5. National Marine Parks
6. Coastal Regulation Zone – I (i)
7. Hill Stations

Although some of the above areas are already under some form of protection, the Committee was of the view that additional protection under the EPA should nevertheless be accorded to either the whole or part of the above areas which fulfill the criteria of ecological sensitivity as defined in this report. Such multiple protection is both feasible under law and desirable under ecological considerations.

CHAPTER 2

Primary Parameters of Ecological Sensitivity

2.1 ENDEMISM

DEFINITION

Endemism refers to any species which is exclusively confined to a particular geographical area and occurs no where else in the world.

ECOLOGICAL SIGNIFICANCE

Endemism species of plants and animals in a region represent a valuable biological endowment of the area/country. Loss of an endemic species is irreparable not only to the country, but to the world as a whole. The concept of endemism is inherently area-specific and it is determined by the unique ecological characteristics of the area. Hence, no disturbance in the area of occurrence of the endemic species should be permitted.

AREA

The area of occurrence of an endemic species needs to be protected in its entirety. The precise demarcation of the area may take into account population density of the endemic species, quality of habitat, level of exploitation and the effect of introduced taxa, pathogens, competitors, parasites and/or pollutants.

ILLUSTRATIVE EXAMPLES

Both Botanical and Zoological Surveys of India have reported several species which are endemic to India. Some of the examples are as follows:

(a). Plants: *Adhaatoda beddomei,* a plant species belonging to family Acanthaceae, is of medicinal value and is confined to Agasthyamalai hills in Kerala. The other plant species of medicinal value is *Aconitum ferox* which is endemic to Sikkim Himalays. *Paphiopedilum duryi* of family Orchidaceae is of great ornamental value and is found in Travancore hills of Southern-Western Ghats.
(b). Animals: *Macaca silenus* (Nilgiri Langur) of family Cercopitahecidae is an endemic primate found in dense evergreen and semi-evergreen forests in the Western Ghat regions of Karnataka, Kerala and Tamilnadu.

2.2 RARITY

DEFINITION

A species with a small world population that is not at present endangered or vulnerable, but is at risk.

ECOLOGICAL SIGNIFICANCE

The ecological significance of a rare species arises from their small world population making them highly susceptible to even a small reduction in their number. Rarity is a natural phenomenon, and not the result of any apparent human action. Rare species may have narrow ecological amplitude, inherently low reproductive potential or may have become marginalised due to poor competitive ability. The survival of the species, therefore, depends upon the habitat remaining undisturbed, since any perturbations in the habitat may lead to the species becoming endangered.

AREA

The area of occupancy of a rare species needs to be protected in its entirety. The precise demarcation of the area will be based on the population density of the rare species, quality of habitat, level of exploitation and the effect of introduced species, pathogens, competitors, parasites and/or pollutants.

KEY WORDS

Risk: Probability of extinction in the wild.

Extinction: A process by which a species cease to exist in the wild.

Endangered: A species is endangered when it is facing a very high risk of extinction in the wild in the near future.

Vulnerable: A species is vulnerable when it is not endangered but is facing very high risk of extinction in the wild in the medium-term future.

ILLUSTRATIVE EXAMPLES

Some of the selected examples are given below:

(a). Plants: *Paphiopedilum hirsutissimum,* an orchid of highly ornamental and commercial value and commonly known as Lady's Slipper, is thinly scattered in Mizo, Naga and Jowai Hills in North-east India. The other plant species is *Clarkella nana* of family Rubiaceae which grows on lithophytic lime stone rocks in Western Himalaya. A beautiful slender herb- *Begonia subpeltata* of family Begoniaceae is found in South Deccan Peninsula, Western Ghats.

(b). Animals: Manipur Brow-antlered Deer or Sangai *(Cervus eldi eldi)* of family Cervidae is found in open jungle and floating swamps (Phumids) of Keibul Lamjo National Park, Manipur. Another animal species is *Ardea goliath* (Giant Heron) which is found in Sunderbans and Arunachal Pradesh.

2.3 ENDANGERED SPECIES

DEFINITION

A species facing a very high risk of extinction in the wild in the near future.

ECOLOGICAL SIGNIFICANCE

The ecological significance of endangered species is that they are likely to be lost for ever to the world unless deliberate efforts are made to protect them. A species becomes endangered *inter alia* due to its excessive exploitation, habitat destruction or any other kind of disturbance. Unless these factors are urgently checked or reversed, the endangered species is destined to become extinct within a relatively short period of time. An endangered species also provides strong signals of ecological distress, having serious implications for food web, community stability, and the integrity and viability of the ecosystem as a whole.

AREA

The area containing an endangered species needs to be protected in its entirety. In case of fragmented areas of occurrence of an endangered species, all fragments having high population density and habitat integrity should be of prime concern.

KEY WORDS

Near future: when the existing population of the species is projected to reduce by 50 per cent within three generations of the species at current rate of decline.

ILLUSTRATIVE EXAMPLES

Some of the endangered species of both plants and animals are listed below:

(a). Plants: *Dendrobium tenuicuale,* an epiphytic orchid found in Andamans Islands. Other arborescent species found in evergreen forests of the Southern-Western is *Meteoromyrtus wynaadensis* of family Myrtaceae. *Nogra filicaulis* of family Fabaceae grows on laterite soils under shade in mesophytic mixed deciduous forests of Singbhum and Gidung in Bihar and Jashpur plateau in Madhya Pradesh.

(b). Animals: *Hylobates hoolock* (Hoolock Gibbon) of family Hylobatidae is found in evergreen and semi evergreen moist deciduous forests in Assam and Garo Hills of Meghalaya. The only species of salamander found in Darjeeling District of West Bengal in India is *Tylotriton verrucosus* (Himalayan Newt), belonging to family Salamandridae.

2.4 CENTRES OF EVOLUTION OF DOMESTICATED SPECIES

DEFINITION

Areas associated with the origin of domesticated species which continue to harbour their wild relatives and/or progenitors.

ECOLOGICAL SIGNIFICANCE

Domesticated animal species or traditional cultivars of crops have a range of variability that is considered less limited than that available to their wild relatives. As domesticated species such animal breeds and crop varieties have been subjected throughout the centuries to attacks from pests and other factors. However, because traditional agriculture utilised several ecological principles like crop rotation and companion planting, several of these problems were effectively curtailed. In the process, however, yields/productivity had to be maintained at sustainable and not maximum levels.

2.5 WILDLIFE CORRIDORS

DEFINITION

(a) A linear two dimensional landscape element that connects two or more patches of wildlife habitats that have been connected in historical time and is meant to function as a conduit for designated animal species. Even isolated strips, but usually attached to a patch of somewhat similar vegetation, could serve as a corridor.

(b) Streams, rivulets, rivers and their flood plains are natural corridors as they facilitate movement and dispersal of designated aquatic species.

(c) Riparian zones, along with intermittent and permanent streams and rivers, provide migration routes for certain designated species, such as butterflies, birds, bats, squirrels and monkeys.

(d) Wetland habitats along the migration route of designated migratory waterfowls that provide passage for large scale movement and food. Such a series of wetland habitats on network of staging sites along the migratory highways so as to reach wintering areas is crucial for the conservation of birds.

ECOLOGICAL SIGNIFICANCE

Corridors serve several ecological functions:

(a) They provide seasonal migration routes between areas where animals physically cross one area to another.

(b) They facilitate habitat supplementation and provide opportunities for the 'source and sink' populations through dispersal route from one area to another. Immature carnivore or any other animal seeking territories would use corridors for dispersal.

(c) They help in maintaining a network of protected areas or protected landscape so as to allow gene flow between sub-populations. Otherwise, small and scattered protected areas would suffer from 'island' syndrome and ultimately fail in maintaining the ecosystem integrity.

AREA

Identification of the areas constituting wildlife corridors is not easy since it not only varies from species to species, but also between any pair of sub-populations of a given species. Consideration also has to be given to the nature and purpose of migration, since the characteristics of the corridors which are critical may vary depending upon the purpose.

KEY WORDS:

Designated Species: All taxa included in the lists to be notified by the Ministry of Environment and Forests under Parameters 2.1 to 2.3.
Landscape: A landscape is a broad-scale area composed of patches, comprising of physical, biological and cultural elements. Landscapes integrate all natural and human induced patterns and processes.

Riparian Zone: Riparian zone are areas characterized by presence of vegetation that requires free or unbound water or conditions that are more moist than normal. Riparian zones are more diverse and productive.

ILLUSTRATIVE EXAMPLES

In terrestrial ecosystems several corridors have been identified. Corridors for individual species movement *viz*. Wild buffalo from Sitanadi Wildlife Sanctuary to Udanti Wildlife Sanctuary in Madhya Pradesh; Elephant from Rajaji National Park to Sonanadi Wildlife Sanctuary to Corbett Tiger Reserve in Uttar Pradesh. Similarly, a corridor to maintain the movement of tiger exists between Arunachal sub Himalayan forests, Assam and Bhutan to Buxa Tiger Reserve in West Bengal.

In river ecosystems, the connecting links between two major river systems or smaller tributaries joining two large rivers are called as corridors. Like terrestrial ecosystems, aquatic ecosystems, specifically the river ecosystems have been fragmented due to construction of dams and barrages and associated development activities and have lost their connectivity with smaller tributaries. Often contiguous river stretches or the tributaries are interrupted by low water level or deposition of sediments, pollution and intensive fishing activities making them ineffective as movement corridors. Consequently the migration of fishes *e.g.* hilsa and mahaseer; movement of large vertebrates like river dolphin, otter and also turtles has been affected.

In some cases, though connectivity exists between two large river ecosystems, but due to intensive anthropogenic pressures they have become unsuitable for animal movements. For example, though the National Chambal Sanctuary is the largest gharial breeding site, the surplus stock are not being able to re-colonize downstream in the Yamuna river because of insufficient water flow, intensive fishing activities, and pollution. Therefore, the confluence part of these two rivers needs to be protected as corridor to facilitate aquatic species movement.

Along the coast, construction of ports and jetties, and aqua-culture activities have fragmented the mangroves and associated intertidal habits. For example, along the eastern coast the saltwater crocodile population occurs in patches and there is very little genetic exchange between these sub populations. Coastal otters are also facing similar problems. Smaller patches of mangrove between two large patches though may seem insignificant, but in fact have high conservation value as they act as migratory route for otters and crocodiles and associated mangrove fauna.

The tiger population of Manas Tiger Reserve in Assam is in genetic contact with that of Buxa Tiger Reserve in West Bengal. The population in neither area is large enough to maintain natural heterozygosity, but the total population along the whole corridor route certainly is. Conservation planning is paying special attention to the maintenance of such corridors and linkages.

In the context of birds, especially the migratory waterfowls, the corridors can be in the form of series of wetland habits along their migration route that provide passage for large scale movement of birds. Water birds specially ducks, waders, cranes and raptors are the predominant elements of Eurasian Migration. While migrating, these birds need staging sites to reach their wintering areas. At the staging sites the birds also get food for their further journey. The protection of network of staging sites along the migratory highways is crucial for the conservation of these birds. The wetlands in northern India, besides being wintering areas for many water birds, provide staging site to large number of species during spring as well as autumn migration.

2.6 SPECIALISED ECOSYSTEMS

DEFINITION

Specialised ecosystems are complex and highly diversified. They exhibit delicate interdependence between biotic and abiotic variables and are characterised by their biological productivity, specialised adaptations in the native or inhabiting organisms resulting in unique biodiversity and giving rise to complex ecological processes.

ECOLOGICAL SIGNIFICANCE

A specialised ecosystem possesses a unique combination of ecological features which are conducive to the emergence and perpetuation of a highly intricate and interdependent assemblage of biota. These systems are also locations of active and abundant speciation and genetic diversification. Specialised ecosystems are characterised by complex and delicate interdependence between biotic and abiotic variables, and are, therefore, extremely vulnerable to slightest perturbations. In most cases, the very complexity of these systems makes it difficult to predict the consequences of any biotic or abiotic changes on the ecosystems as a whole or on any individual species occurring therein. Consequently, these ecosystems are extremely fragile and must be accorded protection from any disturbance.

AREA

Specialised ecosystems are usually extremely sensitive in the abiotic characteristics of the habitat concerned. Since such abiotic characteristics can be seriously affected by perturbations taking place even beyond the immediate vicinity, the area of protection will need to be defined with respect to the critical abiotic characteristics of each identified ecosystems and the manner in which they can possibly be disturbed. Restrictions in activity may, therefore, have to be placed on locations which are relatively distant from the actual location of the ecosystems which would depend upon factors like water currents, wind directions, and other geo-morphological features which may affect soil or chemical characteristics of the habitat.

KEY WORDS

Complex: A wide range of ecological functions which are mutually inter-dependent.

Diversified: A wide range of species performing a given ecological function.

Ecosystem: An unit of nature comprising of both biotic and abiotic components which are interacting and interdependent.

Biological productivity: Rate of evolutionary and speciation activity.
Adaptive diversity: Evolutionary diversification of species derived from a common ancestor into a variety of ecological roles.

ILLUSTRATIVE EXAMPLES

(A) Coral reefs :

corals constitute a complex ecosystem situated in clear shallow warm marine waters with a sandy or rocky substratum. The main component of this system is a colony of small animals known as Cnidarians. A Cnidarian has a central cavity and a terminal mouth surrounded by tentacles. This animalcule is known as a polyp. The polyps ingest the calcium in the sea water and excrete it to from a porous exoskeleton of different shapes. The polyps are associated with endogenous algae especially Dinoflagellates known as Zooxanthellae. Zooplankton present in the water are ingested by the polyps. The polyps by their respiration supply carbon dioxide to the algae. The algae in turn supply the products of photosynthetic processes to the polyps. Such symbiosis results in one of the most productive marine systems.

Various types of fin fishes, turtles, rays and octopuses live among the corals and make the coral system rich in biodiversity. A single reef may harbour as many as 3000 species – 200 species of corals, 520 species of fishes, 400 species of mollusks, 500 species of crustaceans, 200 species of star fishes and many other species of microscopic and macroscopic organisms.

Coral reefs occur in the Andaman & Nicobar, the Lakshadweep, the Gulf of Mannar and the Gulf of Kachchh. Optimal development takes place in water temperatures between 23 to 30 degrees C.

(B) Mangroves :

Mangroves constitute a community of plants and animals adapted to slushy soil, tropical marine waters and the push and pull of the tides. Vivipary is a strategy by which young seedlings remain attached to the parent plant until they are old enough to live independently. They have osmo-regulatory features to handle salinity. The roots have filters that keep out salt. Glands excrete the excess salt that may have entered the plant body. There are also special tissues to store excess salt

that may hinder the plant metabolism. Prop roots firmly anchor the plants in the tidal waters. The scarcity of soil atmosphere is overcome by breathing roots that turn upwards to inhale atmospheric air through openings called lenticels.

The leaf litter of the mangrove vegetation, decomposed by bacteria and fungi, is an important source of food for the molluscs, crustaceans and juvenile fish. Several marine fish migrate to the mangroves to spawn. The fingerlings feed on the organic debris. Some of them become the food of the larger fishes while those that survive migrate to the open sea. Thus, a mangrove food chain is set up. Salt-water crocodiles, monitors and several birds are part of the mangrove community. The Bengal Tiger is an important animal in the Sunderbans mangrove ecosystem.

Extensive mangroves are found in the deltas of the east coast rivers, the Sunderbans area, the deltas of the Mahanadi, the Godavari, the Krishna and Cauvery. The Andaman and Nicobar Islands, the Gulf of Kachchh and the Gulf of Mannar are also noted for their mangroves.

(C) Estuaries :

Estuaries are semi-closed water bodies connected to the sea, within which sea water is measurably diluted by freshwater. Interaction of two chemically and physically different water masses gives rise to complex sedimentological process, morphological response, biological process and chemical characteristics. Estuaries, unlike river mouths, tend to be tide-dominated. Estuarine sediments can come from range of sources including damage basin, continental shelf and coastal waters, atmosphere, erosion of estuarine margin, bottom sediments and biological activity. Based on the degree of separation of mixing of the fresh and salt water masses, three identified different mixing regimes are : (i) stratified (ii) partially mixed and (iii) mixed or homogeneous. The shores of coastal-plain estuary are mainly made of mixtures of silt, mud and sand in varying proportions and degree of compaction. Near the mouth of the estuary where depositional processes occur, the shores and substrate are conspicuously sandy. The muds of the estuary bottom tend to hold the more saline waters as the tides ebb.

(D) Fresh Water Swamps:

Fresh water swamps are slow moving streams, rivers or isolated depressions, which are dominated by herbaceous vegetation. They are also extremely rich in their faunal diversity, including migratory waterfowl. In addition to their richness in terms of specialised flora and fauna, they also regulate hydrological cycle through recharging of the ground water and seasonally controlling the release of excess water. Some of the main examples are as follows:-

(i) Myristica swamp forests :

These are distributed only in Travancore (Kerala) along streams (below 300 M altitude) on sandy alluvium rich in humus and inundated during the latter half of the year. The dominant tree is *Myristica* sp.

(ii) Tropical hill valley swamp forests:

They cover along streams on gravelly and sandy beds in submontane tracts of the Himalayas (in states of Uttar Pradesh, West Bengal and Assam) and at few places in the Western Ghats in particular Wayanad forest division in Nilgiris (Kerala).

(iii) Creeper swamp forests:

These forests are found in Brahmaputra valley in low lying areas on heavy soils. The forests are dense, up to 10 M high, and have many vines. Important tree species are: *Magnolia griffithii, Machilus* sps., *Vatic asps*. and *Eugenia of ormosa.* Creepers and vines included *Calamus leptospadix,* and species of *Cissus* and *Uraria.* Among other aquatic plants, *Phragmites karka* is very common.

2.7 SPECIAL BREEDING SITES/AREAS

DEFINITION

An area associated with any stage of the reproductive behaviour of as designated species.

ECOLOGICAL SIGNIFICANCE

A number of species exhibit the behavioural characteristics of migrating to specific locations for the purpose of breeding and/or rearing of the young. These locations usually cannot be termed as the principal habitat of the adults of the species, which would otherwise perhaps be covered by Parameters 2.1 to 2.3, since they normally do not spend the major portion of their life-cycles in these locations. Nevertheless, these breeding sites/areas are critical for the survival of such species in being able to carry out their normal reproductive patterns of breeding or rearing. Special breeding sites possess specific ecological features which meet any or all of the following essential reproductive requirements:

(a) Attracts adults for courtship and mating. This is important not only for successful reproduction, but also to ensure healthy population.

(b) Conditions suitable for nesting, egg laying, incubation, gestation, hatching and/or giving birth.

(c) Adequate protection to the young from natural predators.

(d) Essential environmental and nutritional requirements for the young to survive and thrive.

Since the migratory behavioural pattern in itself indicates that the natural habitats of the adults of the species are not conducive to breeding and/or rearing functions, special breeding sites acquire considerable significance for the very survival of the species. This is particularly true if the special breeding site of a specific species is either unique or limited to just a few locations. These locations indicate a unique assemblage of ecological features which may be irreplaceable. Thus, any perturbation in the dynamics of these locations and any consequent alteration effected in the breeding system and/or its spatial distribution, may lead to the species being unable to reproduce and therefore becoming extinct. The potential of such elimination of species imparts a great deal of ecological significance for conserving these areas.

AREA

Sites associated with the reproductive, breeding or nurturing bahaviour of designated species and their associated ecosystems.

KEY WORDS

Designated species: All taxa include in the lists to be notified by the Ministry of Environment and Forests under Parameters 2.1 to 2.3. in addition, any taxon whose special breeding sites are to be found only or primarily within the national territorial limits. These may be termed as "reproductive endemics".

Reproductive behaviour: Courtship, mating nest building and nesting, egg laying, incubation, gestation, hatching or giving birth to young ones, and nurturing, including feeding and upbringing of the young.

ILLUSTRATIVE EXAMPLES

- The Sandy beaches of Bhitarikanika Sanctuary, Rushikulya and at the mouth of river Devi along the coast of Orissa together with the associated supporting ecosystems comprising mangroves, estuary and adjoining deep sea area constitute the mass nesting site of the Olive Ridley turtle.
- Andaman and Nicobar Islands and parts of Kerala coast for Olive Ridely Turtles.
- Keoladeo National Park, Bharatpur for Siberian Cranes.
- Sunderbans Mangroves area for Fiddler Crabs.
- Manas Wildlife Sanctuary for Indian Rhinoceros.
- All breeding sites of Gangetic Dolphin.

2.8 AREAS WITH INTRINSICALLY LOW RESILIENCE

DEFINTION

Ecosystems which are susceptible to irreparable damage form an even low level of disturbance.

ECOLOGICAL SIGNIFICANCE

In nature every individual organism is endowed with an in-built resilience, though of varying degrees, the same can be applied to ecosystems too. An ecosystem with intrinsically low resilience means an ecosystem in which the constituent inhabitants (Plants and Animals) have a low potential of recovery from an adverse impact due to limited extraneous environmental perturbations or pulse events. This indicates that any human interference may lead to an imbalance in the entire ecosystem, loss of biodiversity and even extinction of certain species.

AREA

The extent of occurrence of such ecosystems, including sufficient areas for their protection and potential expansion depending upon the abiotic characteristics of the ecosystems.

KEY WORD

Ecosystem: A dynamic complex of plant, animal, fungal, and microorganism communities and their associated non-living environment interacting as an ecological unit.

Resilience: The capacity of an ecosystem to return towards normalcy.

ILLUSTRATIVE EXAMPLES

Many ecosystems such as Evergreen Forests of the northern Western Ghats, "Shola" Forests in the Nilgiri and Palni Hills of the southern Western Ghats, certain Wetlands, and Coral Reefs have low resilience.

'Shola' Forests of the southern Western Ghats: These are compact, closed canopy, evergreen forests occurring as isolated patches at more than 1400. Altitude in depressions of grassy hillside and are associated with swift flowing mountain streams. The canopy of these forests reduces the force of the rain drops, prevents

excessive run-off and protects the soil from erosion. These forests are known for their antiquity. The trees are stunted and uncommon. The trunks and branches are loaded with a wide range of lichens, mosses, ferns, lycopods and other epiphytes. The soil fauna is unique and closely dependent on the leaf litter. If tampered with, the shola forests are liable to disintegrate.

Evergreen Forests of the northern Western Ghats: These are ancient forests that have evolved into climax closed canopy evergreens the fact that the wet period is between three to four months and the dry season lasts for more than eight months. The closed canopy formed by the branches of contiguous trees creates a humid micro-climate within the forest. Once the canopy is opened, the shade loving plants (Sciophytes) are eliminated and replaced by plants that can tolerate higher light intensities. This is in sharp contrast to the wet evergreens of the southern Western Ghats, which have more than eight months and only four dry months. The short duration of the wet period in the north is largely responsible for the intrinsically low resilience of the northern evergreens in the Western Ghats.

2.9 SACRED GROVES

DEFINITION

Forest areas or patches of natural vegetation preserved over generations on religious grounds.

ECOLOGICAL SIGNIFICANCE

Certain areas in the vicinity of human habitation were declared home of the reigning deity and no human interference was allowed in order to maintain its sanctity. Vegetation in such sacred groves is believed to be under the protection of the reigning deity of that grove and removal of even the dead plants/animals or their parts is taboo. In the case of the North-east region, entire hills have been maintained as sacred groves. Selected species of religious significance were sometimes brought from their original habitats and were maintained in the area of the deity. Due to the protection afforded, over time these became naturalized and have given rise to considerable biological diversity. These groves have also acted as sanctuaries for a variety of fauna, thereby creating a rich ecosystem.

These sacred groves, which have served as sanctuaries supporting communities of plants and animals over many generations, are now coming under threat. In recent times, with changing values, the extent of religious protection of these groves has weakened. Hence, it is necessary to bring them under an appropriate legal protection regime in order to preserve their rich biodiversity.

2.10 FRONTIER FORESTS

DEFINITION

Remnants of primeval natural forests that have remained on the whole relatively undisturbed and big enough to maintain their biological diversity including viable populations of species associated with the specific forest-type.

ECOLOGICAL SIGNIFICANCE

As these forests are the only remnants of the natural forest ecosystems, they provide conditions for undisturbed organic evolution and speciation. Such forests are irreplaceable, since they represent evolutionary processes spanning millennia. They serve as important bench-marks for assessing the extent of ecological changes that have taken place or which are in the process of taking place. These forests have become very rare and any further loss will endanger their unique ecological and evolutionary processes.

AREA

The extent of occurrence of such natural forest ecosystems, including sufficient areas for their protection and potential expansion.

KEY WORD

Forest-type: A class/category of forest constituted with respect to its geographical location, prevailing climatic conditions, soil character, composition and condition.

ILLUSTRATIVE EXAMPLES

- Tropical Evergreen Forests in Piyun Valley, Diyun Valley and Patkai Mountain area in Tirap and Lohit Districts of Arunachal Pradesh
- Wet Evergreen Forests in the identified Core areas of Great Nicobar Biosphere Reserves
- Evergreen Forests in Agasthyamalai Hills of the Nilgiri Biosphere Reserves
- Evergreen forests in Nallamalai Hills of the Nilgiri Biosphere Reserves
- Mangrove Forests in the Core area of Sunderbans Biosphere Reserve

2.11 UNINHABITED ISLANDS IN THE SEA

DEFINITION

Islands in the sea and those falling in Coastal Regulation Zone-I which do not have permanent human settlement.

ECOLOGICAL SIGNIFICANCE

Uninhabited islands have evolved, as a rule, their own ecosystems, which are at times unique, in the absence of human interference. Because of their isolation, the biota of such islands are good repository of undisturbed evolution and this is manifest in abnormally high percentage of endemic taxa. The biological component present on these islands is highly susceptible to the introduction of exotic species.

ILLUSTRATIVE EXAMPLES

(a) Permanent Uninhabited Islands

-Most Islands of the group of the Andaman and Nicobar Islands.
-A number of islands in Lakshadweep.

(b) Islands With Some Human Interference

-Pirotan Island in Gulf of Kachchh.
-Krusadi Island in the Gulf of Mannar.

2.12 STEEP SLOPES

DEFINITION

A natural slope of 20 degrees or greater.

ECOLOGICAL SIGNIFICANCE

Slopes are integral parts of any mountainous or hilly terrain, which has evolved through various geological processes. The ecology of different mountainous zones is complicated in view of diversity of physical conditions. Increase in altitude results in the decrease in temperature, rainfall, development of drainage and the rates of stream dissection. Major biotic communities generally appear as irregular bands, often with very narrow eco-tones. On a given mountain, as many as four or five major biomes with many zonal sub-divisions may be present. Consequently there is closer contact between biomes, and more interchange of biota between different biomes than occurs in non-mountainous region. On the other hand, similar communities are more isolated in the mountains, since mountain ranges are rarely continuous. As a result of isolation and topographic differences, many species are unique to the mountain communities. Growing human activities (faulty land use, deforestation etc.) may increase the probability of instability of the slopes and irreversible alteration in the habitats and their interactions resulting in potential loss of species and bio-diversity.

Any zone with a water surplus has a downstream movement, known as draining. Erosion and transfer of sediment both occur through the action of water moving through the terrestrial phases of the hydrological cycles, and as result the drainage catchment of mountainous ecosystem has been considered a fundamental geo-morphological unit. As drainage basins are catchment areas for the stream water, any variation in these areas affects the stream characteristics. Drainage density has a close relation to precipitation, run off and the topography of the drainage catchment. Vegetation and rainfall tend to be closely related, so that the area of high rainfall are often characterized by a dense vegetation cover, as the vegetation enhances the infiltration and reduces run off. The detrimental ecological effects in the form of flood hazards, damage in river region, poor water quality and reduced availability of ground water are similar to those mentioned in Origin of Rivers (Parameter 2.13).

Although it is recognised that the fragility of a specific mountainous ecosystem is dependent on interaction of geological, seismological and biological characteristics, the ecological impact of perturbations in steeply sloped areas can be

so wide spread that mere consideration of the immediate area would be fallacious. Therefore, it is felt that steepness of the slope is sufficient justification without any further qualification.

AREA

The slope of a land area is generally defined as its upward or downward inclination to horizontal plane and it is usually measured as an angle in relation to the horizontal plane.

In the Indian context, the gradient nomenclature, which is usually used in engineering designs and the image processing techniques (GIS), classify slopes as given in the below:

Gradient Nomenclature

Slope	Percent	Description
-	0-3	Flat
2^0	3-8	Gently sloping
4^0	8-15	Sloping
8^0	15-25	Moderately Steep
14^0	25-50	Steep
26^0	50-100	Very Steep
45^0	>100	Extremely Steep

It may be seen that the 20^0 cut off recommended by the Committee represents the upper half of the "Steep" classification and higher gradients. Since a mountain or a hill slope may contain segments having different degrees of inclination, the criterion should be applied to the totality of the slope from the base to the apex. Also, since the angle of a slope is related to the distance from which it is measured, measurements need to be taken from different points along the slope and , if at any point the angle exceeds 20^0, the area above that point should be treated as a steep slope. The relevant area for protection would need to take into account of certain destructive features which are commonly present including various combinations of steep slopes, seismicity, residual soil, high pore water pressure, thick & deeply weathered soil cover, undercutting of the base of the slope, and weak material outcropping below stronger material. Since the horizontal planes near the top and base of a slope are prone to landslides and receive boulders/debris of a slide respectively, suitable buffer zones are designated. In general, a minimum horizontal distance of 5000m at both the ends of a slope is recommended as buffer zones. These issues are illustrated in Figure 1. In mountainous ecosystems, buffer zones may need to be extended further in landslide-prone slopes.

ILLUSTRATIVE EXAMPLES

Fragility of a mountainous ecosystem is dependent on interaction of geology, drainage, soil and degree of slope with natural processes and man's developmental & economic activities. An example from the Indian sub-continent is cited hereunder:

Kashmir Himalayas: The slope and land use pattern of 2 tahsils, viz. Gulmarg and Pahalgam of Kashmir Himalayas are presented in following Table:

Table: Suitability for Development in Gulmarg and Pahalgam Tahsils of Kashmir Himalayas on the Basis of Geomorphic Items and Ecological Fragility*

Feature	Suitability Groups			
	Suitable	**Moderately sustainable**	**Unsustainable**	**Unsustainable**
Geomorphology				
Slope (Degree)	3-11	11-17	17-22	>22
Area under each slope type (km^2)	149.25	180.42	199.72	72.6
Topography	Flood Plain	Dry Farm-Land	Alpine	Rocky Slopes
Zone	Paddy Belt	Forested Slopes	Pastures	Glacial Heights
Geological formation	Older Alluvium, Karewa	Shale, limestone, Clay	Quartzite, Stand-Stone	Metamorphosed Rocks
Altitude (m)	1500-2000	2000-2500	2500-3000	>3500
Natural drainage	Poor	Moderately Good	Good	Very Good
Soil erosion	Practically Negligible	Moderate to Heavy	Severe	Bed-rock Exposed
% of top soil	25	25-75	>50	Nil
Use type				
Settlement	Good	Not Recommendable	Dangerous	Impossible
Construction	Good	Not Suitable	Dangerous	Impossible
Preservation	Poor	Moderate	Good	Very Good
Productions	Good	Moderate	Not Feasible	Impossible

***Source:** Singh, R.B. & A.A. Pirazizy (1990). Anthropogenic impact on landscape synthesis in Kashmir Himalayas: a study of land suitability and capability classification. In R.B. Singh (ed.). Contribution in Indian Geography XI: Environmental Geography. Heritage Publishers, New Delhi

2.13 ORIGINS OF RIVERS

DEFINITION

A glacier, mountain, hill or spring from where a water stream originates is referred to as the origin of a river.

ECOLOGICAL SIGNIFICANCE

Rivers have been an integral part of the human society and always held in reverence since the dawn of civilization for good reason. Because of importance of water to virtually all life forms, a river plays a critical role in all ecosystems which may be in existence along its entire length. Disruption of a riverine system can have ecological consequences which may be so vast that they can not be predicted on an *a-priori* basis. Like most water bodies on the earth's surface, a river is also a medium of support of various life forms-ranging from bacteria to simple forms of plants, and animal life including fish, amphibians, birds and mammals.

Relatively minor disturbances near the origin of a river may result in major changes of the geological and hydrological features of the surrounding areas. This would have major repercussions on the river itself. In addition, this may cause enhanced erosion rates in the mountains, fluctuations in the hydrologic regimes in downstream, silt accumulation rates, flooding water in the low lands and natural system of recharge, all of which can result in serious ecological damage in surrounding areas.

AREA

The area relevant to the origin of a river is not strictly limited to the natural point of origin of the river itself (for example, the exact point at which the water spring emerges), but the entire area necessary for preserving the geological and hydrological features which are critical for the sustainability of the river sources. Thus, it is not enough to protect only the glaciers or the snow receiving slopes which feed the river, but also the channels, fissures and other features which are intrinsic to the process of process of recharging the water source. Similar considerations would apply to the recharging of spring and rain-fed rivers.

KEY WORDS

Stream: Water body flowing in the river – beds or brooks

Glacier: A slowly moving mass of ice which is formed in mountainous regions by the accumulation of snow over thousands of years

Spring: A flow of water from the ground

ILLUSTRATIVE EXAMPLES

(a) Rivers originating from glaciers:

Teesta originates from glaciers at a height of about 6400m and is formed mainly by the union of two streams Lachung chu and Lachung chu which unite at Chungthang. Hence the glaciers which feed both these streams would be considered as the origin of the river.

(b) Rivulets fed by snow covered slopes:

In the upper reaches of the Himalayan region, snow covered slopes during summer start melting. Consequently, a significant quantity of water is released, through rivulets and small streams, into several rivers passing through these ranges. These rivulets are critical for sustaining the supply of water and hence require efficient protection taking into account their geological instability.

(c) Rain-fed rivers

In the case of rain-fed rivers through underground source, geo-hydrological features which channelise the rainfall to the underground sources need to be maintained.

CHAPTER 3

Auxiliary Parameters: Indicators of Ecological Sensitivity

The primary parameters described in Chapter 2 are compelling enough individually to warrant protection of the concerned area. There are, however, other characteristics about which too little is known at present to give any definite judgment. Nevertheless, these characteristics are strong indicators of the possibility of ecological sensitivity. This chapter outlines some of these parameters.

It is recognized that many of the areas covered by these auxiliary criteria may also be falling in one or more of the primary parameters, in which case there is no real issue. However, areas which are not so covered need to be closely investigated in order to ascertain their ecological sensitivity. Priority should be given to those areas which satisfy more than one of these auxiliary parameters, since the *a-priori* case strengthens with every additional characteristic.

As in the case of the Primary Parameters, efforts have been made to provide sufficient details of definition, ecological significance, area coverage and assessment methodologies, along with illustrative examples, to facilitate the process of prioritization and investigation.

3.1 CENTRES OF LESS KNOWN FOOD PLANTS

DEFINITION

Areas associated with the origin of or containing the wild progenitors of less known plants of potential food and horticultural values.

ECOLOGICAL SIGNIFICANCE

In view of the concern of food and nutritional security, these plants represent valuable resources as non-conventional alternative or additional food sources. Such wild food plants posses rich and wide range of genetic resources which are of immense value for human use. Many of them are currently used by some communities, but have yet to attain wider popularity. At some future date, these may become more widely used.

ILLUSTRATIVE EXAMPLES

Some lesser known plants examples in Hindustani regions are as follows:-

Food plants/Regions Category	**Nos.**	**Some examples**
Tuber & root type	7	*Dioserea spp., Paehyrhizus spp., Tacca spp., and Xanthosoma spp.*
Vegetables	11	*Basella rubra, Pentaphragma bagoniaefolium, Hydrolea zeylanica, Ipomoea aquatica.*
Flowers	3	*Bauhinia purpurea, Madhuca spp., Musa spp.*
Fruits	17	*Artocarpus lakoocha, Aegle marmelos, Citrus indica, Elaeocarpus floribyndus, Mangifera indica,*
Seeds/Nuts	11	*Pandanus spurious.* *Borassus flebllifer, Coix lacryma-jobi, Digitaria Cruciata var. esulenta, Dolichos uniflorus, Echinochloa colonum, Mucuma capitata,* *Panicum sumatrense Triticum sphaerococcum, Vigna aconitifolia*
Miscellaneous	8	*Amomum xanthioides, Caryota urens, Murraya koenigii, Phoenix sylvestris*

3.2 WETLANDS

DEFINITION

Wetlands are submerged or water saturated lands, both natural and man-made, permanent or temporary, with water that is static or flowing, fresh, brackish, salty, including areas of marine water, the depth of which at low tide does not exceed six metres.

ECOLOGICAL SIGNIFICANCE

The wetlands maintain conditions vital for ecological processes at landscape level, integrating both aquatic and terrestrial habitat (ecotone). In addition to providing critical habitat for threatened and endangered species for breeding, feeding and migration, they support perpetuation of species of medicinal, agricultural and genetic value. Besides, their role in regulating hydrological cycles in the area and recharging underground aquifers has also been well established. They are thus areas of outstanding natural value for hydrological, geological, scenic and biological resources, that should be carefully managed to maintain these values.

Wetland habitats provide protection to or act as shelters from cyclonic storms, protection to slopes, especially along riverine habitats. They regulate and purify water flow and support natural vegetation on hydric-soils that has significant value for migrant and resident wild fauna.

AREA

As identified by the natural boundaries of the water body.

LIST OF NATIONALLY IMPORTANT WETLANDS/LAKES

Sl. No.	Name	State/U.T.
(A)	**Wetlands**	
1.	Wullar	Jammu & Kashmir
2.	Tso Murari	-do-
3.	Tisgul Tso	-do-
4.	Renuka	Himachal Pradesh
5.	Pong Dam	-do-
6.	Chandratal	-do-
7.	Harike	Punjab
8.	Ropar	Punjab
9.	Kanjli	Punjab
10.	Chilka	Orissa
11.	Kabar	Bihar
12.	Keoladev National Park	Rajasthan
13.	Sambhar	Rajasthan
14.	Kolleru	Andhra Pradesh
15.	Loktak	Manipur
16.	Ashtamudi	Kerala
17.	Sasthamkota	Kerala
18.	Ujni	Maharashtra
19.	Nalsarovar	Gujarat
20.	Deepar Beel	Assam
21.	Rudrasagar	Tripura
(B)	**Lakes**	
22.	Dal	Jammu & Kashmir
23.	Sukhna	Chandigarh
24.	Sagar	Madhya Pradesh
25.	Nainital	Uttar Pradesh
26.	Kodia Kanal	Tamil Nadu
27.	Ooty	Tamil Nadu
28.	Pulicut Lake	Tamil Nadu
29.	Rabindra Sarovar	West Bengal
30.	Powai	Maharashtra
31.	Pichola Complex	Rajasthan
32.	Hussain Sagar	Andhra Pradesh

3.3 GRASSLANDS

DEFINITION

Grasslands are terrestrial ecosystems characterised by plant communities belonging to the grass family – 'gaminoids' and 'forbs'.

ECOLOGICAL SIGNIFICANCE

Population of native animals in grasslands are much more diverse than is usually appreciated and is ecologically very important in the entire food chain. Besides representing rich avi-fauna, these are also home to a number of animals, such as ungulates, carnivores, rodents, lizards and snakes and the larger insects, particularly grasshoppers, beetles and butterflies. A large proportion of them exhibit burrowing habits. Often intervening grassland patches serve crucial corridor for movement and dispersal of native animals.

3.4 UPPER CATCHMENT AREAS

DEFINITION

Catchment area, also referred to as drainage area, is a basin like structure for collecting and draining water. Upper Catchment Area typically refers to a basin which collects precipitation, mostly in the mountainous or hilly region or the upper reaches of a river following its origin. The water collected is absorbed by the soils or drains into the river.

ECOLOGICAL SIGNIFICANCE

The catchment of any region acquires importance because it determines the annual water-yield of the river draining it. The health of a catchment area is indicated by the land pattern and extent of its forest cover. The forests play a valuable role in conserving water. In most of the rain-fed river basins in India where the catchment area is denuded of forests, floods occur after the heavy monsoon showers. The river basins then run dry for several months before the onset of the next monsoon. The opposite is true for rivers where catchment area possesses thick vegetation. The rivers yield water till the end of summer. The ecological importance of rivers has already been indicated earlier in Primary Parameter 2.13.

AREA

The designated 'upper catchment area' from which water is collected into the upper stretch of a river varies widely from river to river. It is dependent on various factors viz. location of origin of the river, slopes of the basin, tributaries, annual discharge, geology, soil characteristics and forest cover.

KEY WORDS

Drainage : A system of channels carrying water
Basin : An area drained by rivers and tributaries
Precipitation : Water which falls on the ground

3.5 NOT SO STEEP SLOPES

DEFINITION

A slope greater than 10 degree but less than 20 degree.

ECOLOGICAL SIGNIFICANCE

The ecological significance of "not so steep" slopes is similar to that given for Primary Parameter 2.12: Steep Slopes. However, since "not so steep" slopes, by and large, are less unstable and more hospitable to biotic communities than "steep slopes", greater consideration has to be given to other factors for determining the extent of ecological sensitivity/fragility. Vegetative regeneration capacity, species types and their importance, habitat characteristics, climate, geology, palaeontological characteristics, seismicity, drainage and rainfall would need to be considered for designating such slopes as "Ecologically Sensitive".

AREA

An area which may have its upward or downward inclination to horizontal plane between 10 and less than 20 degrees. Since the horizontal planes near the top and base of a slope are prone to landslides and receive boulders / debris of a slide respectively, suitable buffer zones are designated. In general, a minimum horizontal distance of 200m at both ends of a slope is recommended as buffer zones.

In mountainous ecosystems, buffer zones need to be extended in landslides prone slopes which tend to possess certain destructive features, including various combinations of steep slopes, residual soil, high pore water pressure, thick and deeply weathered soil cover, undercutting of the base of the slope, and weak material outcropping below stronger material.

3.6 HIGH RAINFALL AREAS

DEFINITION

Areas having precipitation intensity greater than 200 cm per year.

ECOLOGICAL IMPORTANCE

High rainfall areas greatly influence the microclimate of the region making it more conductive to high bio-diversity (Microbial, Plants and Animals) of the region. High rainfall area with high vegetation cover reduces the soil erosion to a great extent, and trees can also trap and re-evaporate significant quantities of moisture to the atmosphere thus maintaining the water cycle of the region and prevents desertification.

Quite often the regime of high rain fall are associated with slopes. In the absence of vegetation or deforestation of these slopes/hills leads to heavy soil erosion due to high intensity rainfall, leading to heavy sedimentation/siltation of the rivers, river-basin causing floods (Figure 2). It also leads to landslides in sensitive regions (such as steep to moderate slopes, and denuded hills).

The stability of a slope that is critically disposed is controlled by the amount of water that infiltrates into it and the state of saturation of the sub soil. As such, normally a landslide is initiated only after the initial phase of south-west monsoon during a high intensity precipitation. However, a good pre-monsoon rain may alter the situation by enhancing the saturation level of sub soil. With the available rainfall data and known landslide events it may be summarized that consecutive rainfall for two days in excess of 30 cm during a continuous rainy season may affect stability of critical slope areas.

High rainfall is one of the main triggering mechanism for mass movements and serious soil erosion. Although practically no significant studies have been made in India on the relationship between mass movements and precipitation, there can be little doubt that at least in the Western Ghats many such natural calamities are induced by heavy rain. Prolonged or intense rainfall, or more particularly a combination of the two are among the most important triggers of landslides.

AREA

Areas which receive high precipitation on a “normal” basis as identified by the Indian Meteorological Department (IMD) or form Remote Sensing Data. This

would exclude areas which receive such levels of precipitation only on an episodic basis.

KEY WORDS

Precipitation : Snow, rain or water which falls or precipitate on the ground

Vegetation cover : Area of a land covered by plant communities

Groundwater aquifers : Layer of rock or soil which can hold or transmit water under the ground

3.7 OTHER UNINHABITED ISLANDS

DEFINITION

Islands in coastal, estuarine and inland water bodies which do not have permanent human settlement.

ECOLOGICAL SIGNIFICANCE

The ecological significance of such uninhabited islands is similar to that of Primary Parameter 2.11 relating to "Uninhabited Islands". However, since these islands are more exposed to human activity and to mainland biota, their ecological sensitivity cannot be presumed without further investigations. Nevertheless, attention needs to be drawn to them since the balance of probability would favour classifying many of them as ecologically sensitive/fragile.

Annexure 3

	INDICATORS	COMPONENTS
1	**RICHNESS**	a) Range of biodiversity components; vegetational density; rich density; rich genetic stock, land races and wild relatives of crop plants. b) Habitats for breeding and feeding grounds; corridors for migrother terrestrial for migratory birds and other terrestrial and aquatic Fauna
2	**DIVERSITY**	a) High biological diversity index of plant and animal community, and key stone species. b) Specially adapted habitats.
3	**ENDEMISM and RARITY**	a) High endemic and rare value of species. b) Centre of endemism.
4	**UNIQUENESS**	a) Representative natural areas, with unique assemblage of plants and animals. b) Representative inter-tidal zones, creeks, estuaries, mangroves, corals. c) Places of outstanding natural heritage and beauty. d) Natural sites of archaeological, historical and religious significance.
5	**SPECIATION**	a) Centres of speciation. b) Centres of evolution.
6	**SPECIES STATUS**	a) Rate of species depletion/extinction. b) Occurrence of endangered and threatened plant and animal species; Schedule I species of Wildlife Protection Act. c) Rate of recolonisation by alien and exotic species.
7	**ECOLOGICAL CRITICALITY**	a) Representative biogeographic locations and functions; transitional and buffer zones; sand dunes, cold and hot desert habitats; natural grassland, pasture and alpine

		meadows; ecotone areas, reserved and notified forests.
		b) Hydrological regime including rate of ground water recharge, water criticality, deficiency, conservancy; shallowness of seasonal rivers; salinity and brackish water.
		c) Geological seismicity; elevation over 1000m and steep slopes.
8	**SOCIO-ECONOMIC CRITICALITY**	a) Densely populated areas with high rate of pollution, including vehicular pollution. b) Tribal settlement/tribal population over 50% of total population. c) Significant level of water logging/soil erosion due to human impact. d) Only source of drinking water for local community. e) Chemical contamination of food chain; trophic level disturbance of food chain. f) Buffer zone of protected areas. g) Silvicultural system – over harvesting, canopy change, threat of human use. h) Representative green belt areas with harmonious human-nature interface. i) Representative ecologically sensitive areas with good ambient air quality.

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