FLORISTIC DIVERSITY AND CONSERVATION STRATEGIES IN INDIA

VOL. V: *IN SITU* AND *EX SITU* CONSERVATION

BOTANICAL SURVEY OF INDIA

Ministry of Environment and Forest

FLORISTIC DIVERSITY AND CONSERVATION STRATEGIES IN INDIA

VOLUME -V
***In Situ* and *Ex Situ* Conservation**

Editors
N.P. Singh
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Front Cover : Mehao lake – an oligotrophic lake in Mehao WLS, Arunachal Pradesh (Photo: Dr. D.K. Singh).

Back Cover : A view of temperate evergreen forest in Mehao WLS, Arunachal Pradesh (Photo : Dr. D.K. Singh)

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PREFACE

India's floristic diversity is enormous, which should be documented and conserved for its sustainable use. Botanical Survey of India has played a significant role and brought out innumerable publications in the form of Floras, Red Data Books, Check-lists, Status reports, scientific articles on medicinal, ethnobotanical, rare, endemic, threatened aspects of plants, etc. To provide an overview on the status of the floristic diversity and its conservation, the department initiated a serial publication entitled "Floristic Diversity and Conservation Strategies in India" The first three volumes of the publication were edited by Dr. P.K. Hajra, ex Director and late Dr. V. Mudgal, Additional Director. The fourth volume has been edited by Dr. N.P. Singh, ex Director and Dr. D.K. Singh, Joint Director, Botanical Survey of India. The present volume, fifth in the series, covers diversity in selected habitats and *in situ* and *ex situ* conservation. The volume deals with 21 chapters, like Biosphere Reserves, Botanic gardens, tissue culture, coastal regions, etc. A chapter is also on the role of herbarium in the conservation of floristic diversity. The views expressed in these articles are those of authors, and any suggestion in this regard will be welcomed.

The editors express their appreciation to all contributors for their sincere efforts and cooperation. They also express their thanks to the Publication unit, Botanical Survey of India, Kolkata for its help in various ways. They also thank Dr. D.K. Singh, Botanical Survey of India, Dehra Dun for his keen interest and valuable help in publication of this volume.

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It is hoped that the present volume will be of immense use to all who have interests in and concern about India's rich florsitic diversity

21 March, 2002

N.P. Singh
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PROTECTED AREA NETWORK

N.P. Singh
D.K. Singh

Protected areas are one of the most widely accepted and practical approaches to biodiversity conservation the world over. Today almost every country in the world has designated protected areas for a range of conservation objectives, such as maintenance of the integrity and diversity of ecosystems, protection of flora and fauna, protection of cultural heritage and unique landscape, etc. In addition to conservation objectives, the protected areas also have significant scientific, educational, cultural, recreational and spiritual value apart from the direct and indirect benefits they provide to local as well as national economies. As all the biological communities, populations, species, genes and the biogeochemical processes which support life are part of the ecosystems, it is imperative to devise effective means to protect them to achieve conservation objectives. The most effective way to conserve biodiversity, therefore, by almost any reckoning, is to check the depauperisation of natural habitats. No wonder, therefore, that the Convention on Biological Diversity recognised and reaffirmed the fundamental requirement of *in situ* conservation of ecosystems and natural habitats in its Article-8. These methods not only seek to protect representative array of ecosystems and their constituent biodiversity in different biogeographical regions by regulating human and other biotic activities, but also ensure natural growth, proliferation and perpetuation of species as part of their natural ecosystems.

The Convention on Biological Diversity defined a protected area as "a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives" (Miller *et al.*, 1995; Anon., 1997), while the *Global Biodiversity Strategy* (WRI/IUCN/UNEP, 1992) defines a protected area as "a legally established land or water area under either public or private ownership that is regulated and managed to achieve specific conservation goals". Whereas, the Fourth World Congress on National Parks and Protected Areas, held in Caracas, Venezuela in 1992 defined protected areas as "an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (IUCN, 1994a).

Normally all the protected areas meet the general guidelines contained in above definitions. In reality, however, the purposes for which different protected areas are established and managed differ greatly.

HISTORICAL PERSPECTIVE

The earliest attempts to abate the excessive use of resources by the human-beings dates back to the Egyptian period. The concept of "Wilderness preserves" for the natural perpetuation of its resident fauna and flora has been one of the few themes which have consistently gained the attention of conservationists over the millenniums. The Egyptian King, Ikhnaton was perhaps one of the first to designate a wilderness area more than 3000 years ago (Alison, 1981). The other such areas came into being through independent initiatives by Assyrian Kings in the 11th Century B.C.; Greek city states from the period of Xenophon (*ca* 300 B.C.) onward; the Chinese beginning with the reign of Hsiaohsuan, *ca* 100 B.C.; The Romans from 23 A.D.; The Mongol Kublai Khan; the Aztec Monezuma; the Inca Pachacuti and so on. Though the conservation perspectives of different societies varied considerably, yet the legal prohibitions enforced from time to time by more than 20 civilisations which appeared on this planet since the advent of man, some of which have already vanished long ago, broadly aimed to check the rate of biological resource consumption and environmental degradation (Alison, *l.c.*).

The earliest recorded conservation initiatives merely represented strongly worded statements of penalties in the event of causing damage to designated marsh-lands or cutting trees in a particular area. The earliest relevant law appears to have been put forth by the Pharaohs of Egypt, who were the first to issue hunting licences to regulate the hunting of waterfowls in congested marshes. Similar restrictions on hunting of animals were enforced by each of the known civilisations. The earliest law, for the protection of trees, was enacted around 1900 B.C. by the authors of *Sumero-Babylonian Lipit Ishtar Law*, which prescribed a fine of "half mina of silver" for cutting a tree.

The earliest recorded English conservation law was formulated by Ine around 700 A.D., whose *Wessex Law Code* prohibited burning down of forests or cutting down a tree "big enough to shelter thirty swine". While the Norman and Angevin Kings of England legislated through "Charters" and "Assizes" during 11th to 13th Century A.D., from the time of Edward I (1272-1307 A.D.) English conservation laws were enacted in the form of "Statutes" by the acts of parliament. During the period that followed, various statutes were promulgated, by the successive rulers of England, relating to environmental protection and hunting, which reached its zenith during the period of Queen Victoria who, between 1860-1890 A.D., spawned eight acts of Parliament dealing with hunting licences, prevention of poaching, protection of wild bird, wildfowl, sea bird, etc.

India, with its vast physical, ecological, biological, social, cultural and linguistic diversity, has a long tradition of conservation of nature and natural resources. Infact the ethos of conservation is ingrained in India's cultural heritage. The co-existence of people and nature in Asia as a whole is the result of a long history as the man occupied Asian region for several hundred thousand years, often playing key role in modifying the ecosystems which are considered to be natural today. The region witnessed some of the earliest domestication of plants and animals, development of some of the earliest cities and irrigation systems (Misra, 1994). A number of modern day protected areas surround the ruins of ancient civilisation, e.g. Ranthambore in India, Wilpattu in Sri Lanka, Angkor, Wat in Cambodia, etc. As the civilisations grew and waned, the people of different cultures adopted different ways to manage their resources to ensure sustainable benefits to their community. They evolved appropriate conservation and management approaches based on their culture, religion, ethics and traditions. The living examples of such traditional conservation measures include "Sacred groves" of India, "Community forests" of the Sherpas in Nepal, Hunting rituals in Myanmar, Thailand, Combodia and Indonesia and mythical and spiritual relations with plants and animals throughout the South and South East Asia (McNeely & Wachtel, 1991).

The protected areas have a long history in South and South-East Asia. The establishment of sacred areas as religious sanctuaries or hunting reserves meant for the royalties continued throughout the region. The first nature reserve in Indonesia was established by the King Srivijaya in 684 A.D. (Mishra, 1994). Babar, the first Moghul Emperor of India, apparently established a special reserve in flood-plains of Punjab for the hunting of rhinos (Gadgil, 1989). Similarly, Nepal's Royal Chitwan National Park, Java's Ujung Kulon and India's Ranthambore were first established as "Shikar" or hunting reserves.

MODERN CONCEPT OF PROTECTED AREAS

The Emperor Ashoka of India as long back as 252 B.C. passed an edict for the protection of fishes, birds, animals and forests. This appears to be the earliest documented instance of deliberate establishment of what we call today the protected areas (Saharia, 1981; Mackinnon *et al.*, 1986). However, the practice of designating religious sanctuaries or exclusive hunting reserves, as stated in preceeding paragraphs, is much older and the tradition still persists in many widely different societies. For example, King William I of England decreed for the preparation of "Doomsday book" in 1084 A.D. to inventory "all the lands, forests, fishing areas, agricultural areas, hunting preserves and productive resources of his kingdom" to help plan its management and development (Mackinnon *et al.*, 1986). The modern concept of conservation which is based on the premise of judicious resource utilisation is, therefore, a combination of these two ancient principles : necessity to plan the management of resources on the basis of inventories, and to take measures to ensure the protection of the resources.

The first "nature reserve" of the modern times was established by the French school of Barbizon which officially protected a part of "Fontainebleau forests" (Chowdhery & Hajra, 2000). However, the first ever national park of the world, the "Yellowstone National Park" was established on the 1st March, 1872 in western North America through a federal law promulgated by the United States of America. Spreading over an area of about two million acres, the park was established to preserve pristine wilderness of the region for the enjoyment and the benefit of the people (Seller, 1997). The key concept behind setting up the new national park was to totally exclude any resident human population from within the park area except of course the park staff (McNeely, 1994; McNeely *et al.*, 1994). The number of protected areas have since grown slowly but steadily, and today there are about 25,000 protected areas established across the world covering about five per cent of its total geographical area (McNeely *et al.*, 1994). Out of these, only 1470 are the National Parks on the pattern of Yellowstone, while the rest are variously designated (IUCN, 1990). Interestingly Australia alone has 45 different categories of protected areas. According to UN list of protected areas, however, there are only 9832 protected areas as of 1994, out of about 37000 recorded in WCMC database, covering more than 9.25 million sq. km or approximately 8.2 per cent of the global area (IUCN, 1994b; Miller *et al.*, 1995) because it includes only those areas which have an area of more then 10 sq. km and are managed by the "highest competent authority" of a country.

The classification

Based on the management objectives, the International Union for Conservation of Nature and Natural Resources (IUCN) and IUCN Commission on National Parks and Protected Areas (CNPPA) identified 10 categories of protected areas (IUCN, 1978) as presented in table I.

Table I
Categories and management objectives of protected areas
(source : IUCN, 1978)

Categories	Management objectives
Strict Nature Reserve/ Scientific Reserve	To protect nature and maintain natural process in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring, education and for the maintenance of the genetic resources in dynamic and evolutionary state.
National Park	To protect outstanding natural and scenic areas of national or international significance for scientific, educational and recreational use. According to 1969 IUCN definition, these are relatively large natural areas not materially altered by human occupation and exploitation, and where the highest competent authority of the country has ensured the prevention of extractive resource utilisation and occupation.

Categories	Management objectives
Natural Monument/Natural Landmark	To protect and preserve nationally significant natural features because of their special interest or unique characteristics. There are relatively small areas focused on protection of specific features.
Managed Nature Reserve/ Wildlife Sanctuary	To assure the natural conditions necessary to protect nationally significant species, groups of species, biotic communities, or physical features of environment where these may require specific human manipulation for their perpetuations.
Protected Landscapes and Seascapes	To maintain nationally significant natural landscapes or the seascape which are characteristic of the harmonious interaction of man and land while providing opportunities for public enjoyment through recreation and tourism within the normal lifestyle and economic activity of these areas. These are mixed cultural/natural landscapes of high scenic value where traditional landuse are maintained.
Resource Reserve	To protect the natural resoruces of the area for future use and prevent or contain development activities that could affect the resource pending the establishment of objectives which are based upon appropriate knowledge and planning.
Anthropological Reserve/ Natural Biotic Area	To allow the way of life of societies living in harmony with the environment to continue undisturbed by modern technology.
Multiple use Management area/Managed Resource Area	To provide for the sustained production of water, timber, wildlife, pasture and tourism, with the conservation of nature primarily oriented to the support of the economic activities.

Categories	Management objectives
Biosphere Reserve	To conserve for present and future use the diversity and integrity of biotic communities of plants and animals within natural ecosystems, and to safegaurd the genetic diversity of species on which their continuing evolution depends. These are internationally designated sites managed for research, education and training.
World Heritage Site	To protect the natural features for which the area is considered to be of outstanding universal significance. This is a select list of world's unique natural and cultural sites nominated by countries that are party to the World Heritage Convention.

The above mentioned IUCN categories of protected areas are based on a set of 12 broad objectives as given below to help management decisions (source : Miller, 1980).

Sample ecosystems : To maintain large areas as representative ecosystems in each of the bioregion of the nation in its natural, unaltered state to ensure continuous evolutionary and ecological processes including migration and gene flow.

Ecological diversity : To maintain representatives of different characteristics of each type of natural community, landscape and land form to protect representative as well as unique diversity of a nation.

Genetic resources : To maintain all genetic materials as elements of natural communities and avoid loss of species, both plants and animals.

Education and research : To provide facilities and opportunities in natural areas for purposes of education, research and monitoring of environment.

Water and soil conservation : To maintain and manage watersheds to ensure an adequate quality and flow of fresh water, and to control and avoid erosion and sedimentation.

Wildlife management : To maintain and manage wildlife resources, including fishery, for their vital role in environmental regulation, production of protein, and as the base for industrial, sport and recreational resources.

Recreation and tourism : To provide opportunities for healthy outdoor recreation for people, and to serve as nucleus for tourism development based on outstanding natural and cultural characteristics of the region.

Timber : To manage and improve timber resources for their role in environmental regulation, and to provide a sustainable production of wood products for the construction of housing and other uses of high nation priority.

Cultural heritage : To protect and make available all cultural, historic and archeological objects, structures and sites for public visit and research as elements of the cultural heritage of the nation

Scenic beauty : To protect and manage scenic resources which ensure the quality of environment near towns and cities, highways and rivers, and surrounding recreation and tourism areas.

Options for the future : To maintain and manage large tracts of land under flexible-landuse methods to conserve natural processes and ensure options for future changes in landuse, incorporate new technologies, meet new human requirements, and initiate new conservation practices.

Integrated development : To focus and organise conservation activities to support the integrated development of rural lands, giving particular attention to the conservation and utilisation of marginal areas and generation of stable rural employment opportunities.

The categories of protected areas were subsequently reviewed and reduced to eight, viz. Scientific Reserve/Strict Nature Reserve, National Park, Natural Monument/Natural Landmark, Managed Nature Reserve/Wildlife Sanctuary, Protected Landscape, Resource Reserve, Natural Biotic Area/Anthropological Reserve and Multiple-use Management Area/ Managed Resource Area. At present, however, the protected areas are grouped under six broad management categories (source : IUCN, 1994). These are :

Category I	Strict Nature Reserve/Wilderness Area : The areas managed mainly for science or wilderness protection.
Category Ia	Strict Nature Reserve : Area of land and or sea possessing some outstanding or representative ecosystems, geological or physical features and/ or species, available primarily for scientific research and/or environmental monitoring.
Category Ib	Wilderness Area : Large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation.
Category II	National Park : Protected areas managed mainly for ecosystem protection and recreation. These include natural area of land and/or sea, designated to (i) protect the ecological integrity of one or more ecosystems for present and future generations, (ii) exclude exploitation or occupation inimical to the purposes of designation of the area and (iii) provide a foundation for spiritual, scientific, educational, recreational opportunities, all of which must be environmentally and culturally compatible.
Category III	Natural Monument : Protected areas managed mainly for conservation of specific natural features. These include areas containing one, or more, specific natural or cultural feature which is of outstanding or unique value because of its inherent rarity, representative or aesthetic values or cultural significance.
Category IV	Habitat/Species Management Area : Protected areas managed mainly for conservation through management intervention. These include area

	of land and/or sea subjected to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.
Category V	Protected Landscape/Seascape : Protected areas managed for landscape/seascape conservation and recreation. Included are the area of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biodiversity. Protecting the integrity of such traditional interaction is vital to the protection, maintenance and evolution of such an area.
Category VI	Managed Resource Protected Area : Protected area managed mainly for the sustainable use of natural ecosystems. Included are the areas containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while at the same time providing sustainable flow of natural products and services to meet community needs.

Within these six broad categories, there are hundreds of country-specific designation of protected areas to meet various conservation/management objectives. The IUCN has been promoting the development of a global protected area system to ensure adequatic representation of all the biome types. Accordingly IUCN, in 1975, developed a biogeographical zone based system to assess the protected area coverage at global level (Udvardy, 1975) dividing the world in eight biogeographic realms, 14 major biomes and 193 biogeographic provinces.

International Conventions

In addition to the vast protected area systems, there are three international initiatives to designate natural sites of global and regional significance for special protection under national arrangement and classified under the IUCN system accordingly. International coordination of efforts is also necessary as the processes and patterns of biodiversity are independant of political, social and economic boundaries.

1. ***The Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention, 1971):*** Signed at Ramsar, Iran in 1971, the convention provides a framework of international cooperation for the protection of Wetland ecosystem, especially those designated to the list of Wetlands of International Importance. A wetland is identified as being of International importance if it meets any one of the following criteria, approved at the fourth meeting of the Conference of Contracting Parties, held at Montreux, Switzerland in 1990.

   A. ***Criteria for representative or Unique Wetlands :*** A wetland would be considered of being internationally important if :

      (a) it is a particularly good representative example of a natural or near-natural wetland characteristic of the appropriate biogeographcial region, or

      (b) it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region, or

      (c) it is a particularly good representative example of a wetland, which plays a substantial hydrological, biological or ecological role in the natural functioning of a major river basin or coastal system, especially when it is located in a trans-border position, or

      (d) it is an example of a specific type of wetland rare or unusual in the appropriate biogeographical region.

   B. ***General criteria based on plants or animals :*** A wetland would be considered of being internationally important if :

      (a) it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any type or more of these species, or

(b) it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna, or

(c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle, or

(d) it is of special value for one or more, endemic plant or animal species or communities.

C. ***Specific criteria based on waterfowl :*** A wetland would be considered of being internationally important if :

(a) it regularly supports 20,000 waterfowl, or

(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity, or

(c) where data on populations are available, it regularly supports one per cent of the individuals in a population of one species or subspecies of waterfowl.

Over 600 Ramsar sites have so far been listed in more than 80 countries (McNeely *et al.,* 1994). Following a recommendation at the fifth Meeting of Contracting Parties to the Convention, held at Kushiro, Japan in 1993, criteria and guidelines are being developed for identifying fish habitats for listing as wetlands of international importance.

2. ***The Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention, Paris, 1972).*** Adopted by the General Conference of UNESCO in 1972, the convention has been joined by 150 countries so far. The "Natural Heritage" designates outstanding physical, biological and geological features; habitats of threatened plant or animal species and areas of value on scientific or aesthetic grounds or from the point of view of conservation. Whereas, the "Cultureal heritage" could be a monument, group of buildings or site of historical, aesthetic, archaeological, scientific, ethnological or anthropological value. So far 690 cultural/natural sites have been protected worldwide as World Heritage (cultural/natural) Sites.

3. ***UNESCO Man and Biosphere (MAB) Programme :*** Though the establishment of Biosphere Reserves is not covered under any specific Convention, it is part of a global programme of international scientific cooperation, launched by UNESCO in 1976, which deals with man-biosphere interactions across the entire range of bioclimatic and geographic zones (Robertson-Vernhes, 1993), One of the central themes of the Man and Biosphere programme is the establishment of a global network of biosphere reserves to cover world's major ecosystems. By the year 2000 there were 391 biosphere reserves spreading across 94 countries.

Characteristic of Biosphere Reserves

(a) The biosphere reserves are protected area of land and/or coastal environment where the people are an integral part of the system.

(b) Biosphere reserves are representative examples of natural biomes, landscapes, ecosystems and genetic variations.

(c) Biosphere reserves are examples of harmonious landscapes resulting from traditional land-use patterns.

(d) Biosphere reserves have examples of modified or degraded ecosystems which could be restored to more natural conditions.

(e) Biosphere reserves generally have a non-manipulative core zone, surrounded by buffer zone and manipulation zone in which base line experimental and manipulative research, education and training is carried out.

(f) Biosphere reserves should be large enough to be an effective conservation unit, and to accommodate different uses without conflict.

(g) Biosphere reserves provide opportunity for monitoring, research, education and training on natural and managed ecosystems.

(h) As the biosphere reserves do not have adequate legal protection, in majority of cases they coincide with or incorporate existing protected areas, like national parks and wildlife sanctuaries, which have legal protection.

(i) The biosphere reserves exemplify voluntary cooperation to conserve and use resources for the well being of people at local, national, regional, and global levels.

(j) Biosphere reserves provide the platform to planners, scientists, managers and local people to join lands for integrated management and sustainable use of natural resources.

Functions of Biosphere Reserves

(a) *Conservation*

- (i) To ensure the conservation of landscapes, ecosystems, species and genetic variations within the species of plant, animals and microorganisms.
- (ii) To ensure the traditional resoruce use patterns.
- (iii) To understand the patterns and processes of functioning of ecosystems.
- (iv) To monitor the natural and man made changes on spatial and temporal scales.

(b) *Development*

- (i) To promote socially, culturally and ecologically sustainable economic development at local level.
- (ii) To develop strategies for improvement and management of natural resources.

(c) *Logistics*

- (i) To provide support for research, monitoring, education and information flow related to local, national and global issues of conservation and development.
- (ii) Sharing of knowledge generated by research through site specific training and education.
- (iii) Development of community spirit in the management of natural resources.

INDIAN SCENARIO

India, with an area of about 3.287 million sq. km and a coastline of over 7500 km, is the second largest country in Asia and seventh in the world. This great geographical expanse of the country, with its extra ordinary diversity of climate, soil and topography is co-terminus with almost all types of ecosystems found anywhere in the world. The diversity spans from the alpine grasslands of Himalayas to coastal mangroves of Sundarbans; from hot deserts of Rajasthan to tropical evergreen and semi evergreen forests of North-east and western ghats; from the freshwater lacustrine systems of Gangetic plains to coral reefs of Andaman sea; from the cold deserts of Ladakh and Lahaul-Spiti to tropical Islands ecosystems, and so on. In each of these ecozones there are hundreds of biotopes each supporting rich and characteristic floristic and faunistic components. The confluence of three major biogeographical realms, viz. Eurasian, Afro-tropical and Indo-Malayan in the Indian region has further enhanced these biological attributes by enabling the intermingling of floristic elements of these regions and making India one of the 12 megadiversity centres ranking third in Asia and eleventh in the world.

Floristic diversity

Owing to the above factors, India harbours over 45,000 species of plants amounting to about 11 per cent of world's flora in just over 2 per cent of latter's landmass. About 33 per cent of Angiosperms occurring in India or about 28 per cent of total Indian flora is endemic to the country (Sharma & Singh, 2001). Table-II presents a comparative account of species in major group of plants so far recorded from India and the world. The figures in the parenthesis represent the number of species considered endemic to the country.

The components of these living resources constitute the basic raw material, up on which our civilisation has laid its foundation, and the future growth and prosperity of our people is interlinked with the enlightened and sustainable use of these resources. Besides, the Indian subcontinent, known as the "Hindustan Centre" - of origin and diversity of crop plants (one of the twelve in the world), harbours about 167 species of domesticated agri-horticultural crop plants, and over 320 species of wild progenitors of these. This rich germplasm resource includes 51 species of cereals and millets, 109 of fruits, 27 spices and condiments, 54 vegetables, 31 pulses, 24 fibre crops, 12 species of oil seeds and various strains of wild tea, coffee, tobacco and sugarcane. These prized materials, together with their wild ancestral forms, serve as building blocks that are used by plant breeders for the development of improved varieties.

Table II
Number of species in different group of plants in India and the World.

Groups	No. of species			% World
	India		World	flora
Angiosperms	17,500	(5725)	2,50,000	7.0
Gymnosperms	48	(10)	650	7.4
Pteridophytes	1,200	(193)	10,000	12.0
Bryophytes	2850	(938)	14,500	19.7
Lichens	2021	(466)	13,500	15.0
Fungi	14,500	(3500)	70,000	20.7
Algae	6,500	(1924)	40,000	16.25
Virus/Bacteria	850		8,050	10.6
TOTAL	**45,469**	**(12756)**	**4,06,700**	**11.18**

The diversity in different group of plants in India presented in the above table, however, is not exhaustive as about 30 per cent of the Indian territory, including those in the Himalaya (both western and the eastern), the Western Ghats and the Andaman & Nicobar Islands, still remain to be floristically explored for the flowering plants alone. Whereas, for the lower group of plants, like Algae, Fungi, Lichens, Bryophytes and the microorganisms (Virus and Bacteria), the major part of our country still remains either unexplored or under-explored (Anon., 1999).

Loss of diversity

The rich floristic diversity in India not withstanding, about 1700 species of Indian flowering plants are threatened with extinction today.

This means about 7 per cent of 26,106 globally threatened species of plants are from India. During last 400 years while about 654 species have become extinct worldover (WCMC, 1992), the India has presumably lost about 17 species, like *Carex repanda, Cyclea debiliflora, Aphyllorchis gollanii, Vanda wightii, Eragrostis rottleri, Eriochrysis rangacharii, Wendlandia angustifolia, Neuracanthus neesianus, Pimpinella evoluta, Ilex gardneriana, Lastreospsis wattii, Sterculia khasiana,* etc. (Anon, 1999a), during the past two centuries. At the same time a number of other species could also not be relocated in their Indian haunts during last 50-100 years (Jain & Sastry, 1984; Nayar & Sastry, 1987, 1988, 1990).

The extinction of the species is a natural phenomenon. Seen on a geological time scale, species normally appear to be ephemerals. It is estimated that over 95 per cent of species that had ever existed on earth are no more present (Raup, 1991). It is rather interesting to note that eversince life appeared some 4000 million years ago (Wilson, 1988; Benton, 1955) the process of speciation has been interrupted by atleast five distinct periods of "mass extinctions" (Sepkoski, 1992). The most recent and the much talked-about of them all occurred about 65 million years ago towards the end of cretaceous which wiped out the dinosaurs from the face of the earth. But the newer, and perhaps more evolved, forms of life always succeeded these catastrophies. The extinction, infact, is regarded as part of the evolutionary process with each species being the potential ancestor of a new species. Extinctions, therefore, have considerable influence on the evolution of life on earth, as the disappearance of a species has invariably been compensated with the evolution of newer species in the past. What is important, therefore, is the comparative rate of extinction and speciation over a given period of time. The spanning gap between the two in the present time, however, is the cause of worldwide concern today. The current rate of species loss is estimated to be 1000-10,000 times higher than the average back-ground extinction rates (Myers, 1980; Reid & Miller, 1989; UNEP, 1995) which exceeds anything recorded during the past 65 million years (May *et al.*, 1995).

The reasons for this colossal loss of biodiversity are two folds, the natural and the man made. The natural causes responsible for threat to plant species include changes in the abiotic parameters in the environment, such as cyclones, long unfavourable weather spells, earthquakes, landslides, etc. and biotic parameters such as natural competition and biological imparities of the species. On the other hand, prominent among the man made causes are the loss or fragmentation of habitat due to wanton clearance of forests for various developmental activities, expansion of agriculture and aquaculture in prime forest lands and natural wetlands, over-exploitation of forest resources beyond the carrying capacity and without any consideration for its sustainability, and the introduction of alien species. And the genesis of the three is the exponential growth in both the human as well as the cattle population over the last century leading to the increasing gap in the demand and supply of the natural resources. The human population in India has grown over four times during the period 1901-2001, and today it represents about 17 per cent of the world's population. Similarly the cattle population in India today constitute about 18 per cent of that of the world. The resulting demand on the forest resources has lead to almost 80 per cent loss in the natural habitats (Mackinnon & Mackinnon, 1986, UNEP, 1995), including the degradation of water bodies. Apart from that, the advent of 'green revolution' in early 1960's, relying on handful of crop varieties has also led to enormous loss in agro-biodiversity of the country. While about 5000 land races of traditional rice varieties have been lost in the North-eastern region of the country alone (Jackson, 1994), many more are estimated to be extinct locally. For example, almost half of the traditionally grown varieties of rice and all of the land races of wheat in Himachal Pradesh have been lost during last few decades (Joshi & Rana, 1996). Similarly, availability of alternative modern sources of food, fibre, fuel, fodder and medicine have adversely affected their traditional sources which sustained the rural folk in not very distant past.

Conservation initiatives

The earliest record of conservation efforts, in any form, in India dates back to 4th century B.C. and is attributed to Kautilya who, in his *Arthashastra,* underlined the need for setting aside forested areas for not only protection of the wildlife, but also to provide the goods and services to the society (Rangarajan, 1992). Similarly, emperor Ashoka, in 252 B.C., laid down 'stone edicts' for the conservation of wildlife (Saharia, 1981; Mackinnon *et al.,* 1986). In fact, the conservation movement in India is as old as the history and cultural heritage of the country. Since the vedic periods, every form of life was loved, worshipped and even sheltered in the ashrams of sages (hermitage), thereby nurturing the philosophy of nature conservation (Jain & Sastry, 1981). Even the reverence shown by the people to the rivers and mountains kept them clean and intact. Setting aside of small patches of forests, the 'sacred groves', maintained by a system of rules and taboos is another expression of great Indian tradition of conservation of natural resources through socio-religious beliefs. The rapid politico-economic changes during the medieval period, however, considerably affected the socio-cultural values of life.

Apart from traditional conservation practices, the concerns for environmental protection and forest conservation is also ingrained in the constitution of India. The Articles 48-A and 51-A(G) of the Directive principles of State Policy in the constitution of India state that 'the state shall endeavour to protect and improve the environment and to safeguard the forests and wildlife in the country', and to protect and improve the national environment including forests, lakes, rivers and wildlife, and to have compassion for the living creatures'. Similar concerns were articulated at United Nations Conference on Human Environment held at Stockholm in 1972 which climaxed in the Convention on Biological Diversity (CBD), popularly known as the 'Earth Summit' at the UN conference on Environment and Development (UNCED) held at Rio de Janerio in June 1992. Keeping pace with the development at international level, India developed an effective organisational infrastructure and evolved legislative policies and programmes for protection of its environment. At the same time numerous policies, programmes and projects were initiated for the conservation and sustainable utilisation of our biological resources.

The major legislative and policy guidelines directly related to biodiversity conservation in India are :

(i) The Indian Forest Act, 1927

(ii) The Wildlife (Protection) Act, 1972

(iii) The Forest (Conservation) Act, 1980, and

(iv) The Environment (Protection) Act 1986.

Other important Central Acts with direct bearing on the components of biodiversity are :

Fisheries Act, 1897.

Livestock Import Act, 1898.

Destructive Insects and Pests Act 1914.

The Indian Forest Act, 1927.

Agricultural Produce (Grading and Marketing) Act, 1937.

Indian Coffee Act, 1942.

Import and Export (Control) Act, 1947.

Rubber (Production and Marketing) Act, 1947.

Tea Act, 1953.

Prevention of Cruelty to Animals Act, 1960.

Customs Act, 1962.

Cardamon Act, 1965.

Seeds Act, 1966.

Wildlife (Protection) Act, 1972 and Wildlife. (Protection) Amendment Act, 1991.

Marine Products Export Development Authority Act, 1972.

Water (Prevention and Control of Pollution) Act, 1974.

Tobacco Board Act, 1975.

Territorial Water, Continental Shelf, Exclusive Economic Zone and other

Maritime Zones Act, 1976.

Water (Prevention and Control of Pollution Cess Act, 1977.

Coconut Development Board Act, 1979.

Maritime Zones of India (Regulation and Fishing by Foreign Vessels) Act, 1980.

Forest (Conservation) Act, 1980.

Air (Prevention and Control of Pollution) Act, 1981.

National Oilseeds and Vegetable Oils Development Board, 1983.

Agricultural and Processed Food Products Export Development Authority Act, 1985/1986.

Environment (Protection) Act, 1986.

Spices Board Act, 1986.

National Dairy Development Board, 1987.

New Seed Development Policy, 1988.

Foreign Trade (Development and Regulation) Act, 1992.

The above central Acts are supported by a number of State legislations concerning the management of various physical as well as biological components of the environment. The constitution of Indian Board for Wildlife (IBWL) in 1952 and the enactment of Wildlife (Protection) Act in 1972, however, are the major landmarks in the country's long history of conservation efforts providing the legal framework for the establishment of national parks and wildlife sanctuaries including the issues related to exploitation and trade in wildlife species, or derivatives thereof.

Recently, through the addition of 11th and 12th Schedules to the constitution of India, by way of 73rd and 74th Amendment Acts of 1992, the function of environmental protection and conservation have been vested with the panchayats and local bodies respectively.

To further augment the national conservation efforts, India has also become an active party to various International Conventions relevant to biodiversity and environment. These are : Convention on Wetlands of International Importance especially as waterfowl Habitat (Ramsar Convention), 1971; Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973; Convention concerning the Protection of World Cultural and Natural Heritage (World Heritage Convention), 1972; Convention on Conservation of Migratory Species of Wild Animals (Bonn Convention), 1979; Convention on Conservation of Antarctic Marine Living Resources (CCAMLR), 1980; UN Convention on Law of the Sea (UNCLOS), 1982 ; International Tropical Timber Agreement, 1983; Montreal Protocol on Substances that Deplete the Ozone Layer, 1987; Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal, 1989; Convention on Biological Diversity (CBD), 1992; Framework Convention on Climate change (Kyoto Protocol), 1992; Convention on Desertification, 1994. And to meet its obligation under these conventions, India has intensified its efforts for biodiversity conservation and sustainable utilisation through formulation of several strategies, like the National Wildlife Action Plan (1973), National Forest Policy (1988), National Conservation Strategy and Policy Statement on Environment and Sustainable Development (1992), and Environmental Action Plan (1993).

Apart from that, the Ministry of Environment and Forests, the nodal ministry of the Government of India concerned with biodiversity conservation, closely cooperates with various agencies dealing with environmental issues, like United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), South Asia Co-operative Environment Programme (SACEP), and International Centre for Integrated Mountain Development (ICIMOD). Besides, while India is the state member of the International Union for the Conservation of Nature and Natural Resources (IUCN), various Government and Non-Governmental Organisations are also members of its different Commissions and Specialist Groups and contribute towards the conservation and sustainable utilisation of the components of biodiversity.

Protected area systems

The National Wildlife Action Plan (1993) recognised the need for establishing a network of protected areas (PA) in representative ecosystems in different biogeographic regions of the country. The Action Plan also emphasised the need for developing appropriate management system for these PAs keeping into the account the aspirations of the local people to enlist their support and participation. But much before the formulation of this Action Plan, the first ever Wildlife preserve in India the Banjar Valley (Presently the Kanha National Park) was established in the year 1900. This was followed by the establishment of Kaziranga and Orang Wildlife Sanctuaries in Assam in 1908 and 1915 respectively. The first National Park of the country, the Hailey National Park, came up in 1935, which was later changed to Ramganga National Park and finally named as Corbett National Park. By 1930's the protected areas in India got the recognition as separate landuse category. During the period 1931-41, 18 more wildlife sanctuaries were established, of which mention may be made of Muddumalai in Tamil Nadu, Bandipur in Karnataka, Pabha in Assam and Jaldapara in West Bengal. With the establishment of Indian Board for Wildlife (IBWL) in 1952 the conservation drive gained further boost and momentum. At the time of first World Conference on National Parks, held at Washington in 1962, India already had 5 national parks and 100 wildlife sanctuaries (Jain & Sastry, 1981).

For effective *in situ* conservation of its biological resources, which of course is the best option to ensure natural growth, proliferation and perpetuation of species as part of their natural ecosystems, and also to fulfil its commitment to convention on Biological Diversity under Article, 8, India today has an elaborate network of 578 protected areas (Table III-V) covering an area of approximately 1,55,508.54 sq. km or 4.73 per cent of the country's total geographical area (Rodgers *et al.*, 2002).

Table III
Distribution of Protected Areas in different Biogeographic zones/Biotic provinces (after Rodgers *et al.*, 2002)

Sl. No.	Biogeographic Zone (code)	Biotic Province (code)	No. of N.Ps.	No. of WLS	Total
(1)	(2)	(3)	(4)	(5)	(6)
1.	Trans Himalaya (01)	1A	2	1	3
		1B	1	3	4
2.	Himalaya (02)	2A	4	25	29
		2B	4	14	18
		2C	2	6	8
		2D	2	11	13
3.	Desert (03)	3A	1	1	2
		3B	0	4	4
4.	Semi-Arid (04)	4A	2	30	32
		4B	6	50	56
5.	Western Ghats (05)	5A	3	11	14
		5B	10	32	42

(1)	(2)	(3)	(4)	(5)	(6)
6.	Deccan Peninsula (06)	6A	9	27	36
		6B	2	25	27
		6C	2	11	13
		6D	6	32	38
		6E	3	24	27
7.	Gangetic Plain (07)	7A	3	17	20
		7B	3	15	18
8.	Coasts (08)	8A	1	4	5
		8B	3	17	20
		8C	0	1	1
9.	North-East (09)	9A	5	15	20
		9B	6	17	23
10.	Islands (10)	10A	8	92	100
		10B	1	4	5
	TOTAL		89	489	578

1A: Ladakh; 1B: Tibetan Plateau; 2A: N.W. Himalaya; 2B: West Himalayá; 2C: Central Himalaya; 2D: East Himalaya; 3A: Thar; 3B: Kutch; 4A: Punjab Plains; 4B: Gujarat Rajputana; 5A: Malabar Plains; 5B Western Ghat mountains; 6A : Central Highlands; 6B : Chhota Nagpur; 6C: Eastern Highlands; 6D: Central Plateau; 6E: Deccan South; 7A: Upper Gangetic Plain; 7B: Lower Gangetic Plain, 8A: West Coast; 8B: East Coast; 8C: Lakshadweep; 9A: Brahmaputra Valley; 9B: North-East Hills; 10A: Andaman; 10B: Nicobars.

Rodgers *et al.* (l.c.) also recommends to further increase the area under protected area to 1,88,764 sq. km or 5.74 per cent of the total geographical area of the country. This, however, would still fall short of the stated goal of bringing a minimum of 9 per cent of the country's geographical area under protected area net work (PAN).

Sikkim, with about 28.88 per cent of its total area under protected area network, is the best covered state followed by Goa (20.39 per cent), Andaman & Nicobar (15.43 per cent), Himachal Pradesh (12.93 per cent), Uttaranchal (12.10 per cent), Arunachal Pradesh (11.82 per cent) and so on. Punjab, with just 0.63 per cent of its area under the PAN, is the least covered state. The Union Territories of Lakshadweep and Pondichery altogether lack in protected areas.

Of the 10 categories of protected areas designated by IUCN (IUCN, 1978; Bainbridge, 1984) India has only four, viz., the National Parks, The Wildlife Sanctuaries, the Biosphere Reserves and the World Heritage Sites. The Category of Managed Resource Areas have not been so formally designated as yet in the country.

National Parks : At present there are 89 National Parks, covering an area of about 37,534.01 sq. km, or 1.14 per cent of the country's geographical area, spread across different biogeographic zones of the country (Table III-V). Madhya Pradesh has the maximum number of 9 National Parks, whereas Sikkim, with 25.14 per cent of its area under the National Park, has the best coverage. On the other hand there are no National Parks in Punjab, Tripura and Delhi (Rodgers *et al.*, 2002). According to stipulation made under the Wildlife (Protection) Act, 1972 .... "No person shall destroy, exploit or remove any wildlife from a National Park or destroy or damage the habitat of any wild animal or deprive any wild animal of its habitat within such National Park except under and in accordance with a permit granted by the Chief Wild Life Warden and no such permit shall be granted unless the State Government, being satisfied that such destruction, exploitation or removal of wild life from the National Park is necessary for the improvement and better management of wild life therein, authorises the issue of such permits" [Section 35(6)]. Further ... "No grazing of any livestock shall be permitted in a National Park and no cattle shall be allowed to enter therein except where such livestock is used as a vehicle by a person authorised to enter such National Park" [Section 35(7)]. To provide more adequate coverage to biological diversity it is suggested to increase the number of National Parks to 163, covering 54,789.24 sq. km or 1.67 per cent of the total area of the country (Rodgers *et al.*, 2002).

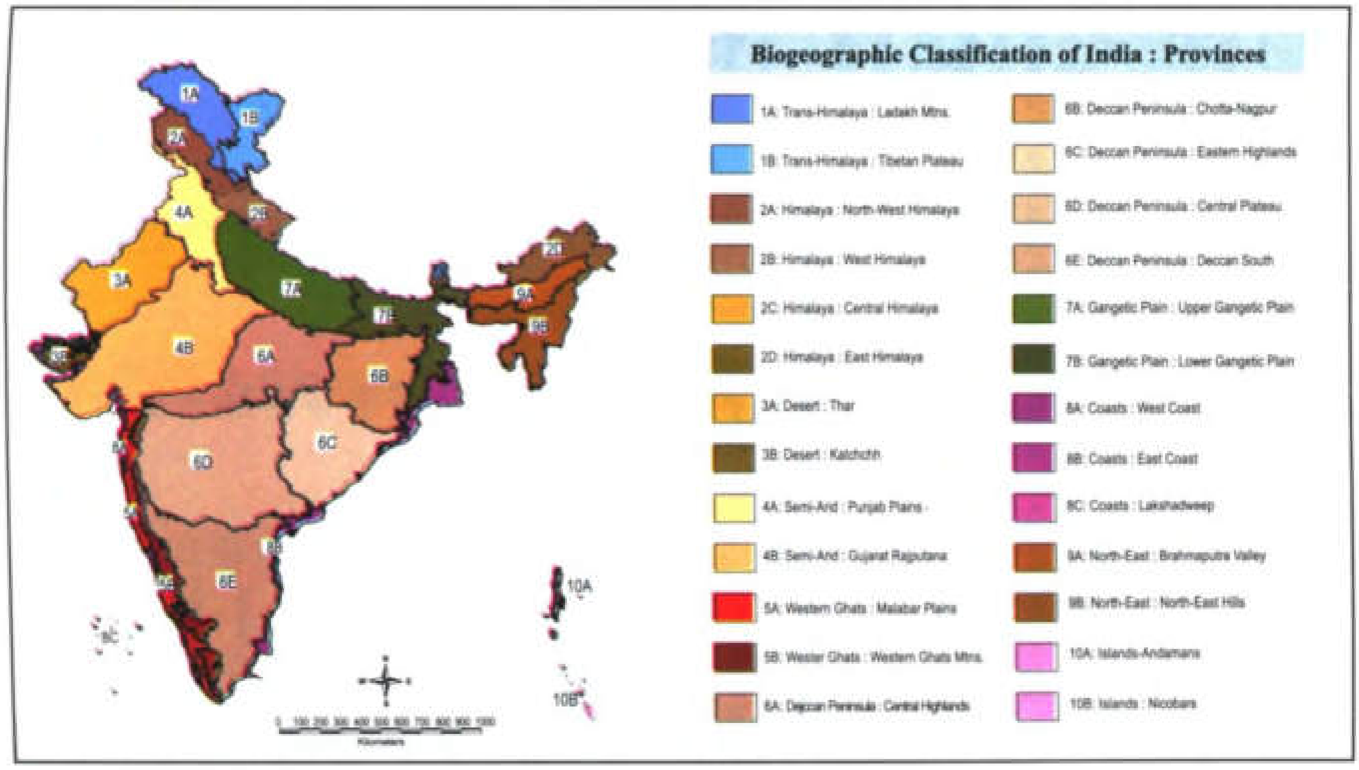
Wildlife Sanctuaries : There are 489 Wild Life Sanctuaries in India at present covering 1,17,974.53 sq. km or 3.59 per cent of total geographical area of the country (Table III-V). The Andaman & Nicobar has the maximum of 96 Wildlife Sanctuaries, whereas Chandigarh with 22.30 per cent of its total area under WLS is interestingly the best covered territory. Rodgers *et al., (l.c.)* have recommended to increase the number of Wild life Sanctuaries in India to 707 to

Table IV
Statewise distribution of protected areas in India
(source : Rodgers *et al.*, 2002)

State/UT		National Parks		Wildlife Sanctuaries		Total	
		No.	Area	No.	Area	No.	Area
1.	Andhra Pradesh	4	373.23	21	12530.08	25	12903.31
2.	Arunachal Pradesh	2	2290.82	11	7606.73	13	9897.55
3.	Assam	5	1968.60	15	883.15	20	2851.75
4.	Bihar	1	335.65	11	2949.67	12	3285.32
5.	Chattisgarh	3	2929.50	10	3419.46	13	6348.96
6.	Goa	1	107.00	6	647.96	7	754.96
7.	Gujrat	4	479.67	21	16422.71	25	16902.38
8.	Haryana	1	1.43	7	162.73	8	164.16
9.	Himachal Pradesh	2	1429.40	32	5770.85	34	7200.25
10.	Jammu & Kashmir	4	4650.07	15	10220.15	19	14870.22
11.	Jharkhand	1	231.67	10	1863.83	11	2095.50
12.	Karnataka	5	2472.18	21	4240.44	26	6712.62
13.	Kerala	3	536.52	12	2143.36	15	2679.88

State/UT	National Parks		Wildlife Sanctuaries		Total	
	No.	Area	No.	Area	No.	Area
14. Madhya Pradesh	9	3656.36	25	7198.19	34	10854.55
15. Maharashtra	5	955.93	35	14747.84	40	15703.77
16. Manipur	1	40.00	3	393.35	4	433.35
17. Meghalaya	2	267.48	3	34.20	5	301.68
18. Mizoram	2	250.00	4	831.00	6	1081.00
19. Nagaland	1	202.02	3	20.34	4	222.36
20. Orissa	2	990.70	18	7115.89	20	8106.59
21. Punjab	0	00.00	10	316.73	10	316.73
22. Rajasthan	4	3856.53	24	5712.63	28	9569.16
23. Sikkim	1	1784.00	5	317.34	6	2101.34
24. Tamil Nadu	5	307.84	19	2539.82	24	2847.66
25. Tripura	0	00.00	4	602.77	4	602.77
26. Uttaranchal	6	4077.00	6	2389.52	12	6466.54
27. Uttar Pradesh	1	490.00	23	5333.47	24	5823.47
28. West Bengal	5	1693.25	15	1055.23	20	2748.48

State/UT	National Parks		Wildlife Sanctuaries		Total	
	No.	Area	No.	Area	No.	Area
29. Andaman & Nicobar	9	1157.14	96	372.13	105	1529.27
30. Chandigarh	0	00.00	1	25.42	1	25.42
31. Dadra Nagar Haveli	0	00.00	1	92.16	1	92.16
33. Daman & Diu	0	00.00	1	2.18	1	2.18
34. Delhi	0	00.00	1	13.20	1	13.20
32. Lakshadweep	0	00.00	0	00.00	0	00.00
35. Pondicherry	0	00.00	0	00.00	0	00.00
Total	**89**	**37534.01**	**489**	**1,17,974.53**	**578**	**1,55,508.54**



Map : Biogeographic Provinces of India (source : Rodgers *et al.*, 2002) cover, 1,33,975.11 sq. km or 4.07 per cent of the total area of the country. The Wildlife (Protection) Act, 1972 stipulates that ... "No person shall hunt any wild animal or remove thereform any wild animal alive or dead, or any trophy, uncured trophy and meat derived from such animal provided that the Chief Wild Life Warden is satisfied that it is necessary that any wild animal in the sanctuary should be hunted or removed (a) for the better protection of wild life or (b) for any other good or sufficient reason, he may, with the previous approval of State Government, grant a permit authorising any person to hunt or remove such wild animal under the direction of an officer authorised by him or cause it to be hunted or removed" [Section 29(1)]. Regulated grazing and movement of livestock, and management intervention are permitted in a Wildlife Sanctuary under the Act.

Table V
Statewise list of National Parks and Wildlife Sanctuaries in India
(source : Mathur, 2000; Rodgers *et al.*, 2002).

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Andaman & Nicobar			
National Parks			
Campbell Bay	10A	1992	429.23
Galathea	10A	1992	110.00
Mahatma Gandhi Marine	10A	1983	281.50
Middle Button Island	10A	1987	0.64
Mount Harriett	10A	1987	46.62
Rani Jhansi Marine	10A	1966	256.14
North Button Island	10A	1987	0.44
Saddle peak	10A	1987	32.54
South Button Island	10A	1987	0.03
Wildlife Sanctuaries			
Aerial Islands	10A	1987	0.05
Bamboo Island	10A	1987	0.05
Barren Island	10A	1987	8.10
Battimalv Island	10B	1987	2.23

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Belle Island	10A	1987	0.08
Bennett Island	10A	1987	3.46
Bingham Island	10A	1987	0.08
Blister Island	10A	1987	0.26
Bluff Island	10A	1987	1.14
Bondoville Island	10A	1987	2.55
Brush Island	10A	1987	0.23
Buchanan Island	10A	1987	9.33
Chanel Island	10A	1987	0.13
Cinque Islands	10A	1987	9.51
Clyde Island	10A	1987	0.54
Cone Island	10A	1987	0.65
Curlew (B.P.) Island	10A	1987	0.16
Curlew Island	10A	1987	0.03
Cuthbert Bay	10A	--	--
Defence Island	10A	1987	10.49
Dot Island	10A	1987	0.13
Dottrell Island	10A	1987	0.13
Duncan Island	10A	1987	0.73
East Island	10A	1987	6.11
East of Inglis Island	10A	1987	3.55
Egg Island	10A	1987	0.05
Elat Island	10A	1987	9.36
Entrance Island	10A	1987	0.96
Galthea Bay	10B	1987	0.00
Gander Island	10A	1987	0.05
Girjan Island	10A	1987	0.16
Goose Island	10A	1987	0.01
Hump Island	10A	1987	0.47
Interview Island	10A	1987	133.87
James Island	10A	1987	2.10
Jungle Island	10A	1987	0.52

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Kwangtung Island	10A	1987	0.57
Kyd Island	10A	1987	8.00
Landfall Island	10A	1987	29.48
Latouche Island	10A	1987	0.96
Lohabarrack (Saltwater Crocodile)	10A	1987	22.21
Mangrove Island	10A	1987	0.39
Mask Island	10A	1987	0.78
Mayo Island	10A	1987	0.10
Megapode Island	10B	1987	0.12
Montogemery Island	10A	1987	0.21
Narcondam Island	10A	1987	6.81
North Brother Island	10A	1987	0.75
North Island	10A	1987	0.49
North Reef Island	10A	1987	3.48
Oliver Island	10A	1987	0.16
Orchid Island	10A	1987	0.10
Ox Island	10A	1987	0.13
Oyster Island -I	10A	1987	0.08
Oyster Island -II	10A	1987	0.21
Paget Island	10A	1987	7.36
Parkinson Island	10A	1987	0.34
Passage Island	10A	1987	0.62
Patric Island	10A	1987	0.13
Peacock Island	10A	1987	0.62
Pitman Island	10A	1987	1.37
Point Island	10A	1987	3.07
Potanma Islands	10A	1987	0.16
Ranger Island	10A	1987	4.26
Reef Island	10A	1987	1.74
Roper Island	10A	1987	1.46
Ross Island	10A	1987	1.01

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Rowe Island	10A	1987	0.01
Sandy Island	10A	1987	1.58
Sea Serpent Island	10A	1987	0.78
Shark Island	10A	1987	0.60
Shearme Island	10A	1987	7.85
Sir Hugh Rose Island	10A	1987	1.06
Sisters Island	10A	1987	0.36
Snake Island -I	10A	1987	0.73
Snake Island -II	10A	1987	0.03
South Brother Island	10A	1987	1.24
South Reef Island	10A	1987	1.17
South Sentinel Island	10A	1987	1.61
Spike Island -I	10A	1987	0.42
Spike Island -II	10A	1987	11.70
Stoat Island	10A	1987	0.44
Surat Island	10A	1987	0.31
Swamp Island	10A	1987	4.09
Table (Delgamo) Island	10A	1987	2.29
Table (Excelsior) Island	10A	1987	1.69
Talabaicha Island	10A	1987	3.21
Temple Island	10A	1987	1.04
Tillongchang Island	10B	1987	16.83
Tree Island	10A	1987	0.03
Trilby Island	10A	1987	0.96
Tuft Island	10A	1987	0.29
Turtle Islands	10A	1987	0.39
West Island	10A	1987	6.40
Wharf Island	10A	1987	0.11
White Cliff Island	10A	1987	0.47
			1,529.27

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Andhra pradesh			
National Parks			
Kasu Brahmananda Reddy	06D	19.03.94	1.42
Mahaveer Harina Vanasthali	06D	05.10.94	14.59
Mrugavani	06D	05.10.94	3.60
Sri Venkateswara	06E	16.10.89	353.62
Wildlife Sanctuaries			
Coringa	08B	05.07.78	235.70
Eturnangaram	06D	11.10.73	806.15
Gundla Brahmeswaram	06E	18.09.90	1194.00
Kaundinya	06E	18.12.90	357.60
Kawal	06D	18.11.65	893.00
Kinnersani	06D	24.02.77	656.00
Kolleru	06D	11.09.63	673.00
Krishana	08B	26.0689	194.80
Lanja Madugu Sivaram	06D	20.05.78	36.29
Manjira	06D	20.05.75	20.00
Nagarjunsagar-Srisailam	06D	05.07.78	3568.09
Nellapattu	06E	25.09.76	4.40
Pakhal	06D	04/03.52	879.30
Papikonda	06D	05.07.78	591.00
Pocharam	06D	20.03.52	130.00
Pranahita	06D	18.03.80	136.02
Pulicat Lake	08B	20.09.76	500.00
Rollapadu	06E	23.04.88	6.14
Sri Lankamalleswaram	06E	15.10.88	464.42
Sri Penusila Narasimha	06E	20.09.76	1030.85
Sri Vankateswara	06E	02.09.85	153.32
			12,903.31

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Arunachal pradesh			
National Parks			
Moluling	02D	13.12.86	483.00
Namdapha	02D	12.05.83	1807.82
Wildlife Sanctuaries			
D'Ering Memorial (Lali)	02D	23.08.78	190.00
Dibang	02D	26.11.91	4149.00
Eagle nest	02D	18.10.89	217.00
Itanagar	02D	14.06.78	140.30
Kamlang	02D	18.10.89	783.00
Kane	02D	17.09.91	55.00
Mehao	02D	15.12.80	281.50
Pakhui	02D	28.03.77	861.95
Sessa Orchid	02D	18.10.89	100.00
Tale Valley	02D	14.07.95	337.00
Yordi Robe-Supse	02D	2001	491.62
			9,897.19
Assam			
National Parks			
Dibru-saikhowa	09A	05.03.99	340.00
Kaziranga	09A	11.02.74	849.79
Manas	09A	07.09.90	500.00
Nameri	09A	06.09.74	200.00
Orang	09A	08.04.99	78.81
Wildlife Sanctuaries			
Bardoibum-Beelmukh	09A	03.07.96	11.25
Barnodi	09A	22.08.80	26.22
Burachapori	09A	11.07.95	44.06
Chakrasila	09A	14.07.94	45.56
Dipar beel	09A	12.01.89	4.14

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
East Karbi Anglong	09A	2001	221.81
Garampani	09A	05.03.99	6.05
Gibbon	09A	30.07.97	20.98
Karbi Anglong	09A	2001	96.00
Laokhowa	09A	10.07.52	70.13
Nambor	09A	2001	37.00
Pabitora		13.08.98	38.81
Padumani-Bherjan-Borjan		13.10.99	7.21
Panidihing		18.08.99	33.93
Sonai-Rupai		12.10.98	220.00
			2,851.75
Bihar			
National Parks			
Valmiki	07B	02.08.89	335.65
Wildlife Sanctuaries			
Barela Salim Ali Zubba Saheni	06B	28.01.97	1.96
Bhimbandh	06B	27.05.76	681.99
Gautam Budha	06B	14.09.76	259.50
Kanwarjheel	07B	20.06.89	63.11
Kaimur	06A	10.08.82	1342.00
Nagi Dam	06B	14.07.87	7.91
Nakti Dam	06B	15.07.87	3.32
Rajgir	06B	25.05.78	35.84
Udaipur	07B	05.05.78	8.87
Valmiki	07B	04.05.78	544.67
Vikramshila (Gangetic Dolphin)	07B	28.08.90	0.50
			3,285.32
Chandigarh			
Sukhna lake	04A	1986	25.42
			25.42

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Chattishgarh			
National Parks			
Indravati	06C	12.05.81	1258.37
Kangerghati	06C	22.07.82	200.00
Sanjay	06A	23.09.81	1471.13
Wildlife Sanctuaries			
Achanakamar	06A	28.06.75	551.55
Badalkhol	06B	28.08.75	104.45
Barnawapara	06C	21.07.76	244.66
Bhairamgarh	06A	11.03.83	138.95
Gomardha	06C	30.07.75	277.91
Pamed	06C	15.10.85	262.12
Semarsot	06B	20.02.78	430.35
Sitanadi	06C	01.11.74	553.36
Tamorpingla	06B	20.02.78	608.51
Udanti (Wild Buffalo)	06C	09.03.83	247.60
			6,348.96
Dadra & Nagar Haweli			
Wildlife Sanctuaries			
Dadra & Nagar Haveli	05B	2001	92.16
			92.16
Delhi			
Wildlife Sanctuaries			
Indira Priyadarshini (Asola)	04A	1992	13.20
			13.20
Daman & Diu			
Wildlife Sanctuaries			
Fudam	05A	---	2.18
			2.18

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Goa			
National Parks			
Bhagwan Mahavir (Mollem)	05B	13.04.78	107.00
Wildlife Sanctuaries			
Bondla	05A	23.03.69	8.00
Chorao Island (Dr. Salim Ali)	08A	1988	1.78
Cotigaon	05A	18.01.69	85.65
Madei	05B	31.05.99	208.48
Mollem	05B	28.12.67	133.00
Netravali	05B	03.06.99	211.05
			754.96
Gujarat			
National Parks			
Bansda	05A	09.04.79	23.99
Gir	04B	21.05.75	258.71
Marine (Gulf of Kachchh)	08A	21.05.75	162.89
Velavadar (Blackbuck)	04B	21.07.76	34.08
Wildlife Sanctuaries			
Balaram Ambaji	04B	07.08.89	542.08
Barda	04B	12.02.79	192.31
Gaga (Great Indian Bustard)	04B	24.11.88	3.33
Gir	04B	18.09.65	1153.42
Hingolgarh Nature Education	04B	29.08.80	6.54
Jessore	04B	06.05.78	180.66
Jumbogodha	04B	22.05.90	130.38
Kachchh Bustard (Lala Great Indian Bustard)	03B	04.07.92	2.03
Kachchh Desert	03B	28.02.86	7506.22
Khijadiya	04B	27.05.81	6.05
Marine (Gulf of Kachchh)	08A	12.08.80	295.03

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Nal Sarovar	04B	08.04.69	120.82
Narayan Sarovar	03B	14.04.81	444.23
Paniya	04B	16.06.89	39.63
Porbandar Lake	04B	03.11.88	0.09
Purna	05B	21.07.90	160.84
Rampura Vidi	04B	18.11.88	15.01
Ratanmahal	04B	19.03.82	55.65
Shoolpaneswar (Dhumkhal)	04B	20.09.82	607.70
Thol Lake	04B	18.11.88	6.99
Wild Ass	04B	12.01.73	4953.70
			16,902.38
Haryana			
National Parks			
Sultanpur	04A	13.07.98	1.43
Wildlife Sanctuaries			
Bhindawas	04A	07.05.86	4.12
Bir Bara Ban	04A	20.12.91	4.19
Bir Shikargarh	04A	29.05.87	6.67
Kalesar	04A	18.12.92	100.28
Khaparwas	04A	27.03.91	0.83
Nahar	04A	30.01.87	2.11
Saraswati Plantation	04A	29.07.88	44.53
			164.16
Himachal pradesh			
National Parks			
Great Himalayan	02A	01.03.84	754.40
Pin Vallwy	01A	09.01.87	675.00
Wildlife Sanctuaries			
Bandli	02A	27.0374	41.32
Chail	02B	21.03.76	108.54

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Churdhar	02B	15.11.85	56.15
Daranghati	02B	27.03.74	167.00
Darlaghat	02B	27.03.74	140.00
Dhauladhar	04A	14.12.94	943.98
Gamgul Siahbehi	02A	27.03.74	108.85
Gobind Sagar	04A	27.03.75	100.34
Kais	02A	26.02.54	14.19
Kalatop-Khajjair	02A	05.12.62	61.00
Kanawar	02A	01.07.49	61.00
Khokhan	02A	26.02.54	14.05
Kibber	01B	25.04.92	1400.50
Kugti	02A	19.09.62	378.86
Lippa Asrang	02A	19.09.62	40.00
Majathal	02A	27.03.74	40.00
Manali	02A	26.02.54	31.80
Naina Devi	04A	05.12.62	123.00
Nargu	02A	27.03.74	278.37
Pong Lake	04A	01.06.83	307.29
Renuka	04A	22.07.64	4.02
Rupi Bhaba	02A	28.03.82	267.00
Sainj	02A	22.02.94	90.00
Sangla (Raksham Chitkul)	02B	31.05.89	650.00
Sechu Tuan Nala	02A	27.03.74	102.95
Shikari Devi	02A	27.03.74	72.00
Shilli	02B	27.03.74	2.13
Shimla Water Catchment	02B	29.07.58	10.25
Simbalbara	04A	08.02.58	19.03
Talra	02B	19.09.62	26.00
Tirthan	02A	17.06.76	61.12
Tundah	02A	17.09.75	64.22
			7,214.36

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Jammu & Kashmir			
National Parks			
City Forest	02A	1992	9.07
Dachigam	02A	04.02.81	141.00
Hemis	01A	04.02.81	4100.00
Kishtwar	02A	04.02.81	400.00
Wildlife Sanctuaries			
Baltal-Thajwas	02A	1987	210.50
Changthang	01B	19.03.87	4000.00
Gulmarg	02A	1987	180.00
Hirapora	02A	1987	114.50
Hokersar	02A	1992	13.75
Jasrota	04A	1987	10.04
Karakoram	01A	19.03.87	5000.00
Lachipora	02A	1987	93.50
Limber	02A	1987	43.75
Nandini	04A	1981	13.50
Overa	02A	1981	32.00
Overa-Aru	02A	1987	425.00
Ramnagar Rakha	04A	1981	12.75
Surinsar Mansar	04A	1981	39.13
Trikuta	04A	1981	31.73
			14,870.22
Jharkhand			
National Parks			
Betla	06B	10.09.86	231.67
Wildlife Sanctuaries			
Dalma	06B	10.07.76	193.22
Hazaribagh	06B	24.05.76	186.25
Koderma	06B	25.01.85	177.95

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Lawalong	06B	07.08.78	207.00
Mahauaduar	06B	23.06.76	63.25
Palamu	06B	17.07.76	794.33
Palkot	06B	23.03.90	183.18
Parasnath	06B	21.08.84	49.33
Topchanchi	06B	03.06.78	8.75
Udhwa Lake	06B	1991	0.57
			2,095.50
Karnataka			
National Parks			
Anshi	05B	02.09.87	250.00
Bandipur	05B	05.06.74	874.20
Bannerghatta	06E	25.09.74	104.27
Kudremukh	05A	02.09.87	600.32
Nagarahole	05B	1988	643.39
Wildlife Sanctuaries			
Adichunchunagiri	06E	21.10.81	0.84
Arabithittu	06E	03.04.85	13.50
Attiveri	05B	2001	2.23
Bhadra	05B	25.09.74	492.46
Biligiri Rangaswamy Temple	05B	14.01.87	539.52
Brahmagiri	05B	05.06.75	181.29
Cauvery	06E	14.01.87	510.51
Dandeli	05B	01.09.87	843.16
Doraji Bear	06E	1992	55.87
Ghataprabha	06E	17.06.74	29.78
Gudavi	05B	10.07.89	0.73
Melkote Temple	06E	17.06.74	49.82
Mookambika	05B	16.06.74	247.00

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Nugu	06E	17.06.74	30.32
Pushpagiri	05B	02.09.87	102.92
Ranebennur (Blackbuck)	06E	17.06.74	119.00
Ranganathittu	06E	01.07.40	0.67
Sharavathi Valley	05A	27.06.74	431.23
Shettihally	05B	23.11.74	395.60
Someshwara	05A	05.06.74	88.40
Talakaveri	05B	31.08.87	105.59
			6,712.62
Kerala			
National Parks			
Eravikulam	05B	28.02.78	97.00
Periyar	05B	27.10.82	350.00
Silent valley	05B	23.11.84	89.52
Wildlife Sanctuaries			
Aralam	05B	15.10.84	55.00
Chimnony	05B	25.08.84	90.00
Chinnar	05B	01.01.84	90.44
Idukki	05B	09.02.76	70.00
Neyyar	05A	06.08.58	128.00
Parambikulam	05B	12.02.73	285.00
Peechi-Vazhani	05A	06.08.58	125.00
Peppara	05A	21.12.83	53.00
Periyar	05B	27.10.82	777.00
Shendurney	05B	25.08.84	100.32
Thattekadu	05A	05.10.83	25.16
Wayanad	05B	30.05.73	344.44
			2,679.88

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Madhya pradesh			
National Parks			
Bandhavagarh	06A	11.05.82	448.85
Fossil	06A	17.06.83	0.27
Kanha	06A	10.10.55	940.00
Madhav	04B	01.01.59	375.22
Panna	06A	19.07.73	542.67
Pench (Priyadarshini)	06A	22.11.75	292.85
Sanjay	06A	23.09.81	466.88
Satpura	06A	13.10.81	585.17
Van vihar	04B	27.07.79	4.45
Wildlife Sanctuaries			
Bagdara	06A	15.02.78	478.00
Bori	06A	01.08.77	485.72
Gandhi Sagar	04B	18.04.81	368.62
Ghatigaon	04B	12.06.81	511.00
Karera	05B	21.05.81	202.21
Ken Gharial	06A	21.10.81	45.20
Kheoni	04B	04.12.82	122.70
Narsingarh	04B	21.09.78	59.18
National Chambal	04B	22.12/78	435.00
Nauradehi	06A	01.02.84	1194.67
Orcha	04B	22.09.94	44.91
Pachmarhi	06A	01.06.77	417.78
Palpur Kuno	04B	16.01.81	344.68
Panna (Gangau)	06A	16.04.79	68.14
Panpatha	06A	04.0683	245.84
Pench	06D	22.11.75	118.47
Phen	06A	10.03.83	110.74
Ralammandal	04B	09.02.89	2.34
Ratapani	06A	02.07.78	823.84

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Sailana	04B	04.06.83	12.96
Sanjay Dubri	06A	30.08.75	364.59
Sardarpur	04B	10.02.83	348.12
Singhori	06A	02.07.76	287.91
Son Gharial	06A	23.09.81	41.80
Veerangna Durgawati	06A	06.01.97	23.97
			10,814.75
Maharashtra			
National Park			
Gugamal	06A	27.11.87	361.28
Nawegaon	06D	22.11.75	133.88
Pench	06D	22.11.75	257.26
Sanjay Ganghi (Borivilli)	08A	04.02.83	86.96
Tadoba	06D	09.04.55	116.55
Wildlife Sanctuaries			
Amba-Barwa	06D	09.04.97	127.11
Andhari	06D	25.02.86	509.27
Aner Dam	06A	10.10.86	82.94
Bhamraghar	06D	06.05.97	104.38
Bhimashankar	05B	16.09.85	130.78
Bor	06D	27.11.70	61.00
Chandoli	05B	16.09.85	308.97
Chaprala	06D	25.02.86	134.78
Deolgaon-Rehkuri	06D	29.02.80	2.17
Dhyanganga	06D	09.05.97	205.23
Gautala	06D	25.02.86	260.61
Great Indian Bustard	06D	27.09.79	8496.44
Jaikwadi	06D	10.10.86	341.05
Kalsubai	06D	25.02.86	361.71
Karanja Sohol	06D	2001	18.32

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Kamala	05A	06.05.68	4.48
Katepurna	06D	08.02.88	73.63
Koyana	05B	16.09.85	423.55
Lonar	06D	08.06.2000	1.17
Marine (malvan)	08A	13.04.87	29.12
Mayureshwar Supe	06B	19.08.97	5.15
Melghat	06A	05.09.85	1150.03
Nagzira	06D	03.06.70	152.81
Naigaon Mayur	06D	08.12.94	29.89
Nandur Madhameshwar	06D	25.02.86	100.12
Narnala	06D	02.05.97	12.35
Painganga	06D	25.02.86	324.62
Phansad	05A	25.02.86	69.79
Radhanagari	05B	02.12.58	351.16
Sagareshwar	06E	16.09.85	10.87
Tansa	05A	12.06.70	304.81
Tipeshwar	06D	24.01.97	148.63
Yawal	06A	27.03.69	177.52
Yedsi Ramlinghat	06D	16.05.97	22.38
Wan	06A	28.07.97	211.00
			15,703.77
Manipur			
National Parks			
Keibul-Lamjao	09B	20.03.77	40.00
Wildlife Sanctuaries			
Kailam	09B	2001	187.50
Yangoupokpi-Lokchao	09B	21.03.89	184.85
Zeilad	09B	2001	21.00
			433.35

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Meghalaya			
National Parks			
Balphakram	09B	15.02.86	220.00
Nokrek Ridge	09B	29.11.86	47.48
Wildlife Sanctuaries			
Baghmara Pitcher Plant	09B	24.05.84	0.02
Nongkhyllem	09B	25.03.81	29.00
Siju	09B	30.03.79	5.18
			301.68
Mizoram			
National Parks			
Murlen	09B	08.07.91	200.00
Phawngpui (Blue Mountain)	09B	22.07.97	50.00
Wildlife Sanctuaries			
Dampa	09B	25.03.85	500.00
Khwanglung	09B	08.07.91	41.00
Lengtentg	09B	08.04.99	120.00
Ngengpui	09B	22.07.97	170.00
			1,081.00
Nagaland			
National Parks			
Intanki	09B	08.03.93	202.02
Wildlife Sanctuaries			
Fakim	09B	16.01.84	6.41
Puliebadze	09B	18.01.80	9.23
Rangapahar	09B	17.06.86	4.70
			222.36

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Orissa			
National Parks			
Bhitarkanika	08B	20.10.88	145.00
Similipal	06B	08.06.80/11.06.86	845.70
Wildlife Sanctuaries			
Badrama	06B	17.12.87	304.03
Baisipalli	06B	07.11.81	168.35
Balukhand Konark	08B	23.04.84	71.72
Bhitarkanika	08B	22.04.75	672.00
Chandaka Dampara	06B	21.12.82	175.79
Chilka (Nalaban)	08B	17.12.87	15.53
Debrigarh	06B	08.02.85	346.91
Gahirmatha	06B	27.09.97	1435.00
Hadgarh	06B	06.12.78	191.60
Karlapat	06C	15.10.92	147.06
Khalasuni	06C	07.01.82	116.00
Kotgarh	06C	13.12.81	399.50
Kuldiha	06B	04.01.84	272.75
Lakhari Valley	06C	08.02.85	185.87
Nandankanan	06C	03.08.79	14.26
Satkosia (north)	06B	19.05.76	745.52
Similipal	06B	03.12.79	1354.00
Sunabeda	06C	10.05.88	500.00
			8,106.59
Punjab			
Wildlife Sanctuaries			
Abohar	04A	27.08.74	186.50
Bir Aishwan	04A	28.02.52	4.67
Bir Bhadson	04A	28.02.52	10.23
Bir Bunerheri	04A	28.02.52	6.50

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Bir Dosanjh	04A	28.02.52	5.18
Bir Gurdialpura	04A	19.09.77	6.20
Bir Mehaswala	04A	28.02.52	1.23
Bir Motibagh	04A	28.02.52	6.40
Harike Lake	04A	26.08.82	86.00
Takhni Rehampur	04A	16.02.93	3.82
			316.73
Rajasthan			
National Parks			
Desert	03A	06.08.80	3162.00
Keoladeo Ghana	04A	27.08.81	28.73
Ranthambore	04B	01.11.80	392.00
Sariska	04B	1992	273.80
Wildlife Sanctuaries			
Bandh Baratha	04B	05.10.85	192.76
Bassi	04B	29.08.88	152.90
Bhensrodgarh	04B	05.02.83	229.14
Darrah	04B	07.11.55	265.80
Jaisamand	04B	07.11.55	52.00
Jamwa Ramgarh	04B	09.10.75	300.00
Jawahar Sagar	04B	09.10.75	100.00
Kela Devi	04B	19.07.83	676.38
Kesarbagh	04B	07.11.55	14.76
Kumbhalgarh	04B	13.07.71	578.25
Mount Abu	04B	07.04.60	288.84
Nahargarh	04B	22.09.80	50.00
National Chambal	04B	07.12.79	280.00
Phulwari Ki Nal	04B	06.10.83	511.41
Ramgarh Vishdhari	04B	20.05.82	301.00
Ramsagar	04B	2001	34.40

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Sajjangarh	04B	17.02.87	5.19
Sariska	04B	07.11.55	492.00
Sawai Man Singh	04B	30.11.84	103.05
Shergarh	04B	30.07.83	98.71
Sitamata	04B	02.01.79	422.94
Tal Chhapper	03A	13.07.71	7.90
Todgarh Raoli	04B	28.09.83	495.27
Van Vihar	04B	07.11.55	59.93
			9,569.16
Sikkim			
National Parks			
Khangchendzonga	01B	26.08.77	1784.00
Wildlife Sanctuaries			
Barsey Rhododendron	02C	1998	104.00
Fambong Lho	02C	1998	104.00
Kyongnosla Alpine	02C	29.08.84	31.00
Maenam	02C	19.03.87	35.34
Shingba (Rhododendron)	01B	29.08.84	43.00
			2,101.34
Tamil Nadu			
National Parks			
Guindy	06E	22.05.76	2.82
Gulf of Mannar	08B	03.03.80	6.23
Indira Gandhi (Annamalai)	05B	23.01.89	117.10
Mukurthi	05B	15.10.90	78.46
Mudumalai	05B	02.01.90	103.24
Wildlife Sanctuaries			
Chitrangudi	06E	21.09.89	0.47
Indira Gandhi (Annamalai)	05B	14.04.76	841.49
Kalakad	05B	06.03.76	223.58

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Kanjirankulam	08B	21.09.89	1.04
Karaivetti	06E	05.04.99	4.54
Karikilli	06E	23.05.84	0.61
Kilaselvanur - Melaselvanur	06E	10.03.98	5.93
Kuthankulam-Kadankulam	05B	30.11.94	1.29
Mudumalai	05B	09.03.42	217.76
Mundanthurai Kalkad	05B	21.03.77	567.38
Point Calimere (e)	08B	13.06.67	17.26
Pulicat Lake	08B	20.09.80	153.67
Srivilliputhur	05B	26.12.88	485.20
Udayamarthandapuram Lake	08B	31.12.98	0.45
Vaduvoor	08B	04.10.96	1.28
Vedanthangal	06E	20.4.25/8.7.98	0.30
Vellanadu	06E	28.09.87	16.41
Vellode	06E	30.06.97	0.77
Vettangudi	08B	03.06.77	0.38
			2,847.66
Tripura			
Wildlife Sanctuaries			
Gumti	09B	08.09.88	389.54
Roa	09B	13.07.88	0.85
Sepahijala	09B	02.02.87	18.53
Trishna	09B	02.02.87	194.70
			603.62
Uttaranchal			
National Parks			
Corbett	07A	11.05.36	520.82
Gangotri	02B	16.09.89	1552.00
Govind	02B	26.02.90	472.08
Nanda Devi	02B	18.08.82	624.62

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Rajaji	07A	12.08.83	820.00
Valley of Flowers	02B	01.01.82	87.50
Wildlife Sanctuaries			
Askot Musk Deer	02B	30.07.86	593.93
Binsar	02B	25.05.88	45.59
Govind Pashu Vihar	02B	22.03.55	481.00
Kedarnath	02B	21.01.72	957.00
Mussoorie	02B	02.09.93	10.82
Sonanadi	07A	09.01.87	301.18
			6,466.54
Uttar Pradesh			
National Parks			
Dudhwa		17.05.77	490.00
Wildlife Sanctuaries			
Bakhira	07A	08.05.90	28.94
Chandraprabha	06A	25.05.57	78.00
Hastinapur	07A	30.07.86	2073.00
Kaimur	06A	10.08.82	500.73
Katerniaghat	07A	31.05.76	400.69
Kishapur	07A	07.10.72	227.00
Lake Bahosi	07A	21.03.88	80.24
Mahavir Swami	06A	25.03.77	5.41
National Chambal	04B	20.01.79	635.00
Nawabgang	07A	07.08.84	2.25
Okhla	07A	08.05.90	4.00
Parvati Aranga	07A	23.05.90	10.84
Patna	07A	22.09.90	1.09
Ranipur	06A	24.01.77	230.31
Saman	07A	23.05.90	5.25
Samaspur	07A	10.08.87	7.99
Sandi	07A	08.05.90	3.09

Name of National Parks and Wildlife Sanctuaries	Biogeographic Province	Date of establishment	Area (sq. km)
Sohagibarwa	07A	29.06.87	428.20
Sohelwa	07A	14.11.88	452.47
Sur Sarovar	07A	27.03.91	4.03
Surha Tal	07A	27.03.91	34.32
Turtle	07A	21.12.89	7.00
Vijai Sagar	06A	26.06.90	2.62
			5,712.47
West bengal			
National Parks			
Buxa	07B	06.01.92	117.10
Gorumara	07B	31.01.94	79.45
Neora Valley	02C	17.04.86	88.00
Singhalila	02C	06.05.86	78.60
Sunderbans	08B	04.05.84	1330.10
Wildlife Sanctuaries			
Ballavpur	07B	11.07.77	2.00
Bethuadahari	07B	29.10.80	0.67
Bibhutibhusan	07B	28.03.85	0.64
Buxa	07B	24.01.86	251.89
Chapramari	07B	24.06.76	9.49
Haliday Islands	08B	24.06.74	5.95
Jaldapara	07B	24.06.74	216.51
Jorepokhri	02B	11.03.85	0.04
Lothian Island	08B	24.06.76	38.00
Mahananda	07B	24.06.76	127.22
Narendrapur	08B	14.04.82	0.10
Raiganj	07B	11.04.85	1.30
Ramnabagan	07B	30.09.81	0.14
Sajnekhali	08B	24.06.76	362.40
Senchal	02C	24.06.76	38.88
			2,748.48

Biosphere Reserves: To re-enforce some of these existing National Parks and Wild Life Sanctuaries, which have (i) minimally disturbed core area typical of a biogeographical unit and, at the same time, are large enough to sustain viable populations of components of biological diversity (ii) have rare, threatened and endemic species, and (iii) have potential for preservation of traditional knowledge of conservation, the Core Advisory Group of Experts, constituted by Indian National MAB Committee identified 14 potential sites in 1979 for establishing Biosphere Reserves, in different biogeographical regions of the country (Table VI).

Table VI
Sites for Biosphere Reserves initially identified by Core Group of Experts

Sl. No.	Biosphere Reserve	States
1.	Nilgiri	Tamil Nadu, Karnataka and Kerala
2.	Namdapha	Arunachal Pradesh
3.	Nanda Devi	Uttaranchal
4.	Uttarakhand (Valley of Flowers)	Uttararanchal
5.	North Islands of Andamans	Andaman & Nicobar Islands
6.	Gulf of Mannar	Tamil Nadu
7.	Kaziranga	Assam
8.	Sunderban	West Bengal
9.	Thar Desert	Rajasthan
10.	Manas	Assam
11.	Kanha	Madhya Pradesh
12.	Nokrek (Tura Range)	Meghalaya
13.	Little Rann of Kutch	Gujarat
14.	Gulf of Mannar	Tamil Nadu

Subsequently some additional Biosphere Reserve sites have also been proposed by National Committee/Expert Groups/State Governments/ Experts, etc. (Table VII). So far, thirteen Biosphere Reserves have been established in different biogeographic zones of the country (R.K. Rai, *pers. com.*) to (i) conserve plant and animal diversity within their natural ecosystemns, (ii) protect the genetic diversity within species to sustain their evolutionary processes; (iii) facilitate multidisciplinary research and monitoring, education and training, and (iv) to ensure sustainable use of natural resources through appropriate technologies for economic well-being of the local populace covering a total area of about 55,550.39 sq. km. (Table VIII). This amounts to about 1.69 per cent of total landmass of the country or about 35.93 per cent of the total PAN area of the country. So far, three Biosphere Reserves of the country, viz. the Nilgiri B.R., the Gulf of Mannar B.R., and the Sundarban B.R., have been designated for inclusion in the World Network of Biosphere Reserves (Sharma *et al.*, 2002).

Table VII
Biosphere Reserve sites suggested by State Governments/ Expert Groups/Experts, awaiting notification

Sl. No.	Biosphere Reserve	State
1.	Abujhmarh	Madhya Pradesh
2.	Amarkantak	Madhya Pradesh
3.	Cold Desert	J & K and Himachal Pradesh
4.	Seshachalam	Andhra Pradesh
5.	Chintapalli	Andhra Pradesh
6.	Lakshadweep Islands	Lakshadweep

These Biosphere Reserves have been designated to serve as wider base for conservation of entire range of biological resources and their ecological functions, to put representative ecosystems under conservation and sustainable use on a long term basis, to ensure participation of local inhabitants for effective management and also devising means for their economic upliftment, and to integrate scientific research with traditional knowledge of conservation, monitoring, education and training as part of the overall management of the Biosphere Reserves.

Research, for generating baseline data on various components of biodiversity, and monitoring, to assess the impact of various

Table VIII
Biosphere Reserves so far established in India

Sl. No.	Biotic Province	Biosphere Reserve	Area (sq.km)	Date of notification	Location
1.	5B	Nilgiri	5520	01.8.86	Part of Wynad, Nagarhole, Bandipur and Mudumalai; Nilambur/Silent valley and Siruvani Hills (Tamil Nadu, Kerala and Karnataka)
2.	2B	Nanda Devi	5860.69	18.1.88	Part of Chamoli, Pithoragarh and Bageshwar district (Uttaranchal).
3.	9B	Nokrek	820	01.9.88	Part of Garo Hills (Meghalaya)
4.	9A	Manas	2837	14.3.89	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darang district (Assam).
5.	7B	Sunderbans	9630	29.3.89	Part of delta of Ganges and Brahmputra river systems (West Bengal).
6.	8B	Gulf of Mannar	10,500	18.2.89	Indian part of Gulf of Mannar between India (Tamil Nadu) and Sri Lanka

Sl. No.	Biotic Province	*Biosphere Reserve*	Area (sq.km)	Date of notifi-cation	Location
7.	10B	Great Nicobar	885	06.1.89	Southern most islands of Andaman & Nicobar (A & N Islands)
8.	9A	Dibru-Saikhowa	765	28.7.97	Part of Dibrugarh and Tinsukia districts (Assam)
9.	6C	Similipal	4374	21.6.94	Part of Mayurbhanj district (Orissa)
10.	2D	Dehang-Dibang	5111.50	02.9.98	Part of East Siang and Dibang valley districts (Aunachal Pradesh)
11.	6A	Pachmarhi	4926.28	03.3.99	Part of Hoshangabad, Betul and Chindwara district (Madhya Pradesh)
12.	2C	Kanchanjunga	2619.92	07.2.2000	Part of North and West districts (Sikkim).
13.	5B	Agasthyamalai	1701.00	12.11.2001	Neyyar, Peppara and Shenduruny Wildlife Sanctuaries and their adjoining areas in Kerala.

anthropogenic practices, including management initiatives, on short as well as long term conservation imperatives, is, therefore, an integral part of the management strategy of Biosphere Reserves.

World Heritage Sites : Under the World Heritage Convention of 1972, five natural sites of the country have so far been declared as "World Heritage Sites". These are:

(i) ***Kaziranga National Park :*** Inscribed in 1985, the Kaziranga National Park is situated in the heart of Assam, and is one of the last areas in the northern India virtually undisturbed by man. It is also home to the largest population of one-horned rhinoceros in the world, besides many mammals like tigers, elephants, panthers, bears, and thousands of birds.

(ii) ***Keoladeo National Park :*** Inscribed in 1986, the Keoladeo National Park had been the former waterfowl hunting reserves of the Maharajas, and remains one of the major wintering areas for large number of migratory birds from countries like Afghanistan, Turkmenistan, China and Siberia. Approximately 364 species of birds, including the rare Siberian crane, have been recorded in the park.

(iii) ***Manas Biosphere Reserve :*** Inscribed in 1985, the Manas Biosphere Reseve is situated on a gentle slope in the foothills of the Himalaya on the Indo-Bhutan Border, where the woodded hills pave way to alluvial grasslands and tropical forests. The Manas B.R. is home to a great variety of wild life, including a number of endangered species, like the tiger, pygmy hog, the one horned rhinoceros and Asian elephant. It is highly threatened because of activities of Bodo militants of Assam. A joint monitoring mission of the Government of India and UNESCO's World Heritage Centre in 1997 confirmed the damage to B.R.'s infrastructure and decline in the population of certain species.

(iv) ***Sundarbans Biosphere Reserve :*** Inscribed in 1987, the Sunderbans cover an area of about 10,000 sq. km of land and water in the Ganges' delta, more than half of which lies in India and the rest in Bangladesh. It has the world's largest mangrove forests and harbours a number of rare and endangred species, like tigers, aquatic mammals, birds and reptiles, etc.

(v) ***Nanda Devi Biosphere Reserve :*** Inscribed in 1988, the Nanda Devi B.R. represents one of the most spectacular wilderness areas in the Himalaya. It is dominated by Nanda Devi Peak which attains a height of over 7,800 m, and is home to several endangered mammals, especially the snow leopard, Himalayan musk deer and "bharal".

Apart from designating a vast network of protect areas in different categories to provide *in situ* conservation to a vast array of species and ecosystems, India has also launched various programmes and projects to further strengthen and streamline its conservation efforts in specific areas. Some such initiatives are also outlined in the following paragraphs.

The Tiger Reserve : Tiger is the most charismatic keysotne species of the South and South-East Asian Countries and Russia because of its royal splendour and the highest position in the food chain. It is our "national animal" as well. It easily inspires awe and admiration, and easily motivates people for its care and conservation as a true 'flagship' species. The Government of India launched the project tiger on April 01, 1973, under which 27 Tiger Reserves, covering an area of about 37,761 sq. km across 17 states of the country have so far been established (Table IX).

Table IX
Tiger Reserves of India

Name	State/UT	Area (sq. km)
1. Bandipur	Karnataka	866.00
2. Corbett	Uttaranchal	1316.00
3. Kanha	Madhya Pradesh	1945.00
4. Manas	Assam	2840.00
5. Melghat	Maharashtra	1597.00
6. Palamu	Jharkhand	1026.00
7. Ranthambore	Rajasthan	1334.00
8. Similipal	Orissa	2750.00
9. Sundarbans	West Bengal	2585.00
10. Periyar	Kerala	777.00
11. Sariska	Rajasthan	866.00

Name	State/UT	Area (sq. km)
12. Buxa	West Bengal	759.00
13. Indiravati	Chattisgarh	2799.00
14. Nagarjunasagar	Andhra Pradesh	3568.00
15. Namdapha	Arunachal Pradesh	1985.00
16. Dudhwa	Uttar Pradesh	811.00
17. Kalakad Mundnthurai	Tamil Nadu	800.00
18. Valmiki	Bihar	840.00
19. Pench	Madhya Pradesh	758.00
20. Dampa	Mizoram	500.00
21. Panna	Madhya Pradesh	542.00
22. Bandhavagarh	Madhya Pradesh	1162.00
23. Taroba	Maharashtra	620.00
24. Bhadra	Karnataka	4.92.00
25. Pench	Maharashtra	257.00
26. Pakhui-Nameri	Arunachal Pradesh-Åssam	1206.00
27. Bori, Satpura, Pachmarhi	Madhya Pradesh	1486.00
Total		**37,761.00**

Ramsar Sites : Wetlands are the transitional zones between the terrestrial and aquatic ecosystems. Apart from harbouring enormous diversity of both flora and fauna and providing habitat for migratory birds, the wetlands also perform essential functions like flood control, sewage treatment, stablisation of shorelines, recharging of under ground aquifers, etc. India by virtue of its geographical expanse and varied geomeorphology has about 4.1 million ha of both inland as well as coastal wetlands of which about 1.5 million ha are natural and the rest are man-made.

In view of the biological, hydrological and socio economic values of the wetlands, the National Committee on Wetlands has identified 21 of them as Wetlands of National importance under the Wetlands Programme of the Ministry of Environment and Forests, for intensive conservation and management purposes. In 1990 six such wetlands have been designated as Wetlands of International Importance or the "Ramsar Sites" under the Ramsar Convention of 1971 (Table X). Recently 10 more wetlands, viz. Tso Murari (Jammu & Kashmir), Lati (Arunachal Pradesh) , Dipor Beel (Assam), Pong Dam (Himachal Pradesh), Kabar Tal (Bihar), East Calcutta Wetlands (West Bengal), Bhitarkanika (Orissa), Point Calimere (Tamil Nadu), Pulicat (Andhra Pradesh and Tamil Nadu) and Andaman & Nicobar have also been identified for designation as Ramsar Sites, to increase the total protected areas of wetlands to about 1.1 million ha (*see* Sharma & Singh, 2001).

Table X
Rsamsar Sites

Name		State	Area (ha)
1.	Chilka	Orissa	1,14,000.00
2.	Harike	Punjab	4,100.00
3.	Keoladeo Ghana	Rajasthan	2873.00
4.	Loktak	Manipur	27,600.00
5.	Sambhar	Rajasthan	7,200.00
6.	Wular	Jammu & Kashmir	18,900.00
	Total		**1,74,673.00**

Forest Preservation Plots : For conservation of representative areas of biodiversity and their closer monitoring, the Indian Council of Forestry Research and Education (ICFRE), under the Ministry of Environment and Forests, has designated 309 'Forest Preservation Plots' covering an area of about 8,500 ha, of which 187 plots are in natural forests and the rest in the plantation forests.

Gene Sanctuaries : Species specific gene sanctuaries for the conservation of rich native diversity of plants have also been established. For example, gene sanctuary for preserving the diversity of wild *Citrus* and *Musa* at Tura Range in Garo Hills of Meghalaya; "*Nepenthes* Sanctuary" at Jarain in Jaintia Hills and Baghmara in Garo hills of Meghalaya; *Rhododendron* and orchid sanctuaries in Sikkim, have so far been established.

The Sacred Grovces : In addition to the conservation initiatives on part of the Central and State Government, India has an age-old tradition of protecting forests by local people out of reverence and fear. The people believe that such untouched forests are the abode of folk-dieties who protect them, and any harm caused to these forests may invite the wrath of the deities. These traditionally managed private or community forests are known as the 'sacred groves' which usually represent the relic climax vegetation of the respective region. The sacred groves or forests are also reported from other countries of Asia and Africa, like Ghana, Senegal, Sumatra, Nigeria, Seria, Turkey, Japan, etc. (MAB, 1975; Gadgil & Vartak, 1976; Ramakrishanan *et al.*, 1998). The importance of such forest patches in biodiversity conservation has been valued since long (Kosambi, 1962; Gadgil & Vartak, 1975; Haridsan & Rao, 1985). In India, the sacred groves occur mostly in Bihar, Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Madhya Pradesh, Meghalaya, Orissa and Rajasthan. A detailed study, however, on the biological diversity of the sacred groves and the cultural diversity surrounding them is imperative to understand the traditional knowledge and practices associated with the nature conservation.

People and the protected areas

For any conservation measures to succeed, it needs to be socially acceptable and economically viable. While all consumptive use of resources from a national park is prohibited and the human habitation excluded, the forestry operations and traditional uses of resources were allowed in a Wildlife sanctuary till recently. But after the amendment in the Wildlife (Protection) Act, except grazing all other consumptive uses have been curtailed in the case of Wildlife sanctuaries also. Even the grazing is regulated by the competent authority. This has led to the belief that the protected areas have negative impact on the socio-economic interest of the people and the societies at large and, therefore, the conservation is incompatible with development. This has often led to the conflict between the conservationists and various stakeholders, or as more aptly put by Sawarkar (1999), between "biocentrism and anthropocentrism" without appreciating the interrelationship between them.

Most of our protected areas have human settlements in them, or have people, with legitimate historical right to the resources, who depended on them for their day to day sustenance needs. The conservation of biodiversity, therefore, requires more flexible approaches wherein local people or the communities could also be involved to ensure that protected areas continued to make their contributions to the society. It is therefore, imperative to integrate protected areas into larger, cross-sectoral planning frameworks. The new management strategies, aiming at building positive relationship, with the people who live in an around the protected areas, received legitimacy in the World Conservation Strategy (IUCN, 1980) and were later converted into directives at the IIIrd World National Park Congress held at Bali in 1982.

The New paradigm for the protected areas, emerging from IVth World Congress on National Parks and Protected Areas held a Caracas in 1992, fully realises the fact that the protected areas simply can not eco-exist with hostile communities around them. However, if the management plan takes into account the cultural and socio-economic characteristics of the local people, the protected areas can make significant contributions to human welfare while upholding the interest of conservation.

In June 1991, the Government of India initiated an ecodevelopment programme for *in situ* conservation of biodiversity involving local communities through "Joint Forest Management". The concept integrates the ecological and economic parameters for conservation of ecosystems by associating local people in the maintenance of designated regions surrounding the protected area, while the people are provided with alternative sources of income and allowed access to the forest produce. The Joint Forest Management (JFM) programme in the present form can be traced to Arabari experiment initiated by the State Forest Department of West Bengal. So far 27 state Governments have initiated the implementation of JFM Programme in their respective states. As on 15th August, 2001, 1,42,54,845.95 ha of forest lands are being managed under JFM programme through 62,890 JFM committees in these states. At present the JFM programme is being operated in degraded forest lands only. But in view of the success stories about the programme emanating from different States, the government may consider extending the scheme to good forests also.

The primary objective of the JFM is to provide a visible role to the local communities, or the stakeholders, in planning, management and protection of forests and, in return, to give them a share in the benefits generated by these forests. On operational parameters, the JFM is a concept of developing partnership between the state forest departments and the fringe forest user groups on the basis of jointly defined roles and responsibilities. JFM is gradually emerging as a powerful tool of sustainable forestry in India. It recognises the livelihood and sustenance needs of the people through the principle of 'care and share'. The concept of JFM has been interpreted in various ways, but the basic element is to establish grassroot, community based institutions for protection and management of forests. The programme aims at empowering the local people for their active participation as partners in the management of forest resources and sharing the benefits derived from its protection and management. The JFM approach optimises the returns, minimises the conflicts and links the forest development with over all development of the land based resources.

Ex-situ conservation efforts

To strengthen and supplement the *in situ* conservation efforts, India has also under taken measures for *ex situ* conservation of both wild as well as domesticated plants, especially the threatened species, as required under the Article 9 of the Convention on Biological Diversity, 1992. The major facilities for *ex situ* conservation are the botanic gardens, field gene banks, seed banks, cryobanks, tissue culture repositories, etc. At present there are 150 organised botanic gardens or large parks in the country, of which 33 gardens (including the historical Indian Botanic Garden of the Botanical Survey of India) are managed by the Central or State Governments; 70 gardens and parks are in public domain and 40 gardens are run by the Universities (Chakraverty & Mukhopadhyay, 1990; *see also* Chakraverty & Mukhopadhyay, 2000).

Considerable attention has been paid to the conservation of genetic diversity of cultivated plants. Collection and preservation of the crop genetic resources is being done by the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. The Indian National Gene Bank of the NBPGR presently comprises a Seed Repository, holding nearly 1,45,000 accessions; Tissue Culture Repository having 800 accessions, and has 1000 samples cryopreserved in liquid Nitrogen. The Bureau is assigned the task of collecting the germplasm and maintaining them in seed banks and field gene banks, for short and medium term preservation. The bureau also supplies these genetic materials to both Indian and foreign agencies, on request, exclusively for research purpose only.

The Department of Biotechnology has also initiated a number of programmes relevant to *ex situ* conservation of biodiversity, such as germplasm facilities, tissue culture pilot plants, biocontrol agents, biofertilisers, clean technologies and bioinformatics. Some of the important National Facilities sponsored by the department are : National Facility for Microbial Type Collections at Chandigarh; Blue-Green Algae at IARI, New Delhi; for Marine Cyano-bacteria at Tiruchirapalli; Plant Tissue Culture Repository at NBPGR, New Delhi, besides the Tissue Culture Pilot Plants for multiplication of Forest Trees at National Chemical Laboratory, Pune and Tata Energy Research Institute, New Delhi. Besides, under the G-15 initiative of the Gene Banks for Medicinal and Aromatic Plants (GEBMAP), three National Gene Banks have also been established at CIMAP, Lucknow; NBPGR, New Delhi and TBGRI, Thiruvananthapuram. In addition, plant tissue culture laboratories have also been established by many organisations, like the Botanical Survey of India (BSI); Indian Council of Forestry Research and Education (ICFRE), Dehradun and Banglore; G.B. Pant Institute of Himalayan Environment and Development, Almora; National Botanical Research Institute (NBRI), Lucknow; Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow, Tropical Botanic Garden and Research Institute (TBGRI), Thiruvananthapuram; State Forest Department of Arunachal Pradesh and several University Departments, etc., for rapid mass propagation of selected rare, threatened and economically important plant species.

Apart from the above facilities directly associated with *ex situ* conservation measures, the herbaria, though indirectly, also play an important role in detection, assessment and monitoring of rare or threatened species thereby augmenting both *in situ* and *ex situ* conservation initiatives. The modern herbaria are a great filing system for information about plants, both primary in the form of specimens and secondary in form of recorded field notes, etc. A herbarium, therefore, functions as a centre for assimilation and dissemination of all basic information, like identity of a plant, its distribution, habitat, frequency and uses. Thus the frequency of collection of a species and its representation in the herbarium provides a preliminary insight into the changing patterns, if any, both quantitative as well as qualitative, in the floristic composition of a particular region (Murti & Singh, 1994).

Role of Botanical Survey of India

To assess long-term changes in the biodiversity, a basic prerequisite is a good knowledge of species and their distribution. Inventorying, research and monitoring, therefore, constitute the key elements of a comprehensive and holistic approach to conservation of biodiversity. They together provide important informations about the existing resources, the lacunae, if any, and the emerging trends in the changes in demography of the species due to various factors. Botanical Survey of India, the apex organisation under the Ministry of Environment and Forests mandated for the survey, documentation and conservation of plant resources, is not only preparing comprehensive inventories of the plant species at state, regional and national level, but also identifies reasons for changes, if any, in the existing species diversity and helps formulate effective conservation strategy, both *ex situ* and *in situ*. The extensive survey and explorations being undertaken by the department in different states of the country has assimilated enormous data on the plant resources of these regions, including rare, threatened, endemic and economic plant species. The areas covered also include a number of protected areas. Besides, the department has also initiated focused studies on the flora of protected areas and fragile ecosystems. The floristic studies on five Biosphere Reserve, viz. Great Nicobar, Nilgiri, Gulf of Mannar, Manas and Nanda Devi have already been completed and published, whereas those on Dihang-Dibang, Dibru-Saikhowa, Nokrek and Kanchendzonga are currently in progress. Similarly studies on 31 National Parks have also been completed by the department. Besides, vegetational account of 23 Tiger Reserves and a few Wildlife Sanctuaries have also been published. These accounts form the base-line data, on the floristic diversity in these protected areas, essential for evolving management strategies and monitoring.

Botanical Survey of India is also actively engaged in the *ex-situ* conservation through the Indian Botanic Garden at Howrah and other Experimental Botanic Gardens associated with regional circles at Itanagar, Barapani, Allahabad, Dehra Dun, Pauri, Mundwa, Yercaud, Jodhpur, Dhanikhari and three National Orchidaria at Yercaud, Howrah and Shillong. These units are engaged in collection, introduction, multiplication and maintenance of germplasm collections belonging to orchids, bamboos, palms, medicinal plants, legumes, ferns, wild edible plants, insectivorous plants, gymnosperms and economically important plant species. Presently the above facilities are serving as living repositories of an estimated 1,50,000 live plants belonging to about 4,000 largely indigenous and selected, highly valued economic exotic species. This includes about 200 species belonging to endemic, rare and threatened category, some of which are also included in Appendix I and II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Some such species are : *Renanthera imschootiana*, *Vanda coerulea*, *Paphiopedilum* spp., *Cycas beddomei*, *Bentinckia condapanna*, *B. nicobarica*, *Trachycarpus takil*, *Cypripedium* spp. *Eremostachys superba*, *Nepenthes khasiana*, *Taxus wallichiana*, *Myristica andamanica*, *Saussurea costus*, *Rauvolfia serpentina*, *Dioscorea deltoidea*, *Podophyllum hexandrum*, *Cythea* spp., *Ceropegia* spp., *Frerea indica* and *Cephalotaxus mannii*, etc.

The Botanical Survey of India, being the Scientific Authority advising the Government of India on matters related to plant resources of the country, plays significant role in various policy formulations on conservation related issues at national and international levels. One of the important factors of any conservation programme is the awareness. In order to disseminate various data and focus attention on threatened plant species the Botanical Survey of India has already completed Red Data Sheets on 1182 species, 708 of which have been published in the four volumes of the *Red Data Book of Indian Plants* brought out by the department so far.

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DIBRU-SAIKHOWA BIOSPHERE RESERVE

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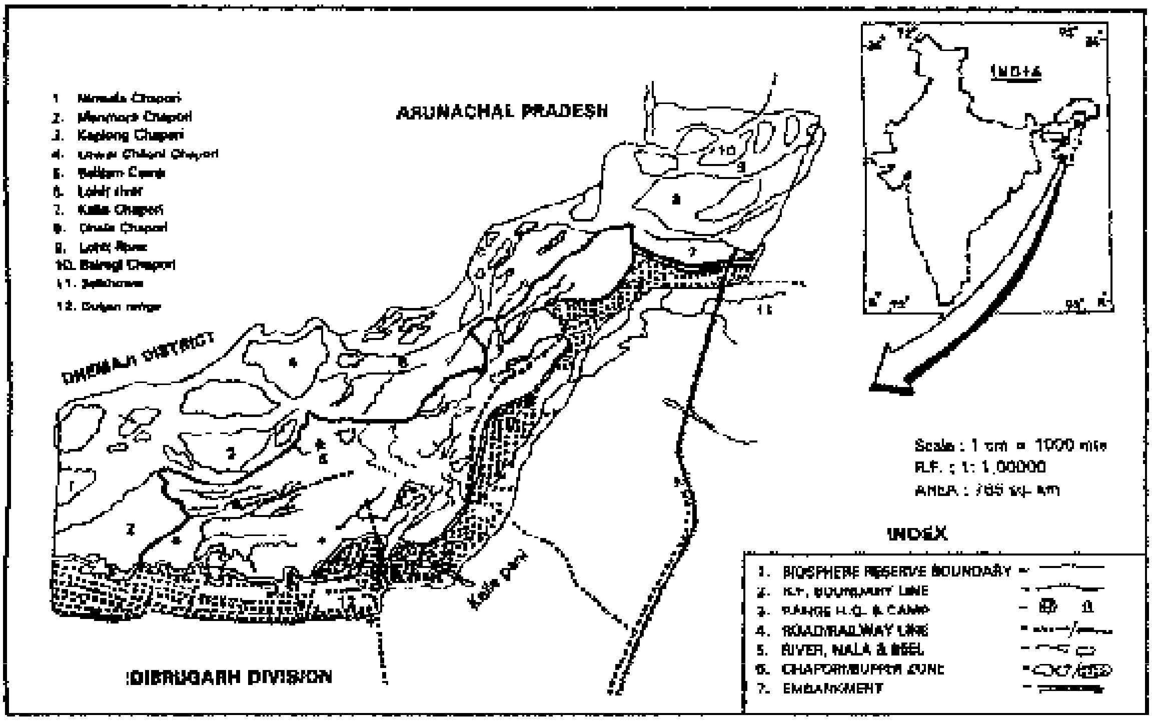
P.J. Bora

Assam, with diverse and luxuriant floristic wealth, has been considered as one of the most prominent biogeographic province in the country. In a strategy for conservation of the rich biological diversity of the region, Dibru-Saikhowa was constituted as biosphere reserve on July 28th, 1997.

The biosphere reserve comprises of erstwhile Dibru and Saikhowa Reserve Forests. Dibru reserve forest was created during the year 1890 with an area of 60,634 acres and subsequently 600 and 498 acres were added to it during 1920 and 1933 respectively. Saikhowa was declared reserved forest during 1929 with an area of 17,063 acres. On 26th September, 1986 preliminary notification was issued to declare the Dibru and Saikhowa reserve forests jointly as Dibru-Saikhowa Wildlife Sanctuary with a proposed area of 640 sq. km which, however, was finally notified on 2nd March, 1995 covering an area of 340 sq. km. Later on, the state government has declared the wildlife sanctuary as National Park and forms the core zone of the present biosphere reserve. Total area of the Dibru-Saikhowa Biosphere Reserve is 765 sq. km and comprises two forest ranges namely, Guijan and Dhola ranges.

Dibru-Saikhowa Biosphere Reserve is located in Tinsukia and Dibrugarh districts of Assam and lies between 27°45' to 27°30' N latitude and 95°10' to 90°45' E longitude. The reserve is bounded by the high bank of mighty river Brahmaputra in the north. The southern boundary is somewhat zigzag and formed by the line from Bangonitoha village near old Assam-Tinsukia road towards east and then the road upto Guijan Bazar, Natungaon Public Works Department (P.W.D.) road upto Kaliapani to Dighaltarang forest beat and through Kalita, Ajika, Kailashpur villages upto Hatighuli gaon (now submerged under river water) and then upto the Brahmaputra dyke near Dhola. The eastern boundary is constituted by the Lohit and streams of Kundil and Noa-Dihing rivers, while the western boundary is a perpendicular line from Dibrugarh-Guijan P.W.D. road upto the river Brahmaputra. The area is a flat terrain on the flood plains of the Brahmaputra and Lohit rivers and slopes gradually from the east to the



Map : Dibru-Saikhowa Biosphere Reserve

west. The altitude at the easternmost Dhola area is *ca* 120 m while towards the western side near Dibrugarh town it is around 116 m above mean sea level.

The biosphere reserve is situated at the confluence of the turbulent rivers like Lohit, Dibang, Dibru and Dangori flowing down from the hills of Arunachal Pradesh, which later on meet the mighty river Brahmaputra at various places. At this junction it appears a gorgeous and huge water body. Besides the mighty rivers, there are more than 30 different rivulets, streams, *nallahs* and *beels* (Table I) within the reserve. Together with these *beels* and swamps the water bodies form approximately 1/5 of the total area of the reserve. The most notable and interesting feature is that large area of the reserve was sunk by a few meters during the earthquake of 1950 causing vast geographical changes. This is clearly visible on the northern part of the reserve. Frequent changes of the river courses have also resulted in the formation of numerous small and large river islands, locally termed as *chapori* (Table II) which represents a wide range of ecotypes. These *chaporis* are subjected to regular denudation during the monsoon period and often change their location and physiography.

Table I

Important *streams, nallahs* and *beels* in Dibru-Saikhowa

1.	Ajuka *nallah*	16.	Koroni *beel*
2.	Ananta *nallah* (Kolia *nallah*)	17.	Katgora *beel*
3.	Banka *beel*	18.	Kurhimari *beel*
4.	Boka *beel*	19.	Laikajan
5.	Burhi *beel*	20.	Mega *beel*
6.	Chabru *nallah*	21.	Morasal *beel*
7.	Dhadum *beel*	22.	Motapung *beel*
8.	Dighali *beel*	23.	Noyanadi
9.	Dimorhula	24.	Thekera *beel*
10.	Garamjan *beel*	25.	Tilak *beel*
11.	Gerakijan	26.	Torali *beel*
12.	Hatighuli *beel*	27.	Raidang *beel*
13.	Jia Dangori *beel*	28.	Rongamara *beel*
14.	Kochuani *beel*	29.	Salbeel *nallah*
15.	Kliapani *beel*	30.	Schoolgorapathar

Table II
Important *chaporis* in Dibru-Saikhowa

1.	Ajukha *chapori*	12.	Kaplong *chapori*
2.	Bairagi *chapori*	13.	Kolia *chapori*
3.	Balijan *chapori*	14.	Kolomi *chapori*
4.	Bokabeel *chapori*	15.	Laibeel *chapori*
5.	Chiloni *chapori*	16.	Laika *chapori*
6.	Churke *chapori*	17.	Mahmora *chapori*
7.	Darkang *chapori*	18.	Nirmala *chapori*
8.	Dodhia *chapori*	19.	Paglam *chapori*
9.	Garamjan *chapori*	20.	Rongdoi *chapori*
10.	Hatighuli *chapori*	21.	Sukhan *chapori*
11.	Kaltia *chapori*		

Within the biosphere reserve, the *chaporis* are inhabited by various groups of ethnic people. They are dependant on the reserve area for their basic needs such as, fuel wood, fodder, fish, cane and other minor forest produces. Fishing within the area is a common practice and fishes are traded in the fringe villages for their economic sustenance. Besides fishing, a particular community practices rearing of cattle in the *chaporis* for milk, which is traded to the nearby township of Tinsukia. There were about 35 villages situated at the fringes of the reserve with a total population of ca. 30,000 peoples (Anonymous, 1998). But due to frequent flood the people inhabiting in these areas are dispersed in different places. Presently, the forest department with the help of the Guijan range has enumerated 15 fringe villages within its jurisdiction and another 5 villages under the Saikhowa range (Table III). The existence of these villages still remains at the mercy of the 'Mother Nature'. Total population in these villages is 7,354 and it is yet to workout the sex ratio within the communities. They mostly belong to the *Mishing* and the tea garden communities, besides *Ahom, Chutia, Deuri, Moran, Tiwa* and *Nepali* communities also form major groups in the area. There are two forest villages, namely Dodhia and Laika spreading over an area of 1,138 hectres, located within the core area of the reserve. As many as 4,000 people inhabit in these ... who belong to the *Mishing* community and ...

their livelihood. It was stated that the proposal of shifting these two villages from the core area is under negotiation with the civil administration.

Table III
Fringe villages and their population

	Name of village	Population
1.	Adabari village	259
2.	Bandar khal	160
3.	Bhuban khal	500
4.	Bindhakata-khalgaon	554
5.	Bindhakata-mulukgaon	90
6.	Chirakhowa village	149
7	Dighaltarang village	1046
8.	Eranati village	300
9.	Garumjan village	408
10.	Gereki village	690
11.	Hatighuli-gohaigaon	1000
12.	Khamtigaon	424
13.	Mingaon	809
14.	Natungaon	329
15.	Paglam	1000
16.	Raidang village	467
17	Rongagora-Balijan village	61
18	Rongmala village	701
19	Tengaban-Mingaon	1067
20.	Udaipur village	160

Geology and Soil

Geologically the region consists of a vast alluvial tract of recent origin ... Himalayas in the Tertiary along the abandoned courses and channels of the Lohit, Noa-Dihing and other rivers was built up during the Pleistocene or at the end of it, while the (b) ***low level alluvium*** of recent origin is deposited by the present day rivers along their valleys.

The soil is mainly alluvial and composed of a mixture of sand and clay in various proportions. The old alluvium deposit consists of alternating beds of pebbles, gravel with loose sand and clay. The new alluvium consists of sand, salt, shingle and clay. These are comparatively sandier than the older group. Towards the southern side of the Reserve, the soil is more clayey and locally termed these as ***allotiya***. It is generally composed of black mud of various consistencies with 0.5 to 1 metre in depth, rests upon a firm bottom of clay. Overall, the soil is of acidic in nature. Soil pH is variable in different parts of the area. It ranges from 4.2-5.5 to slightly alkaline.

Climate

The area falls within the tropical zone and enjoys a tropical climate with a distinct and short cold weather. Presence of extensive water bodies both within and outside the reserve, the area remains highly humid throughout the year. The average relative humidity remains at 78-89% during morning and during afternoon it reduces to 75-77%. Because of the presence of dense and extensive evergreen forests in the adjoining region, the temperature remains moderate and the annual temperature varies from 12°C to 34°C. However, the lowest temperature recorded in the adjoining areas of Tinsukia was 4.6°C on 4th July, 1992. The climate is characterized by the absence of dry hot summer season. The highest temperature is experienced during the southwest monsoon season along with abundant rainfall and highly humid atmosphere. On the basis of the temporal climatic variations, the region experiences 4 (four) distinct seasons, namely pre-monsoon from March to May, summer or monsoon from June to September, retreating monsoon from October to November and the winter from December to February. During the pre-monsoon, casual rainfall is often caused by local atmospheric disturbances. This is popularly known as ***Bordoichilla***.

The rainfall generally increases from the southeast to the northwest towards Arunachal Himalaya. During the period from March to November, rainfall occurs mostly with the thunder. The mean annual rainfall ranges between 2,500 mm to 3,800 mm in different localities within the area.

VEGETATION

There has not been any serious attempt to study the vegetation and forest types of Dibru-Saikhowa Biosphere Reserve in the past, except for a few sporadic explorations to collect plant specimens by Gustav Mann during 1876-1891, Gammie (1895) and Carter and Carter (1921). Kanjilal *et al.* (1934-1940) while studying the flora and vegetation of Assam (*sensu lato*) listed a few plants from the erstwhile Saikhowa Reserve Forest. Other great workers, after Kanjilal *et al.*, who studied the ecology and vegetation of Assam in general were Champion and Sheth (1968), Rowntree (1953), Rao and Panigrahi (1961), Rao (1974), etc. Das and Rajkhowa (1968) has also outlined the woodlands of Assam. But these works have not specifically mentioned about the actual status of the vegetation and forest types of the present day biosphere reserve. More recently, however, Sarma (1996) published locally from Tinsukia a very brief report, although imperfectly, on the Dibru-Saikhowa Wildlife Sanctuary. Sarma, an ardent lover of wild lives, perished his life to a wild tuskar at a very young age, tried to emphasize more on the animal species than the plants occurring in the wild life sanctuary which forms the core area of the biosphere reserve. Gogoi (1997), while studying the flora of Tinsukia district for his doctoral thesis, observed the vegetation of the reserve in very brief.

Dibru-Saikhowa Biosphere Reserve is situated in continuity with the Upper Assam tropical rain forests and expectedly, the tropical wet evergreen forests flourished in the region at a time before the great earthquake of 1950. *Dipterocarpus retusus*, *Altingia excelsa* and *Terminalia myriocarpa* formation was the climatic climax vegetation of the region in the past, which were sunk or disappeared during the natural calamity. Remnant of such formations in small patches can be noticed in certain areas like Rongdoi, Salbeel, Tangkrong and Tilak-bam areas of the reserve.

As stated, the region is intercepted by numerous water bodies and thus, created a number of isolated geographical islands and ecological niches to support a variety of vegetation types. The vegetation in each of these islands (*chaporis*) is very unique in terms of the species composition. For example, pure and extensive formation of *Tamarix dioica* and *Citrus* *indica* in Kolia *chapori*, *Bischofia javanica* Lagerstroemia speciosa formation in Kolomi and Dodhia chapori, patches of *Dalbergia sissoo* amidst extensive grassland in Churke chapori, *Salix tetrasperma* - *Ficus* spp. formations in Torali and Raidang areas are very significant. This exhibits diverse vegetation types in different habitats and ecosystem of the area, which represents the **tropical forest type** comprising of a few localized subtypes.

1. Evergreen and semievergreen forests

These forests represent the relic type of vegetation and presently, they are at a stage of dynamic secondary succession. As a result the evergreen elements do not reach to a height of 30 meters and is unlike in a typical wet evergreen forest that exists elsewhere. The general quality of the forests is poor. *Altingia excelsa, Anthocephalus chinensis, Artocarpus chama, A. lakoocha, Dillenia indica, Dipterocarpus retusus, Lagerstroemia speciosa, Terminalia bellirica, T. chebula, T. myriocarpa* and various other species of *Garcinia* and *Syzygium* are very common evergreen trees in such forests. *Canarium resiniferum* and *Dysoxylum binectariferum* occur occasionally in certain areas. The bushy plants mainly found in these forests are *Aesculus assamica, Callicarpa arborea, Maesa indica, Macaranga denticulata, Vitex negundo*, etc.

Among the climbers, lianas and stragglers most common ones are *Combretum roxburghii, Dalbergia pinnata, Derris elegans* var. *vestita, Holmskioldia sanguinea, Stemona tuberosa, Stephania glandulifera, Thunbergia grandiflora, Tinospora cordifolia* and various other species of *Dioscorea, Rosa, Rubus*, etc. *Gnetum montanum*, although very rare in the biosphere reserve, often twins over the *Dipterocarpus retusus*.

The epiphytic flora in these forests is poor. Species like *Asplenium nidus, Microsorium punctatum, Cymbidium aloifolium, Huperzia squarrosa, Dendrobium aphyllum, D. nobile, Pothos scandens*, etc are some of the common epiphytes. *Psilotum nudum*, a very rare saprophytic fern, occurs in deep forest and is facing extinction in the area due to over exploitation for academic purposes.

2. Moist deciduous forests

This is one of the most common forest types throughout the reserve. In these forests, the deciduous species predominate over the evergreen ones and form the top canopy. Depending on the habitat condition and various species composition, the forests can be categorized into (a) forest occurring in high alluvial land with *Terminalia myriocarpa* formation, (b) forest occurring in low alluvial land with *Bischofia javanica Dillenia indica* formation and (c) the forest occurring in the water logged areas with gregarious and pure formation of *Salix tetrasperma*.

(a) Forests occurring in high alluvial land

The soil in these forest is rich in organic matters and provides habitat for diverse plant species. Most common tree species are *Anthocephalus chinensis, Artocarpus chama, Bischofia javanica, Canarium resiniferum, Dalbergia sissoo, Dillenia indica, Dysoxylum binectariferum, Ficus altissima, F. racemosa, F. rumphii, F. rigida, Garcinia cowa, G. morella, G. pedunculata, Syzygium tetragonum, Terminalia bellirica, T. myriocarpa, Vatica lanceaefolia*, etc. However in these forests, *Terminalia myriocarpa* often occurs as a sporadic tree, but *Bischofia javanica* and *Dysoxylum binectariferum* occur gregariously. In certain areas, *Lagerstroemia speciosa* and *Bischofia javanica* form extensive pure formations. Occasionally *Tetrameles nudiflora, Sapium baccatum* and *Bombax ceiba* appear as top canopy elements.

A typical green cover is formed in these areas consisting of certain species like, *Antidesma bunius, Ardisia floribunda, Callicarpa macrophylla, C. longifolia, Celastrus paniculatus, Cordia dichotoma, Croton joufra, Ficus hispida, F. racemosa, Glochidion assamicum, Litsea salicifolia, Mussaenda roxburghii, Tragia hispida, T. involucrata*, etc. Underneath of this cover grow profusely the smaller species like *Boehmeria macrophylla, Costus speciosus, Leea trifoliata, Pavetta indica, Pouzolzia bennettiana, P. viminea, Psychotria denticulata, P. fulva, P. montana, Spilanthes acmella*, etc. in association with *Alpinia nigra* and few species of grasses.

(b) Forests occurring in low alluvial land

The soil in these forests is characterized by high content of sand and pebbles. The humus deposit is very low. This is because of the fact that frequent flood denudate such areas. The vegetation is represented by the hardy tree species that has adapted to overcome such a situation. Extensive and gregarious patches of the tree species like *Dalbergia sissoo* on the northern part, *Tamarix dioica* on the eastern part and the mixture of *Bischofia javanica, Dillenia indica* and several species of *Ficus* along with occasional occurrence of *Salix tetrasperma* on the south and south western parts of the biosphere reserve are very significant.

At this situation, the trees are exposed to direct sunlight and climbing fern, *Stenochlaena palustris* grows profusely on *Bischofia javanica.*

The herbaceous flora is almost absent except for a few species of grasses and other ephemeral herbs.

(c) Forests occurring along water logged areas

The perennial water bodies in the form of various rivulets (*Jan*) and large ponds (*beel*), created as a result of the great earthquake within the reserve, provide habitat for luxuriant growth of *Cephalanthus occidentalis, Ficus retusa, Pegia nitida, Salix tetrasperma*, etc. *Salix tetrasperma* grows gregariously throughout the biosphere reserve in water-logged areas. This is a significant aspect of the vegetation in the reserve. However, *Ficus retusa* along with *Cephalanthus occidentalis* and *Barringtonia acutangula* occur sporadically. Further, it is interesting to note that the entire trunk, measuring more than 5 meters in length along with the aerial roots of *Ficus* species remain submerged in water throughout the year and sustain by only exposing the crown above the water level. At places, the depth of water measures up to 10 meters deep. This phenomenon of life support system in the reserve is a matter requiring special investigation.

The exposed tree trunks including the branches are covered with a variety of epiphytic orchids. Important orchid species are *Aerides multiflora, Cymbidium aloifolium, Dendrobium transparens, Papilionanthe teres, Rhynchostylis retusa*, etc. *Hoya globulosa, H. parasitica* and *Huperzia squarrosa* are some of the other common epiphytes. Often all these species grow together on same branch and provide a gorgeous look when they flower during the month of April-June.

A large part of these forests is poorly stocked and comes under the category of open areas. However, tangled mass of bamboos, e.g. *Bambusa balcooa, B. pallida, B. tulda*, etc. and canes, namely *Calamus erectus, C. flagellum, C. floribundus, C. latifolius, C. leptospadix, C. tenuis* and *Plectocomia assamica* in association with *Smilax macrophylla* and *S. prolifera* have rendered such open areas almost impenetrable. Tree species like *Castanopsis indica, Cedrela toona, Dillenia indica, Ficus retusa, Lithocarpus listeri, Litsea polyantha, Saurauia napaulensis, S. roxburghii, Sterculia coccinea, Ziziphus jujuba*, etc. occur sporadically amidst the bamboo and cane brakes.

3. Swamps and Marshes

Swamps and marshes are the most interesting features of the vegetation in the reserve. Quite a large number of water bodies are found in the core area that includes the river system, wild seasonal streams, permanent water logged areas with surrounding swamps. Each of these represents diverse and luxuriant aquatic vegetation. Owing to the suitable physio-climatic conditions including high rainfall and wide range of tolerance towards the habitat, the aquatic plants are widely distributed. The pattern of species and intra-specific association is rather regular throughout the area and grow gregariously in the aquatic system.

Salix tetrasperma constitutes as main element of the swamps and grows gregariously throughout the area. Other associated trees are *Bischofia javanica, Dillenia indica, Cephalanthus occidentalis, Pegia nitida* and several species of *Ficus*.

The swamps and marshes are also characterized by the presence of various floating hydrophytes. *Eichhornia crassipes* dominates throughout in both running and stagnant waters. In the stagnant water, however, species of *Lemna* and *Pistia* dominate in association with *Azolla pinnata, Hygroryza aristata, Salvinia natans, Trapa bispinosa* and *Trapa natans*, etc. Other species like, *Ceratophyllum demersum, Hydrilla verticillata, Ottelia alismoides, Limnophila heterophylla, Nymphaea nouchali, Potamogeton crispus, P. pectinatus, Sagittaria sagittifolia, Utricularia aurea, Vallisneria gigantea, V. spiralis*, etc. are some of the important submerged hydrophytes with their floating leaves in the stagnant waters. *Nymphoides hydrophylla* is another species that grows gregariously as free-floating hydrophyte. Extensive patch of floating mass along the marshes is formed by the species like *Arundo donax* in association with *Alpinia* and *Phrynium*. *Eurylae ferox* and *Nelumbo nucifera* grow in the shallow water and submerged crop field in the buffer areas.

The amphibious hydrophytes commonly found in the drains and ditches are *Alocasia fornicata, Alpinia malaccensis, A. nigra, Alternanthera philoxeroides, Enhydra fluctuans, Monochoria hastata, Schumannianthus dichotomus, Schoenoplectus juncoides, S. grossus, Typha elephantina, Xanthium indicum*, etc.

4. Grasslands

Extensive riparian type of grassland is yet another characteristic type of vegetation. These provide habitat for a wide range of wild lives. The vegetation remains nearly under water in most of the places during rainy season and the permanent water level remains within the reach of the root system almost throughout the year. Species like, *Apluda mutica, Arundo donax, Saccharum longisetosum, S. ravennae, Imperata cylindrica, Phragmites karka, Microstegium ciliatum, Saccharum spontaneum*, etc. are some of the tall grasses extensively occur in association with the smaller species like, *Axonopus compressus, Cyanotis vaga, Cynodon dactylon, Eleusine indica*, etc. In the grassland, there are some large and small tree species grow significantly. *Anthocephalus chinensis, Bischofia javanica, Dillenia indica, Duabanga grandiflora, Lagerstroemia speciosa, Randia fasciculata, Ziziphus jujuba*, etc. are some of the common plants grow sporadically. However in Churke *chapori*, extensive and gregarious *Tamarix dioica* formation in association with profuse *Citrus indica* bushes amidst grassland are very interesting which provides the only habitat for the feral horses. It was stated by some of the local villagers of Kolia *chapori* that in the past *Ophioglossum reticulatum* grew abundantly amidst grasses. Presently the species is not seen in such habitat and the physiography of Kolia *chapori* has also been changed to a large extent as a result of regular and severe flood havoc.

FLORISTIC DIVERSITY

The diversity of biological resources of the biosphere reserve was not known till Sarma (1996) provided an enumeration of wild lives wherein he has also mentioned 78 numbers of dominant tree species. The flora of Dibru-Saikhowa biosphere reserve has not been studied in detail and the exact number of species occur in the area is uncertain. During the course of two reconnaissance surveys carried out by the authors in the buffer and core area of the reserve, *ca* 525 species of plants were recorded

(Table IV). However, this is not a final statistics of the flora of the region. The number will increase after thorough and extensive surveys are conducted. It was observed that although the number of species content is slightly low as compared to the neighbouring areas, their gregarious occurrence in the entire reserve is very significant. It is due to the fact that the vegetation is of secondary nature and the habitat is mostly aquatic. Besides the aquatic species, certain terrestrial tree species have also adapted to grow in the aquatic system and constitute the interesting elements in the flora of the biosphere reserve.

Table IV
Statistics of the Flora

Group	No. of families	No. of genera	No. of species
Angiosperms			
Dicots	87	190	396
Monocots	21	43	75
Gymnosperms	7	9	9
Pteridophytes	15	26	45
Total	**130**	**268**	**525**

Angiosperms

Angiosperms are characterized by lesser number of gregarious trees than the herbaceous species. The seasonal succession of the herbaceous species is very high. As stated earlier, this is because of the fact that the area is subjected to frequent denudation by the repeated flood. As a result, most of the herbaceous elements are ephemeral and perish soon before they are known. However, careful and frequent visit to these areas will yield an interesting result.

Out of *ca* 17,500 taxa of flowering plants known from India, 3,017 species are recorded from Assam (Baishya, 1999). District wise distribution of these plants have been worked out for a few districts by several floristic researchers from Gauhati University namely, Kamrup (1309 spp.), Karbi-Anglong (431 spp.), Lakhimpur (604 spp.), Sibsagar

(1115 spp.) and Tinsukia (1256 spp.), etc. But the studies on the floristics of various protected areas are not carried out in this part of the country in detail except for Hajra and Jain (1996).

A perusal of the flora of Dibru-Saikhowa Biosphere Reserve reveals that out of 471 species of angiosperms recorded from the area, 396 species are dicots and 75 species are monocots. This indicates the ratio between monocots to dicots as 1:5.28, which is almost nearer to the world ratio (Table V).

Table V
Ratio of Monocots to Dicots

Ratio	Dibru-Saikhowa Biosphere	Tinsukia dist.	Assam	India	World
Monocot: Dicot	1 : 5.28	1 : 3.96	1 : 2.96	1 : 2.3	1 : 5.88

A comparative analysis of the genera and species based on the available data pertaining to 10 largest families are represented in the table VI. It indicates that the family Poaceae with 23 species belonging to 17 genera is the largest of all. Within the family, the genus *Saccharum* with 3 species forms the major component of the grassland vegetation.

Gymnosperms

Gymnosperms are poorly represented in the flora of Dibru-Saikhowa Biosphere Reserve. *Gnetum montanum*, a very important element of the evergreen forests, occasionally occurs in the *Dipterocarpus* forest. *Podocarpus neriifolius* is a very rare species in the area. However, in the fringe areas of the reserve, *Araucaria cookii*, *Cephalotaxus griffithii*, *Cryptomeria japonica*, *Cycas revoluta*, *Juniperus communis*, *Pinus kesiya* and *Thuja orientalis* are grown in the Tea gardens.

Cryptogams

Information on the cryptogamic flora is wanting. Extensive and gorgeous wetland of the reserve serves as a storehouse of diverse algal

Table VI
Largest families in the flora of Dibru-Saikhowa Biosphere Reserve and their comparison

Family	Dibru-Saikhowa		Tinsukia dist.		Assam		India	
	Genera	Species	Genera	Species	Genera	Species	Genera	Species
Poaceae	17	23	53	76	83	212	264	1291
Asteraceae	15	20	50	69	66	127	166	803
Fabaceae	14	18	36	65	68	171	167	1141
Euphorbiaceae	12	17	23	49	45	102	84	523
Rubiaceae	12	16	26	47	55	127	113	616
Acanthaceae	8	11	12	43	18	87	92	500
Cyperaceae	5	9	10	39	15	81	38	545
Lamiaceae	5	8	15	38	15	56	72	435
Araceae	4	7	17	30	18	47	29	126
Moraceae	4	6	4	27	4	39	13	122

flora. Several blue-green algae and other species of Chlorophyceae in these habitats would provide ample scope for study of this group of plants.

Lichens are represented by several foliose species. As most of the tree species remain submerged under water throughout the year, the diversity of lichens is poor. However, in the fringe areas, the flora is diverse as the host plants are of various natures. The study of lichens in the tea gardens will be very much challenging.

Pteridophytes are also not well represented. But one cannot miss the sight of the dense growth of climbing fern, *Stenochlaena palustris* on each and every tree trunks. It is really interesting to see such a profuse growth of the species in the reserve. The young shoots of this fern are eaten as green vegetable. On sandy habitats near water, *Equisetum debile* and *E. diffusum* grow profusely in certain areas. Among the epiphytic species *Asplenium nidus, Microsorium punctatum, Huperzia squarrosa, Phlegmariurus phlegmaria, Pyrrosia* spp., etc. are common. *Azolla, Ceratopteris* and *Salvinia* are important components in the aquatic ecosystem.

Primitive vascular plants

Occurrence of several species of primitive plants (Table VII) testifies the flora of the area as remnant of the luxurious tropical wet evergreen forests of the past. The significant occurrence of these plants provides sufficient indication of the cradle of flowering plants in Assam.

Table VII
List of primitive species
(Species are in alphabetical order)

Botanical name	Family
Pteridophytes	
Angiopteris evecta	Angiopteridaceae
Botrychium daucifolium	Ophioglossaceae
Cyathea gigantea	Cyatheaceae
Dicranopteris linearis	Gleicheniaceae
Dipteris wallichii	Dipteridaceae

Botanical name	Family
Equisetum debile	Equisetaceae
E. diffusum	Equisetaceae
Helminthostachys zeylanica	Ophioglossaceae
Ophioglossum reticulatum	Ophioglossaceae
Psilotum nudum	Psilotaceae
Gymnosperms	
Gnetum montanum	Gnetaceae
Podocarpus neriifolius	Podocarpaceae
Angiosperms	
Alseodaphne andersonii	Lauraceae
Altingia excelsa	Hamamelidaceae
Cinnamomum bejolghota	Lauraceae
Chloranthus serratum	Chloranthaceae
Dillenia indica	Dilleniaceae
Dipterocarpus retusus	Dipterocarpaceae
Litsea polyantha	Lauraceae
L. salicifolia	Lauraceae
Magnolia griffithii	Magnoliaceae
M. hodgsonii	Magnoliaceae
Michelia baillonii	Magnoliaceae
Mitrephora tomentosa	Annonaceae
Nymphoides hydrophylla	Menyanthaceae
Pegia nitida	Anacardiaceae
Polyalthia longifolia	Annonaceae
P. simiarum	Annonaceae
Persea bombycina	Lauraceae
Saurauia napaulensis	Saurauiaceae
S. roxburghii	Saurauiaceae
Vatica lanceaefolia	Dipterocarpaceae

ECONOMIC IMPORTANCE OF THE FLORA

The reserve abounds in several economically important plants. Utility of a majority of the plant species are still remained untapped as the area is not properly explored and inhabited by the backward ethnic groups of people. Sustainable exploitation of these may lead to the social and economic upliftment of the rural folks living in the area. Many wild plants occurring in the area are useful in different aspects of life of the common people. Such plants are listed in the following categories.

Medicinal plants

A number of medicinal plants occur in the area. Most of these plants are used in folk medicines, in Ayurvedic or in Unani system. Some of the commonly used medicinal plants are listed in the Table VIII.

Table VIII
List of medicinal plants

Botanical name	Family
Abroma augusta	Sterculiaceae
Abrus precatorius	Fabaceae
Abutilon indicum	Malvaceae
Acacia catechu	Fabaceae
Acorus calamus	Araceae
Achyranthes aspera	Amaranthaceae
Aegle mermelos	Rutaceae
Ageratum conyzoides	Asteraceae
Albizia odoratissima	Fabaceae
Alpinia nigra	Zingiberaceae
Alstonia scholaris	Apocynaceae
Amaranthus spinosus	Amaranthaceae
Andrographis paniculata	Acanthaceae
Artemisia vulgaris	Asteraceae
Asparagus racemosus	Liliaceae

Botanical name	Family
Averrhoa carambola	Averrhoaceae
Boerhavia diffusa	Nyctaginaceae
Borreria articularis	Rubiaceae
Calotropis gigantea	Asclepiadaceae
Cannabis sativa	Cannabinaceae
Cassia alata	Fabaceae
C. fistula	Fabaceae
C. tora	Fabaceae
Cardiospermum halicacabum	Sapindaceae
Catharanthus roseus	Apocynaceae
Centella asiatica	Apiaceae
Chenopodium album	Chenopodiaceae
Chrysopogon aciculatus	Poaceae
Cissampelos pareira	Menispermaceae
Citrus indica	Rutaceae
Cleome viscosa	Capparaceae
Clerodendrum colebrookianum	Verbenaceae
Corchorus aestuans	Tiliaceae
Costus speciosus	Zingiberaceae
Crotalaria anagyroides	Fabaceae
Datura metel	Solanaceae
Dillenia indica	Dilleniaceae
Dioscorea spp.	Dioscoreaceae
Drymaria cordata	Caryophyllaceae
Dysoxylum binectariferum	Meliaceae
Eclipta prostrata	Asteraceae
Eleusine indica	Poaceae
Enhydra fluctuans	Asteraceae
Entada rheedii ssp. *sinohimalensis*	Mimosaceae
Eupatorium odoratum	Asteraceae

Botanical name	Family
Garcinia cowa	Clusiaceae
G. pedunculata	Clusiaceae
Hedyotis diffusa	Rubiaceae
Holarrhena pubescens	Apocynaceae
Houttuynia cordata	Saururaceae
Hyptis suaveolens	Lamiaceae
Jatropha curcas	Euphorbiaceae
Adhatoda zeylanica	Acanthaceae
Leucas aspera	Lamiaceae
Mimosa pudica	Fabaceae
Mangifera indica	Anacardiaceae
Mirabilis jalapa	Nyctaginaceae
Mucuna pruriens	Fabaceae
Murraya koenigii	Rutaceae
Ocimum sanctum	Lamiaceae
Oldenlandia corymbosa	Rubiaceae
Paederia foetida	Rubiaceae
Phyllanthus emblica	Euphorbiaceae
Physalis minima	Solanaceae
Plantago major	Plantaginaceae
Pongamia pinnata	Fabaceae
Portulaca oleracea	Portulacaceae
Rauvolfia serpentina	Apocynaceae
Ricinus communis	Euphorbiaceae
Sida acuta	Malvaceae
S. cordifolia	Malvaceae
S. rhombifolia	Malvaceae
Solanum indicum	Solanaceae
S. nigrum	Solanaceae
S. torvum	Solanaceae
Spilanthes acmella	Asteraceae
Spondias pinnata	Anacardiaceae

Botanical name	Family
Stellaria media	Caryophyllaceae
Stephania glandulifera	Menispermaceae
Streblus asper	Moraceae
Terminalia bellirica	Combretaceae
T. chebula	Combretaceae
Tinospora cordifolia	Menispermaceae
Vernonia cinerea	Asteraceae
Vitex negundo	Verbenaceae
Ziziphus mauritiana	Rhamnaceae

Wild edible plants

The flora of the reserve also consists of several edible plants (Table IX). Villagers use these plants either as vegetables or for their edible fruits, beside being used as herbal medicine.

Table IX
List of wild edible plants

Botanical name	Parts used as
Achyranthes aspera	Leafy vegetable
Alocasia fornicata	Tubers and whole Plant vegetables
Alternanthera sessilis	Leafy vegetable
Ampelocissus barbata	Fruits
Antidesma acidum	Fruits
A. acuminatum	Fruits
Ardisia humilis	Fruits
Artocarpus chama	Fruits
A. lakoocha	Fruits

Botanical name	Parts used as
Baliospermum montanum	Fruits
Bambusa tulda	Young shoots as vegetable
Basella alba	Leafy vegetable
Calamus tenuis	Young shoots as vegetable
Chenopodium album	Leafy vegetable
Clerodendrum colebrookianum	Leafy vegetable
Colocasia esculenta	Leaves and tubers as vegetable
Corchorus capsularis	Leafy vegetable
Cuscuta reflexa	Whole plant as vegetable
Diospyros lanceaefolia	Fruits
Drymaria cordata	Whole plant as vegetable
Eryngium foetidum	Leafy vegetable
Ficus glomerata	Young shoots as vegetable
Ficus hirta	Young shoots as vegetable
Flacourtia jangomas	Fruits
Garcinia cowa	Fruits
G. morella	Fruits
G. pedunculata	Fruits
Houttuynia cordata	Leafy vegetable
Ipomoea aquatica	Leafy vegetable
Lasia spinosa	Young leaves as vegetable
Maesa indica	Fruits
Melastoma malabathricum	Fruits
Melochia corchorifolia	Leafy vegetable
Monochoria hastata	Young shoots as vegetable
Murraya koenigii	Fruits and leaves
Oxalis corniculata	Leafy vegetable
Polycarpon prostratum	Leafy vegetable

Botanical name	Parts used as
Portulaca oleracea	Leafy vegetable
Rubus alceaefolius	Fruits
Sarcochlamys pulcherrima	Leafy vegetable
Smilax prolifera	Tender shoots as vegetable
Solanum nigrum	Fruits
Stellaria media	Leafy vegetable
Syzygium tetragonum	Fruits
Trapa bispinosa	Fruits

Other economic plants

There is a great potential for establishing the forest-based industries depending upon the various available species. The tree species occur in the area may boost in besides Plywood industry, several other cottage industries like match box making, boat making, musical instruments and cricket bat making and making of furniture and house-hold structures, etc.

Plywood industry: *Dalbergia assamica, D. sissoo, Dipterocarpus mannii, D. retusus, Gmelina arborea, Lagerstroemia speciosa, Mesua ferrea, Terminalia bellirica, T. myriocarpa*, etc. are some of the much utilized timber yielding species growing in the reserve. Some of these plants are also commonly cultivated in certain selected areas. There are several wild tree species in the reserve, which can be utilized for the plywood industry. *Bischofia javanica, Bombax ceiba, Castanopsis indica, Cinnamomum bejolghota, Cryptocarya amygdalina, Duabanga grandiflora, Ficus retusas, F. rumphii, Mangifera indica, Polyalthia longifolia, Sterculia villosa, Syzygium* spp. and *Vatica lanceaefolia*, etc are some of the important wild species.

Match box industry: Species like *Albizia lebbeck, A. odoratissima, A. procera, Bombax ceiba, Erythrina stricta, Kydia calycina, Toona ciliata* and various bamboo species can be used for making of match stick and boxes.

House hold structures and Boat making: The village people residing in the fringe and other neighbouring villages generally use the timber of *Altingia excelsa, Artocarpus chama, Dillenia indica, Lagerstroemia speciosa*, etc. for making their boat which is the only mode of communication in the area. The villagers also use these wild species for various durable furniture and other household structures.

Musical instruments: The local inhabitants manufacture various musical instruments, such as *Dotara, Tintara* and other similar items from the wood of *Altingia excelsa, Terminalia chebula*, etc.

The wood of *Salix tetrasperma* (*Bhe*) is the only indigenous source in the country for making of cricket bat. Abundance of the plant in the area might boost in establishing the cottage industry for making cricket bat.

Schumannianthus dichotomus (*Pati-doi*) is yet another species grows in abundance in the area extremely used as raw material for making mat.

Dye yielding plants

The local people use quite a few wild plants for preparation of dye for various purposes. A few such plants are listed in the table X.

Table X
List of dye yielding plants

Colours	Name of species	Parts used
Black	*Magnolia hodgsonii, Pithecolobium dulce*	Leaves
Crimson	*Mirabilis jalapa*	Leaves
Red	*Lawsonia inermis, Punica granatum*	Leaves
	Erythrina stricta, Hibiscus rosa-sinensis	Flowers
	Bixa orellana	Fruits
Violet	*Basella rubra*	Fruits
Yellow	*Curcuma longa, Morinda angustifolia*	Rhizome/ roots

Fibre yielding plants

Besides numerous cultivated species, several wild plants also yield different kinds of fibre which are used by the local people for their domestic purposes. Some of these fibres also have great potential commercial value. Such plants are listed in table XI.

Table XI
List of fibre yielding plants

Botanical name	Family	Fibre used
Abelmoschus esculentus	Malvaceae	Bast fibre
Abroma augusta	Sterculiaceae	Bast fibre
Abutilon indicum	Malvaceae	Bast fibre
Aeschynomene indica	Fabaceae	Bast fibre
Ananas comosus	Bromeliaceae	Leaf fibre
Areca catechu	Arecaceae	Leaf sheath fibre
Artocarpus lakoocha	Moraceae	Bast fibre
Bauhinia purpurea	Caesalpiniaceae	Bast fibre
Bixa orellana	Bixaceae	Bast fibre
Bombax ceiba	Bombacaceae	Leaf sheath and mesocarp fibre
Butea monosperma	Fabaceae	Bast fibre
Calotropis gigantea	Asclepiadaceae	Bast fibre
Caryota urens	Arecaceae	Leaf sheath fibre
Cocos nucifera	Arecaceae	Leaf sheath and mesocarp fibre
Corchorus capsularis	Tiliaceae	Bast fibre
Cordia dichotoma	Ehretiaceae	Bast fibre
Ficus benghalensis	Moraceae	Bast fibre
F. religiosa	Moraceae	Bast fibre
Grewia laevigata	Tiliaceae	Bast fibre
Grewia multiflora	Tiliaceae	Bast fibre
Hibiscus rosa-sinensis	Malvaceae	Bast fibre

Botanical name	Family	Fibre used
Hibiscus schizopetalus	Malvaceae	Bast fibre
Imperata cylindrica	Poaceae	Bast fibre
Kydia calycina	Malvaceae	Bast fibre
Melochia corchorifolia	Sterculiaceae	Bast fibre
Phoenix sylvestris	Arecaceae	Leaf fibre
Pongamia pinnata	Fabaceae	Bast fibre
Sansevieria roxburghiana	Haemodoraceae	Leaf fibre
Schumannianthus dichotomus	Marantaceae	Bast fibre
Sida acuta	Malvaceae	Bast fibre
Sida cordifolia	Malvaceae	Bast fibre
Sida rhombifolia	Malvaceae	Bast fibre
Sterculia villosa	Sterculiaceae	Bast fibre
Trema orientalis	Ulmaceae	Bast fibre
Triumfetta rhomboidea	Malvaceae	Bast fibre
Urena lobata	Malvaceae	Bast fibre

Rare and endangered plants

Based on the information gathered by the Botanical Survey of India and Assam Science Society for the flora of Assam, a list of rare and endangered plants of the biosphere reserve is compiled (Table XII).

Table XII
Rare and endangered plants

Botanical name	Family	Status
Angiopteris evecta	Angiopteridaceae	Rare
Helminthostachys zeylanica	Helminthostachyaceae	Rare
Dipteris wallichii	Dipteridaceae	Very rare
Cyathea gigantea	Cyatheaceae	Rare
Psilotum nudum	Psilotaceae	Very rare, probably extinct

Botanical name	Family	Status
Aponogeton appendiculatus	Aponogetonaceae	Endangered
A. natans	Aponogetonaceae	Endangered
Costus speciosus	Zingiberaceae	Endangered
Dendrobium nobile	Orchidaceae	Rare
Dioscorea alata	Dioscoreaceae	Rare
D. bulbifera	Dioscoreaceae	Threatened
Entada rheedii ssp. *sinohimalensis*	Fabaceae	Rare
Hydnocarpus kurzii	Flacourtiaceae	Endangered
Holarrhena pubescens	Apocynaceae	Endangered
Magnolia griffithii	Magnoliaceae	Rare
Rauvolfia serpentina	Apocynaceae	Rare & Endangered
Dischidia benghalensis	Asclepiadaceae	Rare
Zingiber zerumbet	Zingiberaceae	Very rare

PHYTOGEOGRAPHICAL AFFINITIES

The aspect of phytogeography should be studied in the context of the historical geomorphology of the region. Ancient Gondwana land and the Great Ice Age, both have influenced the formation of the present day flora of the region as a whole. Being a part of the Gondwana land, the flora shows relationship with that of Malayasia and Peninsular India and to some extent with that of the African elements. The relationship can be illustrated by an enumeration of some of the common taxa at generic or species level.

Several Sino-himalayan genera occur in the area are *Camellia, Eurya, Hoya, Maesa, Magnolia, Michelia, Saurauia*, etc. *Gnetum montanum, Osbeckia nepalensis, Oxyspora paniculata, Ranunculus hirtellus, Schima wallichii*, etc. are some of the common species migrated from China to this region besides several species of Pteridophytes such as, *Adiantum flabellulatum, Cibotium barometz, Cyathea gigantea, Diplazium bentamense, D. esculentum, Onychium japonicum, Pteris semipinnata, Pronephrium nudatum* etc.

The Malayasian elements that occur in the region are *Aristolochia bracteolata, Catharanthus roseus, Cordia dichotoma, Ixora barbata, Nerium indicum, Plumbago rosea, Vitex trifolia*, etc.

Some of the species belonging to the genera like *Boehmeria, Deeringia, Pholidota*, etc. are distributed from Asia to Australia and New Zealand. Pteridophytic species like *Angiopteris evecta, Antrophyum reticulatum, Blechnum orientale, Diplazium dilatatum, Nephrolepis cordifolia, Pteris ensiformis, Salvinia cucullata, Stenochlaena palustris*, etc. occurring in the area also belong to the cosmopolitan distribution.

Species like *Alstonia scholaris, Cissus quadrangularis, Emilia sonchifolia, Enhydra fluctuans, Leea crispa* and various other species belonging to the genera *Albizia, Atylosia, Elatostema, Flacourtia, Gerbera, Meyna, Phoenix*, etc. have the affinity towards the African flora.

The flora of the region also has significant affinity to the flora of the New World. Species like *Barleria cristata, Cassia alata, C. occidentalis, C. sophera, Chenopodium ambrosioides, Duranta repens, Eichhornia crassipes, Heliotropium indicum, Maranta bicolor, Mirabilis jalapa, Scoparia dulcis*, etc. are the native of the New World besides the genera like *Aralia, Buddleja, Houttuynia, Helianthus, Sapindus, Zanthoxylum*, etc.

ENDEMISM

Due to insufficient information on the flora of Dibru-Saikhowa biosphere reserve, the status of endemism cannot be ascertained. However, on completion of detail explorations, a few endemics known from the Upper Assam belt of wet evergreen forests may be found in the area.

THREATS AND CONSERVATION MEASURES

It is evident that the area was a part of Upper Assam wet evergreen forest belt with *Dipterocarpus* as one of the dominant species beside others. The forest department was regularly operating in the area for timber extraction that had resulted in clearing of large forest area (Anonymous, 1998). The situation was further aggrieved due to the great earthquake of 1950 during which a large area was sunk by a few meters resulting in the physiographical change. As a result, the entire area of the present biosphere reserve is undergoing dynamic secondary succession.

The problem of encroachment for settlement of human population is a common phenomenon everywhere in the country and Dibru-Saikhowa is not an exception. The people residing in the fringe villages are wholly dependant on the reserve for their sustenance. The forest villages located in Laika and Dodhia have encroached upon a large area, although it is stated to be under negotiation with the civil authorities to shift these villages from the core area of the reserve. Besides encroachment, cattle rearing and grazing in the reserve is yet another problem. The flora and vegetation are greatly affected by the presence of numerous cattle sheds, locally known as '*khuti*'s, owned by certain community. Fishing, poaching and illegal felling of the timber on which the people of the area mostly depend for their livelihood should be taken care of for preserving the biodiversity. Above all the biotic factors, constant flood havoc will remain an unsolvable natural factor in Dibru-Saikhowa.

Considering the above constraints some strategies have to be evolved for preserving the wealth of biosphere reserve from further deterioration. Such strategies should involve people's participation. The active participation of the NGO(s) will be more useful in this direction. *Dibru-Saikhowa Wild Life Society* in association with the *Nature's Beckon* of Assam, is one such example devoting its efforts to the objectives of preservation of biological diversity of this wonderful reserve.

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Changing course of river Dibang at Dhola. Continuous erosion of village in fore ground, far end is Kolia Chapori.

Salix- Bischofia swamp at Kolomi Chapori.

Bischofia javanica and secondary scrub along Salbeel area.

Pure formation of *Terminalia myriocarpa*

View of the relic evergreen patch in the reserve.

Dipterocarpus retusus-becoming rare in the area.

Stenochlaena palustris on *Bischofia javanica*.

Lagerstroemia speciosa - a majestic evergreen element.

Canarium resiniferum- cultivated in Dighaltarang village.

Nymphoides cristatum with white flowers.

Aponogeton natans with submerged leaves.

Utricularia aurea with bright yellow flowers.

Hoya globulosa hangs on *Ficus* spp.

Pholidota imbricata along with *Lycopodium* spp. on *Bischofia javanica.*

Ficus rumphii in Gelabeel - crown above the water surface.

Clerodendrum serratum

Cymbidium aloifolium

Cinnamonum obtusifolium

Baringtonia acutangula

DIHANG - DIBANG BIOSPHERE RESERVE

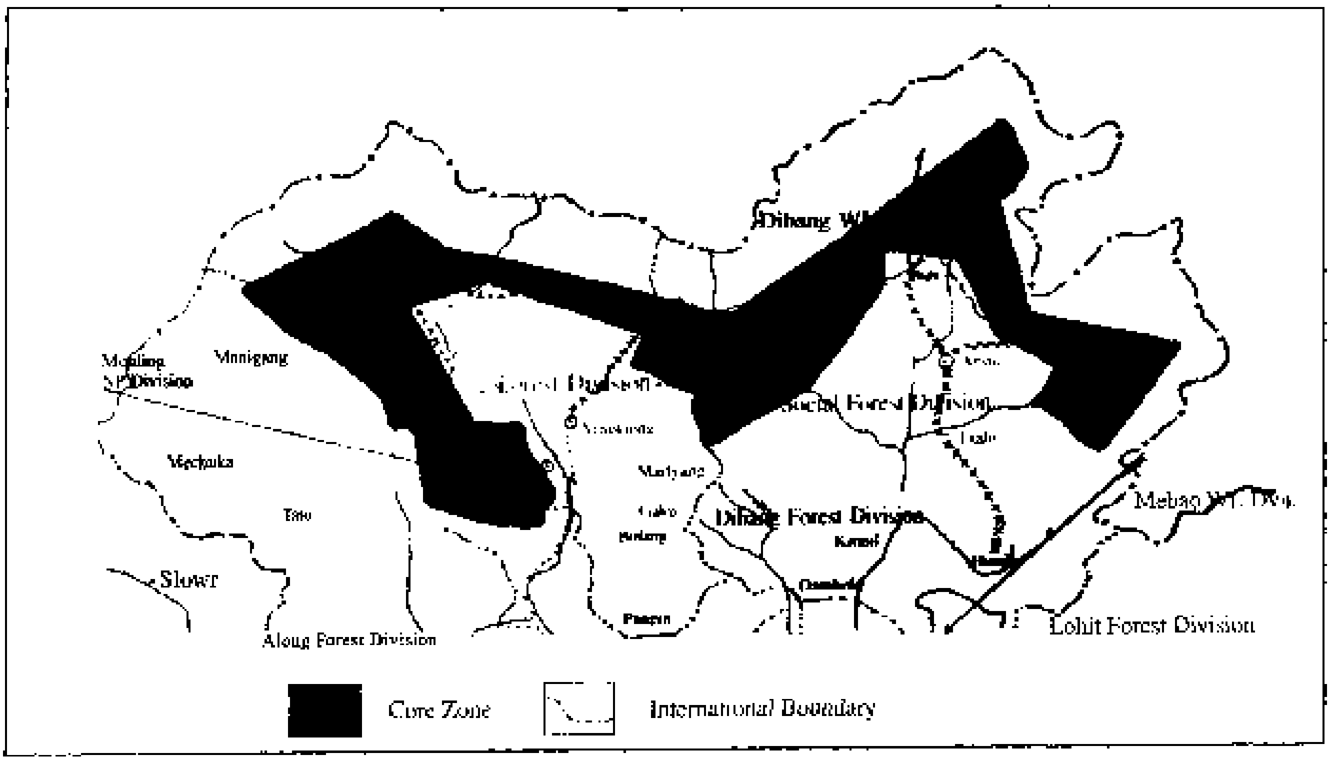
V. Mudgal
M.K. Pathak
M. Bhaumik

Dihang-Dibang Biosphere Reserve was established on 2nd September, 1998 with a total area of 5111.50 sq. km. Out of this, an area of 4094.80 sq. km is comprised of core zone and remaining 1016.70 sq. km buffer zone. The biosphere reserve falls under 10 administrative circles of the four districts, namely, Dibang Valley, East Siang, West Siang and Upper Siang in the state of Arunachal Pradesh. It includes Dibang Wildlife Sanctuary (4194 sq. km), Mouling National Park (483 sq. km) and some adjacent areas. Almost entire area is forested. The biosphere derives its name from two principal rivers, the Dihang and Dibang (Anonymous 1998, 1999; Melkania 1999).

The topography of the biosphere reserve is extremely variable. The area is rugged with steep hills in Dibang valley district, while Siang part is characterized by the beautiful, gentle and wide valley of Siyom on one hand and imposing gorge of the Siang river on the other. The ranges along the northern border have permanent ice fields and glacial lakes. Altitude varies from 500 to over 6000 m. The lower hills witness dense evergreen forests and a large number of rivers and rivulets. The important rivers are Awa, Chinipani, Dibang, Dri, Mattun, Siang, Siyom, Tangon, etc.

The soil is predominantly acidic and rich in humus with high percentage of nitrogen. The soil has thick layer of organic matter as a result of huge quantity of rotting/decaying plant materials. The erosion and deposition by rivers have resulted in a sandy to sandy loam, clayey soil mixed with heterogeneous matrix in some places.

Climate in the biosphere reserve varies from place to place. The area falls under the regions of heaviest rainfall in the country. The average annual rainfall is estimated 2,579 mm in Dibang Valley. The average annual temperature varies between 9.7°C (January) and 24.9°C (September). In winter months it goes below 0°C in upper reaches. Relative humidity ranges from 76% (April) to 87% (August).



Map: Dihang-Dibang Biosphere Reserve (source : P. Ringu, 2002)

Arunachal Pradesh has over 25 major tribes. Some major tribes residing in and around the biosphere reserve are Bokars, Pallibos, Membas, Khambas, Boris, Ashings, Shimongs, Gallongs, Minyongs, Idu (Mishmi) and Adi.

Some important festivals of the local people are Aran or Pombi, Mopun, Solung, Mopin and Reh. Hunting and fishing are their main occupations. In some areas people follow traditional jhum cultivation. In jhum land they grow maize, rice, millet and other vegetables.

Owing to difficult topography and inaccessibility, it is amongst least botanically explored areas of the country. H. Wilcox explored the Mishmi hills in 1826. Griffith followed the same track of H. Wilcox and explored Mishmi hills from October to December in 1836. He published 'Flora of Mishmi Hills', which deals with 900 spp. of angiosperms and 22 species of ferns and fern allies. The botany of 'Abor hills' was published by Burkill (1924, 1925). Similarly explorations were also carried out in 'Mishmi hills' and 'Lohit Valley' that were published subsequently by Kingdon-Ward (1929, 1931, 1953).

Botanical Survey of India, Eastern circle, Shillong surveyed especially the Siang part of the biosphere reserve. Further, Arunachal Pradesh field station also carried out some explorations in the lower regions. Significant contributions were made by Mudgal and Jain (1980), Hajra *et al.* (1996), Chowdhery (1997, 1998, 1999), Pathak *et al.* (1997, 2000) and Pramanik (1998). Pathak and Bhaumik also carried out extensive surveys from different parts of the biosphere reserve between the years 1996 and 2001 and made exhaustive collections. The studies on these collections are continued.

VEGETATION

The biosphere reserve boasts a huge variety of landforms ranging from plains, highlands to snowy peaks. The great altitudinal variation has further added to the diversity of this region. A wide variety of vegetation patterns ranging from grassland to alpine vegetation are found. The mosses and epiphytes are abundant on trees. These virgin forests are very diverse with no human interference. The vegetation pattern along the right bank of the river Mattun is worth mentioning when one moves to Mipidoh and Biyanli from Anini. Here hills with dense forests alternate with grasslands (lofty grasses with some ferns and members of Asteraceae), separated by the patches of pine forests. The same can also be observed when one approaches Maliyne from Italin. The rich vegetation of the biosphere reserve has prompted to propose Dibang part of the biosphere reserve (Dibang Valley dist.) as a 'Hot Spot' (Chowdhery, 1997) of the plant diversity.

Based on altitudinal variations and climatic conditions, the vegetation of the reserve could broadly be grouped into tropical forests (up to 900 m), subtropical forests (900-1800 m), temperate forests (1800-2800 m), subalpine forests (2800-3500 m) and alpine forests (3500 m and above). These are briefly dealt below as the studies in the biosphere reserve are still continued.

Tropical forests

These forests are spread at lower elevations and occur along the northern bank of Tongon river near Athunli, meeting point of Emra and E-Ason rivers in Anelih, meeting point of Edron and Tangon rivers, etc. The area receives heavy rainfall, relatively high summer temperature and mild cold in winter months. These forests are full of economically important plant species. They exhibit tiered arrangement and have an impenetrable herbaceous under growth, particularly during rainy season. The tiers are dense, close together, with tall boles carrying the wide spread canopy to the mountain height. Common tree species found here are *Gmelina arborea, Pterocarpus acerifolium, Duabanga grandiflora, Sapindus mukorossi, Aglaia spectabilis, Magnolia hookeri, M. hodgsonii, Michelia baillonii, Crateva magna, Schima wallichii, Kydia calycina, Fermiana colorata, Sterculia guttata, S. urens, S. villosa, Elaeocarpus aristatus, E. glandulosus, Solanea dasycarpa* var. *assamica, Euodia glabrifolia, Chukrasia tabularis, Toona ciliata, T. microcarpa, Meliosma simplicifolia, Syzygium assamicum, Crypteronia paniculata, Haldinia cordifolia, Litsea cubeba, L. mishmiensis, Persea fructifera. Sapium baccatum, Ficus benjamina, F. hirta* var. *roxburghii, F. semicordata, Engelhardtia spicata,* etc.

In many places, the tree ferns with tall stems and a crown of huge leaves occur gregariously. The shrubby species of these forests are *Desmos chinensis, D. longiflorus, Polyalthia cerasoides, Trivalvaria* *argentea, Capparis tenera, Casearia vareca, Polygala arillata, Eurya acuminata, Saurauia punduana, Sterculia hamiltonii, Citrus aurantium, C. limon, Clausena excavata, Glycosmis cymosa, Paramigyna griffthii, Aglaia edulis, Dobinea vulgaris, Crotalaria alata, Desmodium multiflorum, Flemingia macrophylla, Tephrosia candida, Cotoneaster bacillaris, Prunus persica, Rubus lucens, R. niveus, R. rosifolius, Medinilla himalayana, Melastoma malabathricum, Osbeckia nepalensis, Oxyspora paniculata, Heteropanax fragrans, Sambucus hookeri, Ixora subsessilis, Mycetia nepalensis, Psychotria aborensis, Ardisia virens, Wrightia coccinea, Buddleja candida, Phlogacanthus tubiflorus, Strobilanthes burkillii, Clerodendrum colebrookeanum, C. griffithianum, Dracaena angustifolia, Smilax ovalifolia, Pinanga gracilis,* etc.

The ground flora of these forests is full of herbaceous species like *Cardamine hirsuta, Thlaspi montanum, Viola betonicifolia, V. hamiltoniana, Drymaria diandra, Impatiens bracteolata, I. tripetala, I. urticifolia, I. violaeflora, Mollugo pentaphylla, Eryngium foetidum, Spiradiclis bifida, Anaphalis contorta, Campanula pallida, Pratia montana, Heliotropium strigosum, Lindernia anagallis, Chirita mishmiensis, C. urticaefolia, Rungia parviflora, Gomphostemma aborensis, Plectranthus melissoides, Plantago erosa, Cyathula prostrata, Persicaria chinensis, Houttuynia cordata, Elatostema acuminatum, Procris crenata,* etc. besides several species of sedges and grasses.

These forests also exhibit rich diversity of terrestrial orchids. Some such species are *Arundina graminifolia, Calanthe masuca, C. plantaginea, Cheirostylis griffithii, Diplomeris pulchella, Eulophia bicallosa, Geodorum densiflorum, Goodyera foliosa, G. grandis, Liparis paradoxa, Malaxis acuminata, Phaius tancarvilleae, P. woodfordii, Platanthera clavigera,* etc.

These forests are infested by a large number of climbers and lianas. Among common climbers are *Clematis cadimia, Cissampelos pareira, C. pareira* var. *hirsuta, Cyclea bicristata, Parabaena sagittata, Stephania glabra, Aspidiopterys nutans, Miquelia kleinii, Natsiatum herpeticum, Cissus repens, Tetrastigma bracteolatum, Actinostemma tenerum, Benincasa hispida, Melothria maderaspatana, Trichosanthes cordata, T. tricuspidata, Hedyotis scandens, Paederia foetida, Rubia* *sikkimensis, Codonopsis affinis, Argyreia argentea, Merremia hederacea, M. vitifolia, Piper curtistipes, Dioscorea bulbifera, D. glabra, D. hamiltonii, D. hispida* var. *daemona, D. wattii, Stemona tuberosa, Smilax orthoptera, Pothos cathcartii, P. scandens, Rhaphidophora decursiva, R. hookeri* and others.

Among woody climbers, species like *Clematis gouriana, C. smilacifolia, Naravelia zeylanica, Fissistigma bicolor, Diploclisia glaucescens, Haematocarpus validus, Tinospora cordifolia, Capparis multiflora, Stixis suaveolens, Bytteria grandiflora, Cissus assamica, Tetrastigma planicaule, Sabia lanceolata, Pueraria thunbergiana, Bauhinia scandens, B. vahlii, Acacia pennata, Beaumontia grandiflora, Erycibe paniculata, Thunbergia coccinea, Dioscorea oppositifolia, Heterosmilax japonica, Smilax lanceaefolia.* and others are seen.

Forest structure is incomplete without the mention of epiphytes. Almost every tree is covered by herbaceous epiphytic growth. These include orchids, ferns, Piper, aroids, mosses, member of Gesneriaceae and others. Some of these are *Agapetes griffithii. A linearifolia, Vaccinium sprengellii, Aeschynanthus acuminatus, Aerides multiflorum, Bulbophyllum careyanum, B. protractum, B. scabratum, Ceratostylis subulata, Cleisostoma aspersum, Coelogyne fuscescens, Cymbidium bicolor, Dendrobium aphyllum, D. chrysotoxum, D. falconeri, D. fimbriatum, D. hookerianum, Eria acervata, Luisia filiformis, Oberonia ensiformis, O. falconeri, Phalaenopsis parishii, Saccolabiopsis pusilla, Smitinandia micrantha, Thunia alba, Trichotosia pulvinata, Tylostylis discolor, Vanda bicolor,* etc.

Subtropical forests

These forests occur between 900 and 1800 m altitude. They are dense, almost impenetrable and have more modest sized trees. The components of these forests are *Magnolia griffithii, M. pterocarpa, Michelia champaca, M. doltsopa, Desmos praecox, Garcinia stipulata, Schima wallichii, Reevesia wallichii, Elaeocarpus varunus, Hovenia dulcis, Acer acuminatum, Meliosma dillenifolia, Prunus cerasoides, Macropanax dispermus, Alangium chinense, Canthium glabrum, Wendlandia grandis, Sarcosperma griffithii, Ehretia wallichiana, Knema linifolia, Alseodaphne andersonii, Cinnamomum bejolghota,* *Litsea cubeba, Ficus hookeriana, Engelhardtia roxburghiana, Arenga pinnata, Livistona jenkinsiana, Pandanus furcatus* var. *macrocarpa*, etc.

The under growth in these forests is composed of a large number of shrubby and herbaceous species. A few of them are *Trivalvaria argentea, Camellia caudata, Toddalia asiatica, Euonymous lawsonii, Aglaia edulis, Allophylus serratus, Dobinea vulgaris, Photinia intergrifolia, Rubus ellipticus, Osbeckia rostrata, Psychotria monticola, Ophiorrhiza ochroleuca, Mycetia nepalensis, Agapetis angulata, Inula eupatorioides, Gaultheria codonantha, Maesa rugosa, Buddleja asiatica, Daphne involucrata, Ficus subincisa. Didymosperma nana*, etc.

Ground flora of the subtropical forests is indeed full of herbaceous species. Some common and interesting elements of these forests are *Corydalis pseudolongipes, Thlaspi montanum, Viola canescens, V. inconspicua, V. pogonantha, Polygala erioptera, P. sibirica, Salomonia cantoniensis, Impatiens bicornuta, Potentilla nepalensis, Epilobium cylindricum, Begonia nepalensis, Oenanthe javanica, Aster sikkimensis, Pepromia heyneana, Pilea anisophylla, Alpinia nigra, Amomum maximum, Cautleya gracilis, Curcuma amada, Globba multiflora, Zingiber purpureum, Musa balbisiana, Disporum cantoniense, Paris polyphylla, Tupistra clarkei, Curculigo crassifolia, Tacca integrifolia, Commelina maculata, Murdannia loriformis, Pollia hasskarlii, Ropalephora scaberrima, Tricarpelema thomsonii, Juncus ochraceus, Alocasia indica, Arisaema concinnum, Lasia spinosa, Carex baccans, Cyperus cyperoides, C. laxus, Eleocharis tetraquetra, Fimbristylis falcata, Kyllinga brevifolia, Agrostis griffithiana, Arundinella bengalensis, Arundo donax, Ichnanthus vicinus, Panicum incisum, Paspalum scrobiculatum, Phragmites karka, Pogonatherum paniceum, Polypogon monspeliensis*, etc.

These forests also exhibit rich diversity of epiphytic orchids. A few of them are *Agrostophyllum brevipes, Esmeralda cathcartii, Bulbophyllum affine, Cleisostoma paniculatum, Coelogyne barbata, C. rigida, Dendrobium fimbriatum, D. nobile, Eria bambusifolia, Gastrochilus distichus, Kingidium taenialis, Liparis bistriata, Oberonia acaulis, O. emarginata, Otochilus albus, Spiranthes sinensis, Vanda cristata*, etc.

Among subtropical terrestrial orchids, species like *Anoectochilus sikkimensis, Anthogonium gracile, Calanthe angusta, Cheirostylis griffithii, Eulophia bicallosa, Galeola falconeri, G. lindleyana, Goodyera schlechtendaliana, Haberaria dentata, Herpysma longicaulis, Liparis cathcartii, Malaxis muscifera, Phaius woodfordii*, etc. are commonly found.

Temperate forests

These forests are found in cold climatic regions ranging from altitude 1800 - 2800 m and the area receives moderately high rainfall. These forests are represented by tree species like *Acer acuminatum, A. laevigatum, A. pectinatum, A. sikkimensis* var. *serrulatum, Prunus cerasoides, Brassaiopsis aculeata, Canthium glabrum, Symplocos cochinchinensis, Lindera neesiana, Castanopsis lancifolia, Lithocarpus dealbata, L. elegans, Quercus lamelosa, Populus ciliata*, etc.

Shrubby vegetation is quite dense in temperate forests and comprises *Eupetalea pleiosperma, Polygala arillata, Hypericum uralum, Saurauia punduana, Zanthoxylum acanthopodium, Euonymus theifolius, Cotoneaster bacillaris, Photinia integrifolia, Spirea callosa, Dichroa febrifuga, Hydrangea robusta, Osbeckia crinita, Luculia gratissima, Gaultheria hookerii, Rhododendron arboreum* ssp. *delavayi* var. *peramoenum, R. calastrotum* ssp. *riparium, R. cephalanthum, R. griffithianum, R. tephropeplum, Vaccinium forrestii, Strobilanthes divaricatus, Wallichia triandra*, etc.

The ground floor is covered by herbaceous species such as *Aconitum lethale, Coptis teeta, Corydalis pseudolongipes, Viola canescens, Stellaria uliginosa, Potentilla nepalensis, P. peduncularis, Astilbe rivularis, Epilobium cylindricum, Begonia silkkimensis, Adenostemma lavenia, Blumea lacinata, Dichrocephala integrifolia, Gnaphalium affine, Myriactis nepalensis, Pratia montana, Torenia violacea, Lecanthus peduncularis, Ophiopogon intermideus, Paris polyphylla, Polygonatum cathcartii, Streptopus simplex, Curculigo crassifolia, Juncus inflexus, Arisaema decipiens*, etc.

These forests abound in various kinds of epiphytes. Some epiphytic orchids are *Bulbophyullum cauliflorum, Calanthe chloroleuca, Coelogyne corymbosa, Cymbidium elegans, Dendrobium candidum,* *Goodyera vittata, Habenaria dentata, Liparis cathcartii, Malaxis muscifera, Neottia acuminata, Oberonia acaulis, Pleione hookeriana,* etc.

Coniferous forests are extensive in this region. They are confined at higher elevations on mountain slopes and certain places in patches. However, pure formations of coniferous forests have not been observed so far. In Malinye, Alembro, Mipidoh, Alinye, Chigupani and Bruini the coniferous forests are of mixed type. Among the gymnosperms, *Pinus* spp. and *Taxus baccata* ssp. *wallichiana* are most common.

Subalpine and alpine forests

These forests are found in the northern side of the biosphere and have fair representation of shrubby species and alpine ephemerals. The vegetation is scarce. Plants of this area complete their life cycle in short span of time. During the favourable season, they produce beautiful and bright coloured flowers to attract insect pollinators.

Bushes, creeping shrubs, herbs and grasses are predominant here that serve as a source of many medicinal plants. Some of the plants growing in this region are *Aconitum ferox, A. lethale, Coptis teeta, Viola glaucescens, Cotoneaster bacillaris, Potentilla peduncularis, Bergenia purpurascens, Dipsacus atratus, Aster albescens, Gnaphalium hypoleucum, Dichrocephala integrifolia, Veronia cineriea, Gaultheria hookerii, G. seshagiriana, Rhododendron calostrotum* ssp. *riparium, R. cephalanthum, R. exasperatum, R. pemakoense, R. pumilum, Lysimachia prolifera, Gentiana speciosa, Calanthe chloroleuca, Gymnadenia orchidis, Herminium longilobatum, Platanthera bakeriana, Arisaema rhizomatum,* etc.

Grasslands

Most of the grasslands arise due to jhuming in the periphery of the reserve. Numerous grasses invade such areas afterwards. Some of them are *Themeda villosa, Saccharum ravennae, Paspalum scrobiculatum, Miscanthus nepalensis, Imperata cylindrica, Capillipedium assimile, Neyraudia reynaudiana,* etc.

Bamboo forests

These forests are found almost in all the vegetation types. Some common bamboo species found here are *Bambusa pallida, B. tulda, Chimonocalamus griffithianus, Dendrocalamus giganteus, D. hamiltonii, D. hookeri, D. sikkimensis, D. strictus, Dinochloa maclellandii, Neomicrocalamus mannii, Schizostachyum fuchsianum, S. helferi, S. polymorphum, P. pallidum,* etc.

Degraded forests

The impact of both biotic and abiotic factors on the forests has resulted into degraded forests. Degraded forests show low species diversity. Common species found here are *Oroxylum indicum, Duabanga grandiflora, Saurauia nepalensis, S. roxburghii, Bauhinia purpurea, Macranga peltata, Eurya acuminata, Maesa indica, Clerodendrum colebrookieanum, Callicarpa arborea, Mikania micrantha,* etc.

GYMNOSPERMS

The sub-tropical and temperate zones of the biosphere reserve provide an ideal habitat for the rich growth of gymnosperms. The following species reported from here are *Abies densa, A. spectabilis, Amentotaxus assamica, Cephalotaxus griffithii, Gnetum montanum, Juniperus recurva, Larix griffithiana, Tsuga dumosa, Taxus wallichiana, Pinus armandi, P. merkusii, P. spinulosa, Cupressus torulosa,* etc. (Beniwal & Haridasan, 1992).

PHYTOGEOGRAPHICAL AFFINITIES

The flora of the Dihang-Dibang Biosphere Reserve shows close affinity with the tropical southeast Asian-Malayan and temperate Himalayan-Chinese and Japanese floras. Besides, it also bears some affinity with peninsular India, Srilanka and Euro-Siberian floras.

South-East Asian - Malaysian affinities

Flora of Myanmar, Thailand, Indo-China, Malaysia and Indonesia bears a close affinity with the biosphere reserve flora. Some common elements found are *Hodgsonia macrocarpa, Crateva magna, Engelhardtia* *spicata, Duabanga grandiflora, Exbucklandia populnea, Firmiana colorata, Oroxylum indicum, Actinidia callosa, Lithocarpus elegans. Tetrameles nudiflora, Bischofia javanica, Toona sureni, Musa balbisiana, Eria paniculata, Hedychium coccineum*, etc.

Himalayan-Chinese-Japanese affinities

The biosphere reserve provides the meeting ground for many temperate Chinese-Japanese elements. Some elements like *Magnolia campbellii, Michelia doltsopa, Litsea cubeba, Betula alnoides, Millettia pachycarpa, Rhododendron neriifolium, Stachyurus himalaicus, Lindera pulcherrima, Mahonia nepaulensis, Tsuga dumosa*, etc. are common to both north west himalaya and eastern himalaya. *Juncus inflexus, Polygala sibirica, Stellaria uliginosa* etc. are Euro-Siberian elements in the biosphere reserve.

FLORISTIC DIVERSITY

Flora of Dihang-Dibang Biosphere Reserve is very rich. Most of its area is still unexplored on account of difficult and unapproachable terrain. In the present state of knowledge the statistics of the flora is presented below (Table I).

Table I
Statistics of the flora

Group	Family	Genera	Species
Angiosperms	162	779	1801
Dicots	137	581	1278
Monocots	25	198	523
Gymnosperms	05	10	13

A conspectus of angiosperm families showing diversity of genera and species is given also (Table II) below.

Table II
A conspectus of families showing number of genera and species

Family	Genera	Species
Ranunculaceae	6	10
Dilleniaceae	2	2
Magnoliaceae	3	16
Illiciaceae	1	1
Eupteleaceae	1	1
Annonaceae	8	14
Menispermaceae	11	17
Berberidaceae	1	1
Podophyllaceae	1	1
Lardizabalaceae	1	1
Fumariaceae	2	
Brassicaceae	3	6
Capparaceae	3	6
Violaceae	1	8
Flacourtiaceae	4	4
Polygalaceae	2	7
Xanthophyllaceae	6	9
Tamaricaceae	2	2
Hypericaceae	1	2
Clusiaceae	3	6
Theaceae	5	10
Actinidiaceae	1	4
Stachyuraceae	1	1
Dipterocarpaceae	3	3
Malvaceae	8	11
Bombacaceae	1	1
Sterculiaceae	7	13
Tiliaceae	3	6
Elaeocarpaceae	2	7
Linaceae	2	2

Family	Genera	Species
Malpighiaceae	2	5
Geraniaceae	1	1
Balsaminaceae	1	15
Oxalidaceae	1	2
Rutaceae	10	20
Simaroubaceae	2	3
Burseraceae	2	4
Meliaceae	7	16
Dichapetalaceae	1	1
Olacaceae	3	5
Icaciniaceae	3	3
Aquifoliaceae	1	1
Celastraceae	4	8
Hippocrateceae	1	1
Rhamnaceae	5	8
Vitaceae	4	15
Leeaceae	1	5
Sapindaceae	4	6
Hippocastanaceae	1	1
Aceraceae	1	6
Sabiaceae	11	15
Moringaceae	1	1
Connaraceae	1	1
Fabaceae	35	62
Caesalpiniaceae	6	14
Mimosaceae	3	12
Rosaceae	10	28
Saxifragaceae	4	4
Hydrangeaceae	1	1
Crassulaceae	2	2
Hamamelidaceae	3	3
Rhizophoraceae	1	1
Combretaceae	3	7

Family	Genera	Species
Hernandiaceae	1	1
Myrtaceae	3	10
Melastomataceae	8	20
Lythraceae	1	3
Crypteroniaceae	1	1
Sonneratiaceae	1	1
Onagraceae	2	4
Passifloraceae	1	1
Cucurbitaceae	15	25
Begoniaceae	1	14
Cactaceae	1	1
Tetramelaceae	1	1
Molluginaceae	1	1
Apiaceae	6	7
Araliaceae	9	17
Connaraceae	1	1
Alangiaceae	1	1
Caprifoliaceae	4	10
Rubiaceae	34	64
Valerianaceae	2	2
Dipsacaceae	1	1
Asteraceae	32	55
Campanulaceae	4	13
Ericaceae	6	37
Plumbaginaceae	1	1
Primulaceae	1	3
Myrsinaceae	6	24
Sapotaceae	2	3
Ebenaceae	1	2
Styracaceae	2	2
Symplocaceae	1	1
Oleaceae	5	10
Apocynaceae	9	9

Family	Genera	Species
Asclepiadaceae	4	7
Loganiaceae	1	1
Buddlejaceae	1	2
Gentianaceae	5	6
Boraginaceae	9	11
Convolvulaceae	6	13
Solanaceae	7	22
Scrophulariaceae	14	23
Gesneriaceae	13	28
Bignoniaceae	2	2
Pedaliaceae	1	1
Acanthaceae	10	40
Verbenaceae	8	17
Lamiaceae	21	38
Plantaginaceae	1	2
Nyctaginaceae	1	1
Amranthaceae	7	13
Chenopodiaceae	1	2
Phytolaccaceae	1	1
Polygonaceae	6	20
Rafflesiaceae	1	1
Aristolochiaceae	1	1
Piperaceae	2	21
Saururaceae	1	1
Chloranthaceae	2	2
Myristicaceae	1	1
Lauraceae	9	27
Proteaceae	2	2
Thymelaeaceae	4	10
Loranthaceae	2	5
Balanophoraceae	2	2
Euphorbiaceae	24	35
Urticaceae	15	43

Family	Genera	Species
Ulmaceae	2	2
Canabinaceae	1	1
Moraceae	5	34
Juglandaceae	1	2
Myricaceae	1	1
Fagaceae	3	14
Betulaceae	2	2
Salicaceae	3	4
Hydrocharitaceae	2	2
Orchidaceae	64	224
Zingiberaceae	8	26
Costaceae	1	1
Marantaceae	1	3
Musaceae	1	6
Iridaceae	1	1
Liliaceae	10	17
Hypoxidaceae	1	4
Agavaceae	2	3
Taccaceae	1	1
Dioscoreaceae	1	13
Stemonaceae	1	1
Smilaceae	2	12
Pontederiaceae	2	3
Commelinaceae	12	16
Juncaceae	1	5
Arecaceae	7	16
Pandanaceae	1	1
Araceae	11	34
Lemnaceae	2	2
Aponogetonaceae	1	1
Eriocaulaceae	1	1
Cyperaceae	14	44
Poaceae	50	87

An analysis of families in table II presents an interesting data pertaining to the diversity of species and genera in the biosphere as shown below.

(i) Generic diversity under families

Families	with	1	genus	65
Families	with	2	genera	27
Families	with	3	genera	13
Families	with	4	genera	09
Families	with	5	genera	05
Families	with	6-10	genera	23
Families	with	11-15	genera	09
Families	with	16-20	genera	00
Families	with	21-30	genera	02
Families	with more than 30		genera	05

(ii) Species diversity under families

Families	with	1	species	42
Families	with	2	species	22
Families	with	3	species	10
Families	with	4	species	07
Families	with	5	species	03
Families	with	6-10	species	23
Families	with	11-20	species	27
Families	with	21-30	species	09
Families	with	31-40	species	06
Families	with	41-50	species	02
Families	with	51-75	species	03
Families	with	75-100	species	01
Families	with more than 100		species	01

Similarly important data also emerge when an analysis of species diversity with in genera is made.

Species diversity within genera

Genera	with	01	species	463
Genera	with	02	species	136
Genera	with	03	species	61
Genera	with	04	species	39
Genera	with	05	species	29
Genera	with	06-10	species	31
Genera	with	11-15	species	09
Genera	with	16-20	species	05
Genera	with	21-30	species	02
Genera	with	31-50	species	01

An account of dominant families by number of species is also given (Table III).

Table III
Twenty dominant families by number of species

Family	No. of species
Orchidaceae	224
Poaceae	87
Rubiaceae	64
Fabaceae	62
Asteraceae	55
Cyperaceae	44
Urticaceae	43
Acanthaceae	40
Lamiaceae	38
Ericaceae	37
Euphorbiaceae	35
Araceae	34
Moraceae	34
Rosaceae	28
Gesneriaceae	28
Lauraceae	27

Family	No. of species
Zingiberaceae	26
Cucurbitaceae	25
Myrsinaceae	24
Scrophulariaceae	23

Twenty dominant families by number of genera are given in table IV.

Table IV
Twenty dominant families by number of genera

Family	No. of species
Orchidaceae	64
Poaceae	50
Fabaceae	35
Rubiaceae	34
Asteraceae	32
Euphorbiaceae	24
Lamiaceae	21
Cucurbitaceae	15
Urticaceae	15
Cyperaceae	14
Scrophulariaceae	14
Gesneriaceae	13
Commelinaceae	12
Menispermaceae	11
Araceae	11
Rutaceae	10
Rosaceae	10
Acanthaceae	10
Liliaceae	10
Araliaceae	09

Family	No. of species
Boraginaceae	09
Apocynaceae	09
Lauraceae	09

Twenty dominant genera by number of species are given in table V.

Table V
Twenty dominant genera by number of species

Genera	No. of species
Dendrobium	31
Ficus	28
Bulbophyllum	20
Piper	19
Eria	19
Coelogyne	18
Rhododendron	17
Carex	16
Begonia	14
Liparis	14
Dioscorea	14
Elatostema	13
Cymbidium	12
Arisaema	12
Oberonia	10
Calanthe	09
Ophiorhiza	09
Agapetes	09
Litsea	09
Hedychium	09

A comparative account of dominant families in Dihang-Dibang Biosphere Reserve, Arunachal Pradesh, Eastern Himalaya, N.E. Region, India and Myanmar is given in the table VI.

Table VI
Comparative account of dominant families of Dihang-Dibang biosphere reserve and adjacent regions

Dihang-Dibang Biosphere Reserve	Arunachal Pradesh (Chowdhery *et al.*, 1999)	E. Himalaya (Hooker, 1906)	N.E. Region (Rao & Murti, 1990)	India (Hooker, 1906)	Myanmar (Hooker, 1906)
Orchidaceae	Orchidaceae	Orchidaceae	Poaceae	Orchidaceae	Orchidaceae
Poaceae	Leguminosae (s.l.)	Poaceae	Orchidaceae	Leguminosae (s.l.)	Leguminosae (s.l.)
Rubiaceae	Asteraceae	Leguminosae	Leguminosae (s.l.)	Poaceae	Poaceae
Fabaceae	Rubiaceae	Compositae	Asteraceae	Rubiaceae	Rubiaceae
Asteraceae	Ericaceae	Cyperaceae	Cyperaceae	Euphorbiaceae	Euphorbiaceae
Cyperaceae	Poaceae	Urticaceae	Labiatae	Acanthaceae	Acanthaceae
Urticaceae	Urticaceae	Scrophulariaceae	Scrophulariaceae	Compositae	Cyperaceae
Acanthaceae	Rosaceae	Rosaceae	Acanthaceae	Cyperaceae	Urticaceae
Lamiaceae	Cyperaceae	Rutaceae	Euphorbiaceae	Labiatae	Asteraceae
Ericaceae	Euphorbiaceae	Euphorbiaceae	Rubiaceae	Urticaceae	Scitamineae

ENDEMISM

As the survey of the biosphere reserve is continued, no comprehensive account of endemic flora is available. Species which are either endemic to Arunachal Pradesh or north east India or adjoining regions found in the biosphere reserve are given on (Table VII).

Table VII
Endemic plants of Arunachal Pradesh, northeast India and adjoining areas found in the biosphere reserve

Botanical name	Family
Aboriella myriantha	Moraceae
Acanthus leucostachyus	Acanthaceae
Acer oblongum var. *microcarpum*	Aceraceae
A. sikkimensis var. *serrulatum*	Aceraceac
Aconitum lethale	Ranunculaceae
Agapetes marginata	Ericaceae
A. nutans	Companulaceae
A. refracta	Ericaceae
Aglaia edulis	Meliaceae
Albizia arunachalensis	Mimosaceae
Arachnis cathcartii	Orchidaceae
Aschyanthus parasiticus	Gesneriaceae
Bauhinia ovatifolia	Caesalpiniaceae
Begonia aborensis	Begoniaceae
B. iridescens	Begoniaceae
B. scintillans	Begoniaceae
Bulbophyllum orantissimum	Orchidaceae
Calamus leptospadix	Arecaceae
Calanthe densiflora	Orchidaceae
Camellia siangensis	Theaceae
Capparis pachyphylla	Capparaceae
Ceratostylis subulata	Orchidaceae

Botanical name	Family
Chirita mishmiensis	Gesneriaceac
Cissus assamica	Vitaceae
Clerodendrum lasiocephalum	Verbinaceae
Codonopsis affinis	Companulaceae
Coptis teeta	Ranunculaceae
Cuculigo crassifolia	Hypoxidaceae
Cymbidium hookerianum	Orchidaceac
Dalbergia oliveri	Fabaceae
Dendrobium cathcartii	Orchidaceae
D. hookerianum	Orchidaceae
D. sulcatum	Orchidaceae
Desmodium likabalium	Fabaceae
Didymosperma nana	Arecaceae
Dioscorea laurifolia	Dioscoreaceae
D. wattii	Dioscoreaceae
Diplomeris pulchella	Orchidaceae
Dipsacus atratus	Dipsacaceae
Dumasia villosa	Fabaceae
Dysoxylum pallens	Meliaceae
Elatostema imbricans	Urticaceae
E. macintyrii	Urticaceae
Eria clausa	Orchidaceac
E. ferruginea	Orchidaceae
E. lohitensis	Orchidaceae
Esmeraldia cathcartii	Orchidaceae
Galeola falconeri	Orchidaceae
G. lindleyana	Orchidaceae
Garcinia acuminata	Clusiaceae
Globba multiflora	Zingiberaceae
Glycosmis cymosa	Rutaceae
Herminium longilobatum	Orchidaceae

Botanical name	Family
Hopea shingkeng	Dipterocarpaceae
Impatiens bracteolata	Balsaminaceae
I. laevigata	Balsaminaceae
I. mishmiensis	Balsaminaceae
Indigofera nigrescens	Fabaceae
Leycesteria dibangvalliensis	Caprifoliaceae
Lindera neesiana var. *griffithii*	Lauraceae
Liparis assamica	Orchidaceae
L. distans	Orchidaceae
L. plantaginea	Orchidaceae
Litsea mishmiensis	Lauraceae
Livistona jenkinsiana	Arecaceae
Lobelia mishmica	Companulaceae
Loxostigma griffithii	Gesneriaceae
Luculia pinceana	Rubiaceae
Lysimachia congestiflora forma *santapaui*	Primulaceae
Maesa nayarii	Myrsinaceae
Magnolia baillonii	Magnoliaceae
M. griffithii	Magnoliaceae
M. insignis	Magnoliaceae
Michelia doltsopa	Magnoliaceae
Miliusa dolichantha	Annonaceae
Musa velutina	Musaceae
Mycetia radiciflora	Rubiaceae
Oberonia acaulis	Orchidaceae
Paphiopedilum wardii	Orchidaceae
Peliosanthes teta ssp. *humilis*	Liliaceae
Phlogacanthus gracilis	Acanthaceae
P. parviflorus	Acanthaceae
P. tubiflorus	Acanthaceae

Botanical name	Family
Pilea insolens	Urticaceae
Polynura geminata	Rubiaceae
Prenanthes scandens	Asteraceae
Primula mishmiensis	Primulaceae
Psychotria aborensis	Rubiaceae
P. burkillii	Rubiaceae
Pueraria bella	Fabaceae
Pyrenaria barringtonifolia	Theaceae
Rhaphidophora hookerii	Araceae
Rhododendron dalhousiae var. *rhabdotum*	Ericaceae
R. pemakoense	Ericaceae
R. tephropeplum	Ericaceae
Rhynchotechum calycinum	Gesneriaceae
Rubus burkillii	Rosaceae
Sadiria subsessilifolia	Myrsinaceae
Sauropus stipulatus	Euphorbiaceae
Sonerila arunachalensis	Melastomataceae
Spiradiclis bifida	Rubiaceae
S. cylindrica	Rubiaceae
Strobilanthes aborensis	Acanthaceae
Syzygium aborense	Myrtaceae
S. mishmiensis	Myrtaceae
Tetrastigma obovatum	Vitaceae
Trichodesma khasianum	Boraginaceae
Tylostylis discolor	Orchidaceae
Viola pogonantha	Violaceae
Vitis planicaulis	Vitaceae
Wallichia triandra	Arecaceae
Xanthophyllum burkilli	Xanthophyllaceae
Zanthoxylum burkillianum	Rutaceae

PRIMITIVE ANGIOSPERMS

Dihang-Dibang Biosphere Reserve is storehouse of a large number of primitive genera. A list of some such genera is given in table VIII.

Table VIII
Primitive angiosperms

Family	Genera	No. of species in the biosphere reserve
Annonaceae	*Alphonsea*	1
	Artabotrys	1
	Desmos	3
	Fissistigma	3
	Miliusa	2
	Mitrephora	1
	Polyalthia	1
	Trivalvaria	1
Chloranthaceae	*Chloranthus*	1
Dilleniaceae	*Tetracera*	1
Eupateleaceae	*Eupatelea*	1
Hammamelidaceae	*Altingia*	1
	Corylopsis	1
	Exbucklandia	1
Illiciaceae	*Illicium*	1
Lardizabalaceae	*Holbellia*	1
Lauraceae	*Alseodaphne*	1
	Bellschmiedia	2
	Cinnamomum	4
	Cryptocarya	1
	Lindera	1
	Litsea	9

Family	Genera	No. of species in the biosphere reserve
	Persaea	4
	Phoebe	3
Magnoliaceae	*Magnolia*	8
	Michelia	7
	Pachylarnax	1
Menispermaceae	*Aspidocarya*	1
	Haematocarpus	1
	Pycnarrhena	1
Myristicaceae	*Knema*	1
Saururaceae	*Houttuynia*	1

RARE AND THREATENED TAXA

Indiscriminate exploitation of plant resources and loss of natural habitats are the main causes of depletion of flora. A number of rare and threatened species surviving in the biosphere reserve are *Coptis teeta*, *Fissistigma rubiginosum*, *Capparis pachyphylla*, *Acer laevigatum*, *A. oblongum* var. *microcarpum*, *A. sikkimensis* var. *serrulatum*, *Lagerstroemia minuticarpa*, *Begonia burkillii*, *B. scintillans*, *Psychotria aborensis*, *Codonopsis affinis*, *Rubus calophyllus*, *Balenophora dioica*, *Sapria himalyana*, *Costus speciosus*, *Rheum nobile*, *Saurauia griffithii*, *Aquilaria malaccensis*, *Podophyllum hexandrum*, *Taxus wallichiana*, *Arachnis cathcartii*, *Cymbidium hookerianum*, *Diplomeris pulchella*, *Galeola lindleyana*, *G. falconeri*, *Liparis distans*, *Dioscorea laurifolia*, *Cyathea* spp. (tree fern), etc.

ECONOMICALLY IMPORTANT PLANTS

The flora of Dihang-Dibang Biosphere Reserve contains a large number of economically important plants such as medicinal plants, ornamental plants, wild relatives of cultivated crop plants, timber and other species.

Medicinal Plants

The biosphere reserve contains a large number of medicinal plant species. Some such species are *Alpinia alughas, Alstonia scholaris, Acorus calamus, Clematis gouriana, Coptis teeta, Dillenia indica, Michelia champaca, Illicium griffithii, Tinospora cordifolia, Cissampelos pareira, Mahonia napaulensis, Podophyllum hexandrum, Gynocardia odorata, Hydnocarpus kurzii, Polygala sibirica, Portulaca oleracea, Sida acuta, Urena lobata, Oxalis corniculata, Impatiens tripetala, Zanthoxylum acanthopodium, Toddalia asiatica, Murraya paniculata, Paramignya griffithii, Garuga pinnata, Euonymus tingens, Sapindus mukorossi, Spondias pinnata, Cassia occidentalis, Bauhinia vahlii, Rubus moluccanus, Cotoneaster microphyllus, Terminalia arjuna, T. bellirica, T. chebula, Osbeckia crinita, Trichosanthes cordata, Begonia rex, Opuntia monocantha, Hydrocotyle himalaica, Hedera helix, Haldina cordifolia, Mussaenda glabrata, Valeriana grandiflora, Vernonia cineria, Plumbago zeylanica, Maesa indica, Olea dioica, Exacum tetragonum, Gentiana speciosa, Cordia obliqua, Solanum nigrum, S. ferox, Scoparia dulcis, Oroxylum indicum, Strobilanthes orbiculatus, Phlogacanthus thyrsiflorus, Ajuga bracteosa, Plantago major, Rheum nobile, Aristolochia indica, Piper betle, P. longum, P. pepuloides, Cinnamomum tamala, Lindera neesiana, Viscum articulatum, Aquilaria malaccensia, Phyllanthus indica, Ficus benjamina, F. hetrophylla, Betula alnoides, Populus ciliata, Amomum aromaticum, Hedychium coronarium, Costus speciosus, Musa velutina, Tacca integrifolia, Dioscorea pentaphylla, Floscopa scandens, Caryota urens, Pothos scandens, Arundinella nepalensis, Arundo donax, Coix lachryma-jobi, Vetiveria zizanioides, Alpinia malaccensis, Curcuma amada, C. aromaticum, C. longa, Cymbidium aloefolium, Murdannia nudiflora,* etc.

Ornamental Plants

A large number of wild ornamental plants also occur in the reserve. These ornamental plants include Orchids, Rhododendrons, Begonias, Hedychiums, Impatiens and others. Some of them are :

a) **Orchids** - *Aerides multiflorum, Arundina graminifolia, Calanthe densiflora, Coelogyne barbata, Cymbidium elegans, Dendrobium* *aphyllum, D. chrysanthum, D. chrysotoxum, D. nobile, Phaius tancarvillae, Pleione praecox*, etc.

b) **Rhododendrons** *Rhododendron dalhousiae, R. exasperatum, R. lanigerum, R. pumilum, R. tephropeplum, R. thomsonii, R. maddenii, R. campanulatum*, etc.

c) **Begonias** - *Begonia inflata, B. griffithiana, B. sikkimensis, B. rex, B. scintillans*, etc.

d) **Hedychiums** - *Hedychium coronarium, H. coccineum, H. gracile, H. gardnerianum, H. stenophyllum*, etc.

e) **Impatiens** *Impatiens cathcartii, I. arguta, I. tripetala, I. laevigata, I. racemulosa*, etc. Some other wild ornamental plants include *Tacca integrifolia* and species of *Michelia, Magnolia, Camellia, Aster, Jesminum, Ixora, Melastoma, Phlogacanthus, Agapetes, Rosa, Musa, Rhaphidophora, Clematis, Thunbergia, Arisaema*, etc.

Wild relatives of crop plants

The wild relatives of cultivated plants known from biosphere reserve are *Camellia cordata, Atrocarpus chama, Citrus medica, Coffea benghalensis, Coix lachryma-jobi, Musa rosacea, M. velutina*, etc.

Timber plants

Magnolia griffithii, M. campbelli, M. pterocarpa, Michelia champaca, Garcinia pedunculata, Dipterocarpus mannii, Bombax ceiba, Pterospermum acerifolium, P. lancifolium, Sterculea urens, S. villosa, Elaeocarpus aristatus, E. varunus, Gmelina arborea, Ailanthus integrifolia, Aglaia hiernii, Toona sureni, Acer laevigatum, A. laurinum, Dalbergia sissoo, D. oliveri, Mangifera sylvatica, Albizia sherriffii, A. procera, Pithecelobium dulce, Terminalia arjuna, T. myriocarpa, Haldina cordifolia, Alseodaphne andersonii, Litsea cubeba, Cinnamomum bejolghota, Castanopsis castanicarpa, C. indica, Alnus nepalensis, Betula alnoides, Populus ciliata, etc. are some of the common timber species found in the biosphere reserve.

CONSERVATION

People inhabiting in the vicinity of the reserve derive their sustenance from these forests. In order to reduce the pressure on forests an increase in agriculture production is required to meet the demand of food and fodder, etc. from the limited areas available near by.

The jhum cultivation practiced by the local inhabitants causes adverse effect on the virgin forests and thus, encourage the growth of secondary forests having less floristic diversity. This practice can be reduced by creating awareness about the ill effects of the jhuming among the local people and involving them into beneficial joint forestry programmes already approved by the Government of India.

The species identified as rare and threatened can be multiplied through *ex situ* conservation techniques like tissue culture and rehabilitation in botanic gardens. Similarly, the over exploitation of medicinal plant species can also be regulated. The cultivation of medicinal plants must be encouraged among the local people to meet the desired supply of raw material to the pharmaceutical industries who are mostly dependent directly on forests resources. Further, the germplasm of valuable *Musa, Dioscorea, Citrus*, orchids, bamboos, cereals, etc. should also be conserved that will help a breeder to evolve new varieties in future. A judiceous use of forest resources will bring prosperity not only to local inhibitants but to nation as whole.

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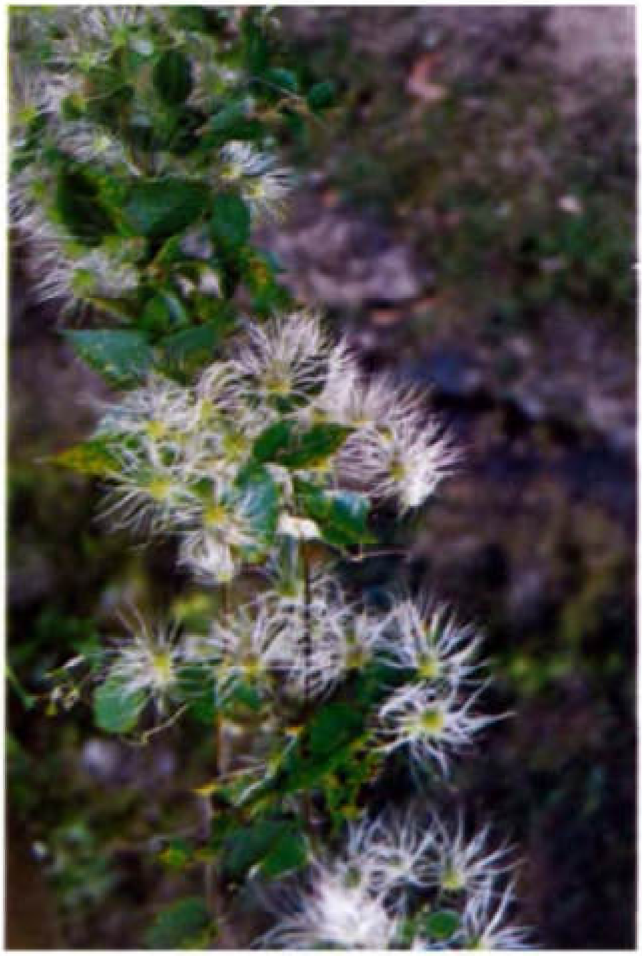
A view of tropical forest

A view of subtropical forest

Upper Tangon valley

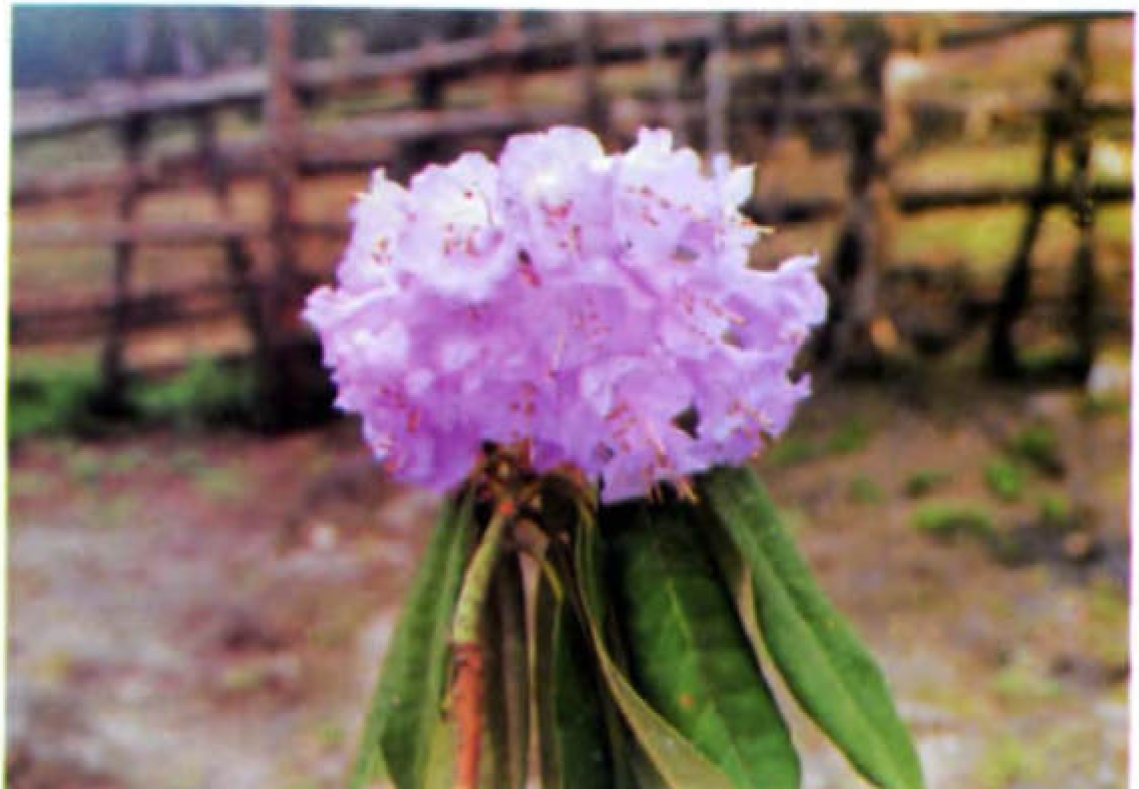


Clematis connata

Anemone griffithii - popularly known as Nakli teeta

Impatiens citrina

Hodgsonia macrocarpa



Rhododendron campanulatum

Circium lepskyi

Agapetes variegata var. *glabratula*

Hedychium ellipticum

Alpinia malaccensis

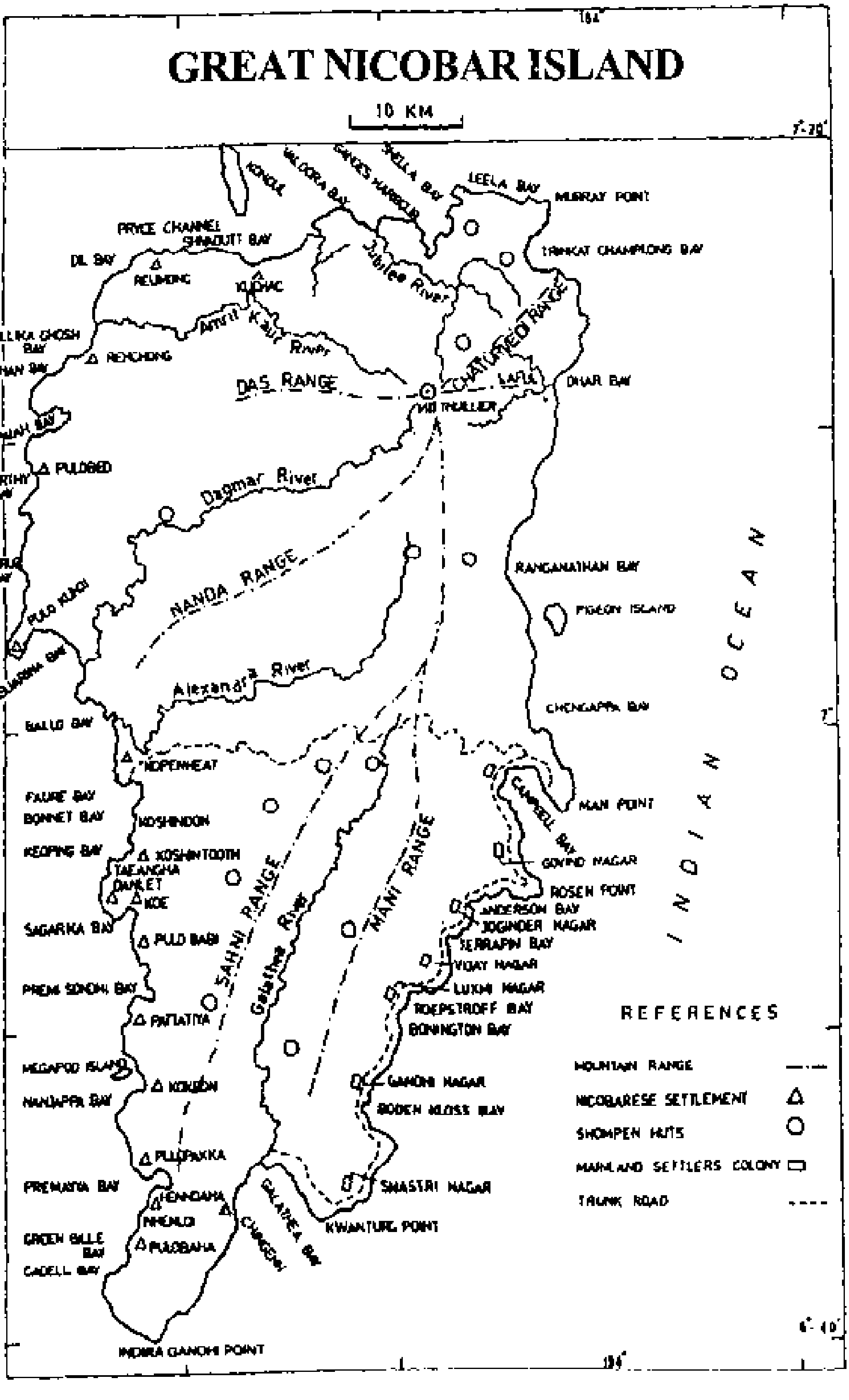
GREAT NICOBAR BIOSPHERE RESERVE

N.P. Balakrishnan

The Great Nicobar is a continental island belonging to the Andaman and Nicobar archipelago, the southern-most among this group of about 325 islands and situated at the trijunction of Andaman Sea, Bay of Bengal and Indian Ocean, between 6° 45' N and 7° 15' N latitudes and 93° 38' E and 93° 55' E longitudes (Map 1). The island Biosphere Reserve lies about 482 km south of Port Blair town and 145 km north of the northern-most tip of Sumatra in Indonesia. The island is about 55 km long from Murray Point in the north to Indira Gandhi Point in the south. It has a width of about 30 km in the northern part, but narrows down to only 3 km in the southern tip. The total geographical area is approximately 1045 sq. km. The biosphere reserve encompasses a total area of 885 sq. km and represents tropical biome and Indo-Malayan biogeographic region with 2 core and 2 buffer zones.

The island is highly rugged with very narrow flat land along the sea coast and hill ranges in the interior running in north-south direction. The relief consists of numerous spurs and ridges enclosing narrow valleys converging to a peak at the northern part, the highest point in this island known as Mount Thiller (670 m above m.s.l.). From this peak five main ranges of hills radiate southwards, called Das Range, Chaturvedi Range, Nanda Range, Sahni Range and Mani Range. These hill ranges rise abruptly to a substantial height from seashore, from where one can enjoy a spectacular panoramic view of the island, with deep gorges and valleys, covered by dense evergreen forests abutting into the sea all around. The coastline is highly indented and several creeks penetrate into the island from inland bays. Some of the bay mouths are studded with several damaged and partially submerged rocky pinnacles which become visible only in low tide. The principal bays around the island are the Galathea, Ganges harbour, Valdora and Trinkat Champlong. The coastline is generally coral with magnificient coral reefs at certain places, extending far away from the shoreline, providing ideal situations for underwater photography. There are practically no deep lagoons.

Five perennial rivers Alexandra, Dogmar, Amrita Kaur, Jubilee and Galathea with their several tributaries constitute the main drainage system


GREAT NICOBAR ISLAND
10 KM
LEELA BAY
MURRAY POINT
PRYCE CHANNEL
DIL BAY
REUMONG
TRINKAT CHAMPLONG BAY
Jubilee River
CHATURVEDI RANGE
MALLIKA GHOSH BAY
MOHAN BAY
REHCHONG
DAS RANGE
DHAR BAY
PULOBED
MURTHY BAY
Dagmar River
NANDA RANGE
RANGANATHAN BAY
PIGEON ISLAND
PULO KUNJI
CASUARINA BAY
Alexandra River
CHENGAPPA BAY
BALLU BAY
KOPENHEAT
FAURE BAY
BONNET BAY
KOSHINDON
MAN POINT
KEOPING BAY
KOSHINTOOTH
TAEANGHA
DAKKET
KOE
GOVIND NAGAR
ROSEN POINT
SAGARIKA BAY
PULO BABI
SAHNI RANGE
Galathea River
MANI RANGE
ANDERSON BAY
JOGINDER NAGAR
SERRAPIN BAY
VIJAY NAGAR
PREM SONDHI BAY
LUXMI NAGAR
PATTATIYA
TOEPSTROFF BAY
BONINGTON BAY
REFERENCES
MEGAPOD ISLAND
KOKEON
NANJAPPA BAY
GANDHI NAGAR
BODEN KLOSS BAY
MOUNTAIN RANGE
NICOBARESE SETTLEMENT
SHOMPEN HUTS
MAINLAND SETTLERS COLONY
PULOPAKKA
TRUNK ROAD
PREMAIYA BAY
HENNDAHA
SHASTRI NAGAR
GALATHEA BAY
CHINGENH
KWANTUNG POINT
GREEN BILLE BAY
PULOBAHA
CADELL BAY
INDIRA GANDHI POINT
INDIAN OCEAN

Map 1

of the island. Apart from these, there are about 25 smaller fresh water streams originating from the hill ranges and flowing directly into the sea. Such fresh water resources of the island enjoy unrivalled position among the whole of Andaman and Nicobar Islands. This river system coupled with heavy rainfall has given rise to a rugged terrain in the interior of the island. The mouths of the rivers are often blocked by narrow sandbars preventing navigation from sea into the river.

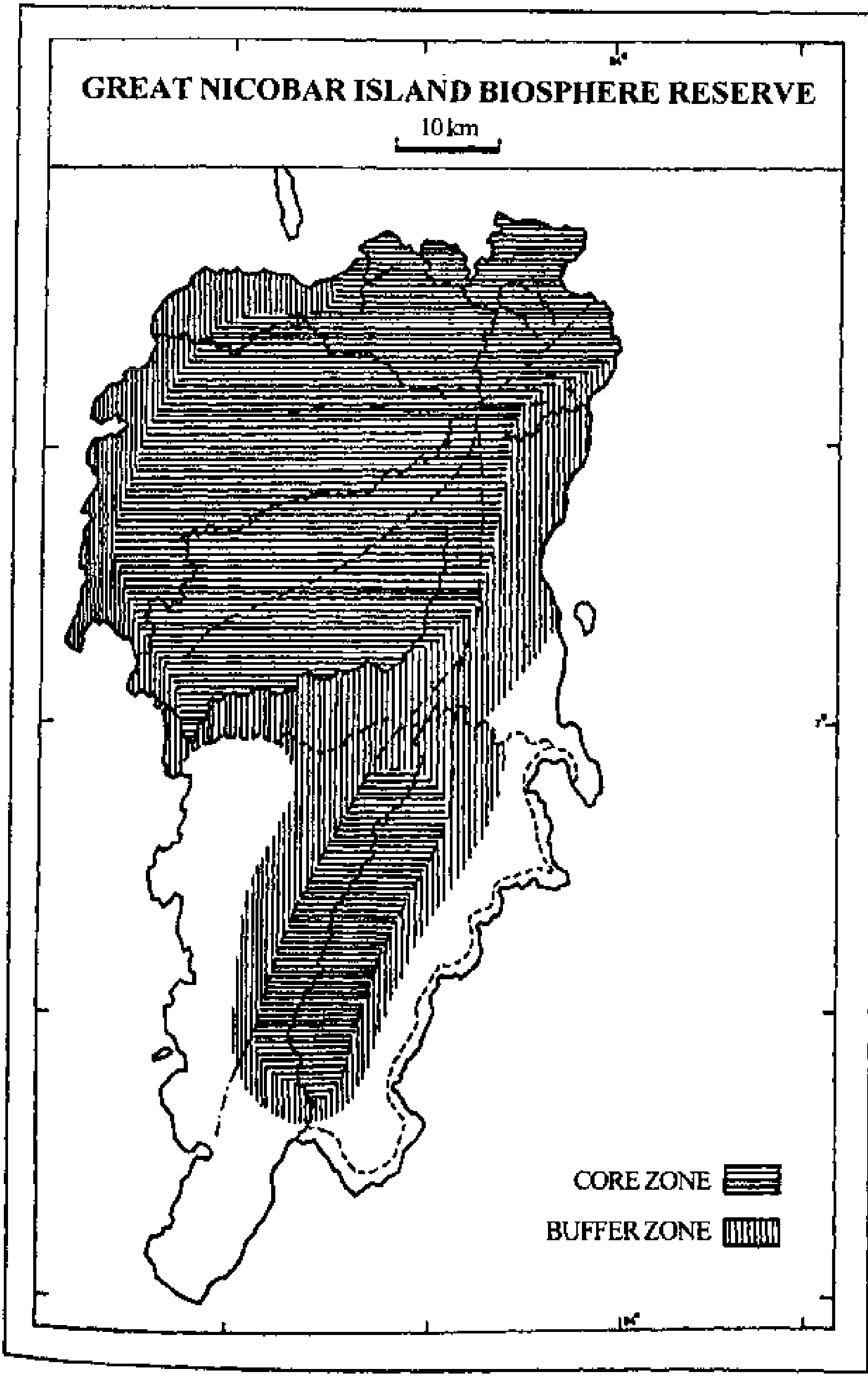
The Andaman and Nicobar archipelago forms a chain of islands as a continuation of the Arakkan Yoma range of Myanmar in the north to the Sumatra of Indonesia in the south. These groups of islands are projections of a long narrow submarine range of mountain, with only the peaks being visible above the sea. Geologically these islands are quite young in age, probably formed in upper Mesozoic (ca 100 million years ago). This mountain range has a narrow deep oceanic furrow on the western boundary which abuts on the main Indian continental plate on the west.

The soil of the island is immature, loose in texture, poor in drainage and low in moisture retaining capacity. They are chiefly made up of soft micaceous sandstone, silt stone and claybeds with minor basaltic rocks and gravelly sandstone beds. Sandy alluvial soil in the saline swamps and creeks, formed by the deposition of the material from the higher slopes in heavy rains, support rich mangrove forests at river mouths and creeks around the island. The coral alluvium on the beaches along the coast supports rich tree vegetation. In flat lands and along the stream banks, the soil is fresh water alluvium. The rich grey, brown and red soils derived from calcareous sandstones support luxuriant forest vegetation. Heavy clay to clay loams are found mostly in valley areas. Soil depth varies with slopes, shallow soils characterising higher elevations and deep soil in the valleys and river beds.

The proximity to the equator and surrounded by sea provide hot and humid uniform climate with the day temperature of around 30 degree celsius. The high rainfall during the two monsoon seasons, the south-west (May - September) and the north-east (October - December), causes an almost continuous heavy precipitation and percolation of water through the streams and beaches into the sea, assisted by steep slopes and loose texture of soils, causing large-scale removal of humus and organic matter continuously. This results in low humus and organic matter in the hilly areas. There is also no humus enrichment of the rain forests because of rapid decomposition of organic matter. The general view that the soils of these rain forests are highly fertile, is a misconception based on the density of the forests. However, the soils of the rain forests of Great Nicobar Island are generally poor in nutrient content which is a characteristic feature of all tropical 'ombrophilous' forests. This is due to the fact that in tropical rain forests favourable climatic conditions facilitate quick mineralisation of dead biotic materials and the released nutrients are immediately absorbed by roots of dense vegetation. Thus, though the amount of nutrient in soil is low, the entire nutrient capital necessary for the continous growth of the lush vegetation is tied up in the living plants themselves, leaving very little to the soil.

This island, remote though it is, could not escape from human interference. Extensive clearance of forests has been made particularly around Campbell Bay, the headquaters of the island, where the harbour and the town is located. From this town a 40 km long north-south road along the east coast extends up to Indira Gandhi Point, the southern-most tip of the island. Along this road refugees and exservicemen are settled for agricultural expansion, causing further deforestation along the eastern slopes of the hills. Moreover, considerable damage has been done to the forests around Indira Gandhi Point during recent developmental activities. Another road of about 43 km has been constructed in the east-west direction across the island connecting the Campbell Bay on the east coast with the settlements of the Nicobarese tribes along the west coast. This road cutting across the dense evergreen forests over the hills caused further depletion of precious forest wealth. The soil and the rocks are not stable nor hard in these hills, and hence this road has caused and continues to cause considerable landslides particularly during heavy rains, resulting in heavy damage to the precious forests and the rare plants.

One can see from reports of earlier expeditions that, in the year 1847 when the island was first botanised, the total forest area was about 97% of the whole landmass, which has now come down to 75% due to the recent deforestation for road construction, rehabilitation of refugees and other settlers from mainland, their agricultural activities and other developmental works. A report on the multidisciplinary team constituted under the Ministry of Agriculture and Irrigation, Govt. of India, which visited this island in 1975, expressed serious concern over the deforestation in these islands which would affect the stability of the ecosystem and environment (Anonymous 1975). A report on land utilisation and associated


GREAT NICOBAR ISLAND BIOSPHERE RESERVE
10 km
CORE ZONE
BUFFER ZONE

Map 2

problems in Andaman and Nicobar Islands by Mc Vean (1976) published by IUCN with assistance from Govt. of India, stressed that the deforestation should stop immediately and suggested that some areas in these islands should be conserved as 'Biosphere Reserves' as inviolates, so that these may serve as the gene pool reserve for the threatened species of plants and animals. Consequently, the MAB National Committee under the Ministry of Environment and Forests, Govt. of India launched a project, called "Status survey of the floral constituents in the island ecosystem of Great Nicobar in the present context of changing habitats" under Man and Biosphere Programme in Botanical Survey of India, Andaman & Nicobar Circle, Port Blair under the leadership of the present author in the year 1975. Associated by his colleagues, D. K. Hore and R. P. Dwivedi, intensive survey and study of the vegetationa and flora of this islands was conducted for about 5 years and the reoprt has been published (Anonymous 1989), recommending the establishment of a Biosphere Reserve. The Ministry of Environment and Forests finally declared a major part of the Great Nicobar Island as Biosphere Reserve (Map 2) on 6th January, 1989.

The island presents varied natural panorama and is covered with virgin lush vegetation with tropical evergreen forests extending from sea coast to the higher reaches of the hills. This forest wealth is by far the richest natural and irreplaceable endowment of the island. The great strength of this natural wealth lies in its utter immensity, density and vitality. One would scarcely desire that this virgin forest should be manhandled or allowed to disappear, even in parts. This natural tropical ecosystem, located near to the equator, is so well-balanced and complex and at the same time delicate and fragile that a small imbalance can be detrimental to its balance and may cause complete collapse in future.

VEGETATION

Vegetational accounts on Great Nicobar Biosphere Reserve based on one or two explorations have been published by Sahni (1953) and Thothathri *et al.* (1973). The following accounts on the vegetation and flora are based on the personal observations during the several intensive botanical explorations conducted to the island between the years 1975 and 1982 by the present author and his associates D.K. Hore, R.P. Dwivedi and T. Chakrabarty of Botanical Survey of India, Port Blair.

The forests of Great Nicobar Biosphere Reserve represent the tropical evergreen type, predominantly phanerophytic, overwhelmingly covered by typical broad-leaved and multi-storeyed evergreen trees with some semidecidous elements, comprising of straight-boled and often buttressed tall trees, forming a closed canopy above, supporting diverse life forms of palms, shrubs, lianas, climbers, epiphytes and ferns and other herbs underneath. The vegetation of Great Nicobar Biosphere Reserve is largely of the Nicobar type with the major and minor types as shown in Table-I.

Table I
Vegetation types

Major	Minor
1. Sandy beach formations	i) Herbaceous beach vegetation
	ii) Shrubby beach vegetation
	iii) Woody beach vegetation
	iv) *Casuarina* forests
	v) *Pandanus* vegetation
	iv) Mixed littoral forests
2. Mangrove vegetation:	i) Mangrove scrubs
	ii) Mangrove forests
	iii) *Nypa* swamps
3. Lowland swamps:	i) *Pandanus* swamp
	ii) *Areca* swamp
4. Evergreen hill forests:	i) Mixed evergreen
	ii) Pure evergreen
5. Man-made vegetation:	i) Coconut plantations
	ii) Secondary formations

1. Sandy beach formations

Starting from the proximity of seashore, the sandy beach formation extends usually up to 50-100 m into the sea and up to 100-200 m towards the interior of the island, at certain places much less or much more. The seaward vegetations are normally between high tide and low tide zones, where marine angiosperms occur, eventhough algal vegetation can be seen deeper into the sea. The inland areas are not usaully inundated by sea or fresh water. However, sometimes during storms and high tides, high waves splash over them, causing considerable inundation by sea water.

i) **Herbaceous beach vegetation:** This includes both submerged and non-submerged terrestrial plants.

(a) ***Submerged*:** Marine algae are found everywhere around this island. The sandy beaches with shallow waters strewn with rocks and boulders and the coral reefs extending further into the sea facilitate luxuriant growth of algae. The common genera of algae found in this island are *Acetabularia, Caulerpa, Codium, Dictyosphaeria, Enteromorpha, Halimeda* and *Ulva* of green algae (Chlorophyceae), *Padina, Sargassum* and *Turbinaria* of brown algae (Phaeophyceae) and *Ceramium* of red algae (Rhodophyceae). Among the marine angiosperms (flowering plants) which grow submerged in sea water, commonly called 'sea grasses', the main genera are *Cymodocea, Enhalus, Halodule, Halophila* and *Thalassus*. These sea grasses are especially common on sandy soils in quiet waters up to a metre or so below the ebb level.

(b) ***Non-submerged*:** On open sandy beaches we get the herbaceous strand vegetation comprising of the dominant creeper *Ipomoea pes-caprae*, with large pink or bluish pink funnel-shaped flowers and bilobed leaves, spreading on large areas. This is usually intermingled with grasses like *Ischaemum muticum* and *Thuarea involuta* and the sedge *Cyperus pedunculatus*. The lauraceous yellowish stem parasite *Cassytha filiformis* is often found in this area on the shrubs and bushes.

ii) **Shrubby beach vegetation :** Further interior along the beaches, one can find taller shrubby formations. *Scaevola sericea*, which often forms gregarious dense hedge-like formations facing the sea, is the most dominant species in this zone. In other places one can find shrubs and small trees like *Argusia argentea, Atlantia monophylla, Cordia subcordata, Dendrobium umbellatum,Dodonaea viscosa, Clerodendrum inerme, Sophora tomentosa*, etc. The spiny straggler with yellow flowers, *Caesalpinia bonduc* is also common at certain places.

These shrubby formations are often densely entangled with climbers such as *Flagellaria indica* and *Vigna marina*.

iii) **Woody beach vegetation:** The most dominant tree species along the beaches is *Barringtonia asiatica* with its large characteristic woody branches spreading sea-wards and often resting on beaches. This is associated with other trees such as *Calophyllum inophyllum*, *Glochidion calocarpum*, *Guettarda speciosa*, *Hernandia nymphaefolia*, *Pongamia pinnata*, etc. The ground flora in this woody vegetation is sparse and mainly consists of *Crinum asiaticam*, *Dracaena angustifolia* and *Tacca leontopodiodes*. The common epiphytes found in these forests are *Asplenium nidus*, *Dendrobium crumenatum*, *Phymatosorus scolopendria*, *Trichoglottis cirrhifera*, etc.

iv) ***Casuarina* forests :** Along certain beaches, especially in the long beaches of the northern parts of west coast near the mouths of Alexandra and Dogmar rivers, one can find vast areas covered by pure stands of *Casuarina equisetifolia* growing naturally. Sometimes they are associated with *Pandanus*. It is interesting to note that this exotic species efficiently suppresses all emerging seedlings of local trees and shrubs, resulting in its complete dominance and absence of any undergrowth in these forests.

v) ***Pandanus* vegetation :** At several places along the open beaches one can find pure stands of *Pandanus tectorius*, extending to wide areas. These trees love open sunshine and do not extend to the interior areas of the island where there is dense vegetation.

vi) **Mixed littoral forests :** This zone lies just behind the open beach vegetation. The demarcation between woody beach vegetation and littoral forests are not discernible at several places. These forests are characterised by the abundance of palms in the shrubby and low tree layers and many trees ladden with climbers, rattans and epiphytes, especially the ferns. The dominant canopy trees are *Barringtonia racemosa*, *Heritiera littoralis*, *Mangifera camptosperma*, *Syzygium samarangense*, *Terminalia bialata*, *T. procera* and occasionally *Cocos nucifera*. The shrubby vegetation is composed of *Ardisia solanacea*, *Atlantia spinosa*, *Hedyotis paradoxa*, *Tabernaemontana crispa*, etc. The herbaceous vegetation is very poorly developed. The climbers *Calamus andamanicus*, *Dinochloa andamanica*, *Heptapleurum venulosum*, *Mucuna gigantea*, *Poikilospermum suaveolens*, *Thunbergia laurifolia* and *Uvaria cordata* are commonly seen in these forests. Epiphytic orchids like *Aerides emercii* and *Cleistostoma uraiensis* are often seen on trees.

2. Mangrove vegetation

Mangroves, the most chracteristic vegetation of the coastal tidal zone, play valuable and critical role in the coastal ecosystems and maintain high levels of carrying capacity. Since they are closely correlated with conditions of climate, soil, topography, tidal patterns, salinity of water, drainage and aeration of the soil, they can be zoned into different communities, each occupying its own ecological niche and dominated by a few species with various adaptations to cope with the varied enviromental conditions.

i) **Mangrove scrub** : The scrubby vegetation of pioneering salt marshy plants like *Acanthus volubilis* and *Acrostichum speciosum* are found on the seaward side on muddy and swampy shores. Mangrove trees are not common in these areas though they may be found in small isolated patches. Further seawards one can often see scattered small trees of *Sonneratia caseolaris, Avicennia marina, Excoecaria agallocha*, etc.

ii) **Mangrove forests** : Mangrove forests usually have dense canopy. Its undergrowth is very sparse and climbers and epiphytes are rare, though they are common in interior areas. The common species of this community are *Bruguiera gymnorrhiza, Carallia brachiata, Rhizophora apiculata, R. mucronata, R. stylosa, Sonneratia acida*, etc. Climbers and epiphytes commonly seen are *Derris trifoliolata, Dischidia benghalensis* and *Hoya parasitica*. Occasionally epiphytic orchids and ferns are also seen.

iii) ***Nypa*** **palm swamp** : It covers the riverine swampy areas and estuaries and are subject to daily brackish water flooding during high tides. They also line along tidal creeks where fresh and salt water mix. Very frequently it forms pure stands with closed canopy without any undergrowth. The most dominant species is *Nypa fruticans*, sometimes associated with *Dolichandrone spathacea* at the mouths of creeks. The sheltered muddy ground of this palm grove is an ideal habitat for reptiles like crocodiles, varanus, snakes and different species of turtles, crabs, etc.

3. Lowland swamps

This type of vegetation is found in the lowland areas near the major banks of the rivers of the island and the lowland forests of the littoral zones, dependant generally on the depth and quality of water, drainage and flooding conditions.

i) ***Pandanus* swamp :** Away from the seashore in the lowland areas, where the soil is moist and swampy, the wild screw-pine *Pandanus leram* generally occur in large populations. Usually this is not associated with any other tree species. The fruit of this plant, almost as big as a jackfruit, forms the main staple diet of the Nicobarese and Shompen tribals.

ii) ***Areca* swamp :** This type of ecosystem is found only in Great Nicobar Island, and nowhwere else in india. Due to heavy rain, the lowland shallow forest floors get inundated with water often remaining stagnant for a long time. The sea water also enters these forests during very high tides and storms. Hence, in these lowland areas one finds a slightly saline soil environment. This is commonly seen in littoral zone of certain areas where the wild betel-nut palm (*Areca catechu*) trees grow naturally and abundantly. They always prefer moist and shaded places. Occasionally they are also found in depressed valleys in inland evergreen forests. These arecanut trees are often associated with *Ficus rumphii, Mangifera camptosperma, Pandanus tectorius, Syzygium samarangense, Terminalia bialata*, etc.

4. Evergreen hill forests

The tropical humid rain forests of Great Nicobar Island are basically broad-leaved, multi-storeyed and evergreen and occasionally with some semideciduous elements. The canopy is very high, dense, closed and supports various climbers and epiphytes like rattans, lianas, orchids, ferns, etc. The canopy is variable in height, coverage and crown sizes, with the emergent layer reaching up to 40 m high. These luxurient rain forests are very rich in biodiversity. It is possible to discern two types of evergreen forests in these islands as follows, though the demarcation is often not well marked.

i) **Mixed evergreen forests :** At low altitudes, littoral and mixed evergreen forests are often seen intermixed with each other depending upon the topography. Along lowland coastal areas, where there is no chance of salt water mixing with the fresh water, the transitional zone from littoral areas is characterised by trees of the genera *Antidesma,* *Chisocheton, Elaeocarpus, Ficus, Meliosma*, etc. Herbaceous species of the genera *Aglaonema, Coelorhachis, Goodyera, Homalonema, Phrynium, Nervilia, Rhynchotechum, Staurantherea, Tournefortia*, etc. are found along wet stream sides. The tree ferns *Cyathea alobo-setacea* and *Cyathea nicobarica* and giant-leaved fern *Angiopteris evecta* also grow luxuriantly in the interior areas. A liana with pendulous branches, *Indorouchera griffithiana* and epiphytes like *Erla, Aeschynanthus, Hoya, Procris, Pothos*, etc. and several Hymenophyllaceous ferns are frequently found on trunks and branches.

In the interior at certain places, where the moisture content of the soil is low due to steep slopes of hills, these forests contain certain deciduous or semideciduous trees mixed with evergreen trees. However, pure deciduous formations are totally absent in this island. The major deciduous and semideciduous trees found in these forests are *Anthocephalus chinensis, Artocarpus chama, Dehaasia triandra, Lagerstroemia ovalifolia, Pterocymbium tectorium, Terminalia bialata, T. catappa* and *T. citrina*. A rare gymnospermous tree, *Gnetum gnemon* occurs scattered in this region. The ground occasionally becomes wet during rains but the rain water drains out quickly leaving the soil mostly dry and hence the ground flora is comparatively poor. However, in the valleys and riversides, where moisture is retained for a longer period, species of *Aglaonema, Hetaeria, Phrynium, Piper*, etc. can be seen. The common epiphytes found in these forests are ferns like *Asplenium, Nephrolepis, Drynaria*, etc. and orchids like *Cymbidium, Luisia, Pholidota, Pteroceras*, etc. Rare palms like *Rhopaloblaste augusta* and *Pinanga manii* are also found in this transitioanl zone.

ii) **Pure evergreen forests :** Moderate temperature, bright sunshine and excessive rainfall with high humidity are the main factors responsible for the luxuriant growth of the rich tropical evergreen forests in this island, similar to any such forests in Malesia. These types of pure evergreen forests occur on low and high hills and valleys in the interior of the island, where the top soil is thick, fertile with abundant litter and retains moisture for a long period even after the cessation of rainfall. The height of the major trees ranges from 15 to 40 m. Most of the trees are associated with lianas, climbers and epiphytes. The top canopy trees are *Actephila excelsa, Aglaia gangoo, Aglaia spectabilis, Calophyllum soulattri, Chydenanthus excelsus, Dacryodes rugosa, Dysoxylon* spp., *Elaeocarpus serratus, Fagraea auriculata, Horsfieldia irya, Kibara coriacea, Knema andamanica, Litsea glutinosa, Nephelium lappaceum, Nothaphoebe panduriformis, Planchonella longipetiolata, Pometia pinnata, Sterculia macrophylla* and different species of *Ficus*. Often these are associated with climbers and lianas like *Aristolochia tagala, Dinochloa andamanica, Dioscorea* spp., *Freycinetia insignis, Phanera nicobarica, Tinomiscium petiolare* and the rattans like *Calamus* spp. and *Daemonorpus* spp. Clumps of bamboos are rarely seen in thickets along the rivers. Different shrubs like *Cyrtandra* spp., *Cyrtandromoea nicobarica, Ixora* spp., *Melastoma affine, Psychotria* spp., *Randia longiflora, Saurauia bracteosa, Uncaria* spp., etc. are also seen. Besides, several pteridophytes and orchids are also observed. The tree ferns of *Cyathea* spp. are also common in these forests.

5. Man-made vegetation

i) **Cultivated formations** : Nicobarese, the coastal tribal people living mostly along the west coast of the island, are mainly dependant on coconut and hence they have cleared the coastal vegetation and replaced it with coconut plantations in and around their villages. Owing to the population pressure, they are becoming more demanding and a considerable long tract of the southern section of the west coast has become coconut plantations.

Shompens, the aboriginal nomadic tribal people living in the interior forest areas, also raise some cultivated plants like *Musa, Pandanus, Cocos, Capsicum, Citrus, Colocasia*, etc. around their homesteads. However, being meagre in population and nomadic in habit, they do not destroy any large tracts of forests.

ii) **Secondary formations:** Since the inception of human settlements in this island from around the year 1969, large areas of forests have been cleared for plantation of monculture exotic species. They include, apart from food crops, timber trees of *Dipterocarpus* spp., *Pterocarpus dalbergioides, Tectona grandis*, etc. and different species of bamboos and rattans.

Pure grasslands are not found in this island unlike in other northeren islands of Nicobar group. However in disturbed habitats, certain grasses along with other weeds appear very soon after the start of the monsoon.

Among them the most common ones are *Chrysopogon, Centotheca, Coelorachis*, etc. of grasses, *Cyperus* spp. and *Fimbristylis* spp. of sedges and *Eupatorium, Tridax, Lippia*, etc. of the other weeds.

A considerable area of coastal as well as littoral forests around Indira Gandhi Point were deforested in 1969 during the construction of a Light House and later recently for certain defence establishments. This area is now occupied by a secondary formation of *Guettarda Hernandia Trema* association with the ground layer dominated by *Mananthus sumatrana*.

FLORA

The flora of Great Nicobar Biosphere is unique, rich and diverse in species content, the result of its long isolation imposed by physical barriers, the undulating topography and tropical humid climate. The ecosystem in this island is well balanced but is also fragile. It supports several endemics and also elements of Malaysian and Indonesian floras, not found anywhere else in mainland regions of India.

Till recently there was no satisfactory picture of the flora of this island biosphere reserve. The earliest account on the flora of this island was that of Wallich (1850) based on Steen Bille's voyage to this isalnd. Accounts of certain new and interesting species were published by Kurz (1875, 1876), who though did considerable work on other islands of Nicobar group could not make any major survey of the flora of Great Nicobar Island. The recent exploration reports of Sahni (1963) and Thothathri *et al.* (1973 a, 1973 b, and 1977) also added to the knowledge of the flora. However, the most significant advances have been made only since 1972, when the Botanical Survey of India started a regional centre at Port Blair and made intensive explorations in this island, producing rich collection of materials and several new species and papers on the flora. Among them mention may be made of Balakrishnan (1976, 1977, 1978, 1980a, 1980b), Balakrishnan and Burtt (1978, 1989), Balakrishnan and Chakrabarty (1978), Balakrishnan and Nair (1979), Hore (1984) and Hore and Balakrishnan (1984). Now a much clearer picture of the floristic composition is available.

Renvoize (1979) mentioned that this island probably contain about 700 species of vascular flora, related to the flora of Malaya. Jacobs (1978) remarked that the flora of this island is closely related Sumatran flora. The present knowledge indicates that both the above statements are true.

The present estimate indicates that in Great Nicobar Biosphere Reserve there are about 722 indigenous and naturalised species of vascular plants including Pteridophytes, Gymnosperms and Angiosperms. Among them, there are 78 species endemic to this island constituting about 10 % of the flora. The dominant families among the dicotyledons are Rubiaceae, Euphorbiaceae and Fabaceae and among the monocotyledons they are Orchidaceae, Cyperaceae and Poaceae. These data are given below in tabular form (Tables II & III). A very interesting feature noticed is that certain Malesian families are found either in Nicobar group of islands or in Andaman group of islands and never in both. These are listed in table IV.

Table II
Summary of the flora*

Group	Number of			
	Families	Genera	Species	Endemics
PTERIDOPHYTES	27	44	82	2
GYMNOSPERMS	3	3	4	0
ANGIOSPERMS	109	382	636	76
Monocots	(20)	(84)	(144)	(18)
Dicots	(89)	(298)	(492)	(58)
Total	139	429	722	78

Table III
Dominant families and genera

Group and families	No. of species	Dominant genera	No. of species
PTERIDOPHYTES			
Aspleniaceae	9	*Asplenium*	9
Polypodiaceae	9	*Lindsaea*	5
Thelypteridaceae	7	*Selaginella*	5
GYMNOSPERMS			
Gnetaceae	2	*Gnetum*	2
Cycadaceae	1	*Cycas*	1
Podocarpaceae	1	*Podocarpus*	1
MONOCOTYLEDONS			
Orchidaceae	33	*Cyperus*	16
Cyperaceae	32	*Fimbristylis*	7
Poaceae	27	*Homalomena*	4
DICOTYLEDONS			
Euphorbaceae	46	*Ficus*	11
Rubiaceae	43	*Ipomoea*	8
Fabaceae	20	*Ixora*	6

Table IV
Family distribution

Families	Andaman islands	Great Nicobar	Malaysia & Indonesia
Saurauriaceae	-	+	+
Hypericaceae	+	-	+
Dichapetalaceae		+	+
Polygalaceae	+	-	+

Families	Andaman islands	Great Nicobar	Malaysia & Indonesia
Dipterocarpaceae	+		+
Simaroubaceae	+		+
Cornaceae		+	+
Ancistrocladaceae	+		+
Monimiaceae		+	+
Elaeagnaceae	+		+
Burmanniaceae		+	+

ENDEMISM AND RARE TAXA

The most interesting aspect of the floristic diversity of Great Nicobar Biosphere is the presence of several rare species of plants on the island. Some of these species are endemic to this island or to the Nicobar group or to the Andaman and Nicobar group of islands and not found elsewhere in the world. As in most tropical islands, the most peculiar feature of the endemic and rare plants of this island is their restricted distribution. Most of the endemics in this island (so also in other islands of Andaman and Nicobar group) are rare, confined to the narrow type locality and many are being threatened with extinction. The extreme competition for space and sunlight in a tropical evergreen insular ecosystem limits the area for dispersal of most of the species, confining them to a limited ecological niche. This is the reason why most of the endemics have been collected only once, many only from the type localities and several never since the type collection, as listed by Balakrishnan and Rao (1983). Hence destruction of even a small area of forests in this island may cause extinction to the endemics of that area. Apart from these endemics, there are a large number of species in this island which are Malaysian or Indonesian but not found in mainland India. These extra-Indian Malesian elements living and surviving in this small island with an area of about 1045 sq. km, can be considered as endemics as far as India is concerned, rare and endangered and precious for our country. There are some species reported by Kurz in 1875 and 1876 from this island but never collected since then, indicating extreme rarity or even the possibility of extinction.

These three categories are listed in the following tables V, VI and VII.

Table V
Endemic species

(Arranged in the family sequence of Bentham & Hooker's classification. Indicating whether they are endemic to Great Nicobar Island only, or to Nicobar group of islands only or to the Andaman & Nicobar group of islands only)

Botanical name	Endemic to Gt. Nicobar	Endemic to all Nicobars	Endemic to A-N Islands
A. **PTERIDOPHYTES**			
Cyathea alobosetacea		+	
Cyathea nicobarica		+	
Lindsaea tenera			+
B. **DICOTYLEDONS**			
Clematis smilacifolia ssp. *andamanica*			+
Dillenia andaminca			+
Artabotrys nicobarianus		+	
Miliusa tectona			+
Orophea katschallica			+
Polyalthia parkinsonii			+
Pseuduvaria prainii			+
Uvaria nicobarica	+		
Cyclea pendulina		+	
Sterculia macrophylla			+
Glycosmis pentaphylla var. *andamanensis*			+
Glycosmis pentaphylla var. *insularis*			+
Glycosmis pilosa		+	
Paramignya andamanica			+
Aglaia spectabilis			+
Codiocarpus andamanicus			+
Semecarpus kurzii			+

Botanical name	Endemic to Gt. Nicobar	Endemic to all Nicobars	Endemic to A-N Islands
Phanera nicobarica	+		-
Otanthera nicobarensis		+	
Memecylon andamanicum			+
Hedyotis paradoxa			+
Ixora barbata			+
Ixora brunnescens			+
Ixora microsiphon		+	
Ixora rosella			+
Jainia nicobarica	+		
Mussaenda jelinekii	+		
Ophiorrhiza nicobarica	+		
Psychotria andamanica			+
Psychotria platyneura			+
Tarenna weberaefolia			+
Embelia microcalyx		+	
Maesa andamanica			+
Jasminum multiflorum var. *nicobaricum*			+
Alstonia kurzii			+
Chilocarpus sunainanus	+		
Tabernaemontana crispa			+
T. crispa var. *nicobarica*		+	
Cyrtandromoea nicobarica	+		
Cyrtandra burttii	+		
Cyrtandra occidentalis	+		
Knema andamanica			+
Dehaasia candolleana			+
Litsea kurzii			+
Neolitsea nicobarica		+	
Actephila excelsa var. *puberula*			+
Claoxylon rostratum			+
Cleistanthus balakrishnanii	+		

Botanical name	Endemic to Gt. Nicobar	Endemic to all Nicobars	Endemic to A-N Islands
Drypetes bhattacharyae			+
Drypetes leiocarpa		+	
Euphorbia epiphylloides			+
Glochidion calocarpum			+
Macaranga nicobarica		+	
Mallotus oblongifolius var. *rubriflorus*			+
Sphyranthera lutescens			+
Trigonostemon villosus var. *nicobaricus*	+		
Elatostema novarae		+	
Pellionia procridifolia		+	
C. MONOCOTYLEDONS:			
Aerides emercii		+	
Anoectochilus nicobaricus	+		
Eria bractescens var. *kurzii*		+	
Phalaenopsis speciosa			+
Pomatocalpa andamanica			+
Vanilla andamanica			+
Amomum fenzlii		+	
Phrynium paniculatum	+		
Dioscorea vexans		+	
Bentickia nicobarica		+	
Calamus andamanicus			+
Daemonorps kurzianus			+
Pinanga manii			+
Rhopaloblaste augusta		+	
Pandanus leram		+	
Aglaonema nicobaricum		+	
Dinochloa andamanica			+
TOTAL	13	22	43

Table VI
S-E. Asian species present in Great Nicobar Island and in Andaman & Nicobar Islands
(Arranged in the family sequence of Bentham & Hooker's system of classification)

Species	Extra-Indian distribution
A. PTERIDOPHYTES :	
Syngramma alismifolia	Malesia.
Vittaria ensiformis	Malesia and Madagascar.
Lindsaea parasitica	Malesia.
L. tetragona	Malesia, Fiji and Solomon Islands.
Bolbitis sinuata	Thailand, Malesia and New Guinea.
Nephrolepis falcata	Thailand, Vietnam and Malesia.
Davallia solida	Myanmar, Malesia and Australia.
Humata heterophylla	Malesia to Pacific Islands.
H. pectinata	Sumatra to Solomon Island.
Asplenium sublaserpitiifolium	S. China and Malaysia.
A. tenerum var. *retusum*	Malaysia.
Cyclosorus heterocarpus	S. China and Malesia.
C. polycarpus	Thailand and Malaysia.
Crepidomanes bilabiatum	Thailand and W. Malesia.
Reediella humilis	Thailand, Malesia to New Zealand.
Vandenboschia maxima	S. Japan, Vietnam, Thailand and Malesia to Pacific Islands.
Colysis macrophylla	S. China, Malesia to New Guinea.
C. membranacea	Vietnam, Malesia and New Guinea.
Microsorium insigne	Malaysia and Philippines.
B. DICOTYLEDONS :	
Frisodielsia glauca	Malaysia and Philippines.
Goniothalamus giganteus	Thailand and Malesia.
Uvaria rufa	Thailand, Indo-china, Malesia to New Guinea.
Tinomiscium petiolare	Malaysia, Sumatra and Java.

Species	Extra-Indian distribution
Casearia fulginiosa	Malaysia and Philippines.
C. grewiaefolia var. *deglabrata*	Malesia to Pacific islands.
Xanthophyllum vitellianum	Sumatra and Java.
Calophyllum macrocarpum	S. Thailand and Malaya to Borneo.
Saurauia bracteosa	Java.
Sterculia hyposticta	Malesia.
Elaeocarpus macrocerus	Myanmar, Indo-china, Malaysia and Indonesia.
Indorouchera griffithiana	Malaya, Borneo and Java.
Atlantia sinplicifolia	Malaysia.
Dacryodes rugosa	Malaya, Borneo, Sumatra and Java.
Aglaia argentea	Malaya and Java.
Dysoxylum arborescens	Indo-China and Malesia.
D. densiflorum	Sumatra and Java.
D. macrocarpum	Java.
D. thyrsoideum	Malaya.
Sandoricum koetjape	Myanmar, Thailand, Indo-China and Malesia.
Smythea lanceata	Malaysia, Java and Philippines.
Allophylus dimorphus	Indo-China and Philippines.
Meliosma lanceolata	Sumatra, Java and Borneo.
Connarus semidecandrus	Indo-China, Thailand, Malesia to Pacific Islands.
Combretum yunnanense	China, Indo-China, Malaya and Java.
Ochthocharis javanica	Thailand, Sumatra, Java, Borneo and Philippines.
Memecylon excelsum	Sumatra, Java, Borneo and Malaya.
Mastixia trichotoma var. *maingayii*	Malaya, Sumatra and Java.
Alangium javanicum	Java.
Gardenia tubifera	Malaya, Sumatra and Java.
Greenia jackii	Malaya.
Ixora kurziana	Sumatra and Java.

Species	Extra-Indian distribution
Mussaenda villosa	Thailand, Malaya and Borneo.
Timonius compressicaulis	Malaya, Sumatra and Java.
Uncaria cordata var. *ferruginea*	Malaya, Sumatra, Java and Borneo.
U. lanosa var. *ferea*	Malaya, Sumatra, Java and Borneo.
Vernonia cymosa	Java.
Symplocos fasciculata	Malaya, Philippines and Java.
Alstonia macrophylla	Thailand and Malesia.
Rauvolfia sumatrana	Malaya and Sumatra.
Hoya wrayii	Malaya.
Aeschynanthe volubilis	Java.
Rhychotechum parviflorum	Malaya, Sumatra and Java.
Mananthus sumatrana	Java and Sumatra.
Strobilanthes timorensis	Timor Island.
Teijsmanniodendron pteropodum	Malaya and Indonesia.
Apama tomentosa	Java.
Aristolochia jackii	Sumatra and Borneo.
Piper clypeatum	Malaya.
P. miniatum	Malaya and Java.
Knema laurina	Thailand, Malaya, Borneo, Sumatra and Java.
Myristica elliptica	Malaya, Sumatra and Borneo.
Kibara coriacea	Malaya, Sumatra, Java and Celebes.
Nothophoebe panduriformis	Malaya.
Helicia serrata	Malaya, Borneo, Sumatra and Java.
Phaleria macrocarpa	Malaya and Java.
Actephila excelsa var. *javanica*	Thailand, W. Malesia, Celebes and New Guinea.
Alchornea rugosa	S. China, Myanmar, Malesia, New Guinea and Australia.
Antidesma tetrandrum	Sumatra and Java.
A. tomentosum	Malaya, Sumatra, Java, Borneo and Celebes.
Aporusa villosa	Myanmar, Indo-China and Thailand.

Species	Extra-Indian distribution
Baccaurea sumatrana	Malaya, Sumatra and Borneo.
Blumeodendron kurzii	Myanmar, Thailand, W. Malesia, Philippines and New Guinea.
B. tokbrai	Malaya, Sumatra, Java, Molluccas and New Guinea.
Breyia racemosa	Thailand, Malaya, Sumatra, Borneo, Philippines and Timor.
Drypetes microphylla	Malaya, Borneo, Sumatra and Philippines.
D. sumatrana	Myanmar, Cambodia, Thailand and Sumatra.
Glochidion sunmatranum	Malesia to Australia.
Macaranga triloba	Myanmar, Thailand and W. Malesia.
Mallotus oblongifolius	Malesia to N. Australia.
M. penangensis	Malaya, Sumatra, Borneo and Philippines.
Neoscrotechinia nicobarica	Myanmar, Malaya, Borneo, Philippines and Java.
Phyllanthus gomphocarpus	Malaya and Sumatra.
Spathistemon javensis	Malaya, Borneo, Java and Philippines.
Cypholophus moluccanus	Sumatra to Pacific Islands.
Gironneira subaequalis	China, Myanmar, Thailand, Malesia to Pacific Is.
Ficus magnoliaefolia	Java.
C. **MONOCOTYLEDONS**:	
Appendicula reflexa	Thailand, Sumatra to New Guinea.
Ceratostylis subulata	Myanmar, Malaya and Java.
Cleisostoma uraiensis	Taiwan and Philippines.
Cymbidium pubescens	Myanmar, Thailand, Malaya and Indonesia.
Dendrobium pensile	Malaya.
Haeteria obliqua	Malaya and Indonesia.

Species	Extra-Indian distribution
H. oblongifolia	Myanmar, Thailand, Malesia and N. Australia.
Nervilia punctata	Thailand, Malaysia and Indonesia.
Phalaenopsis speciosa var. *tetraspis*	Java.
Plocoglottis javanica	Myanmar, Thailand, Malaysia and Indonesia.
Podochilus microphyllus	Myanmar, Thailand, Malaya, Sumatra and Java.
Pteroceras berkeleyii	Malaya.
Spathoglottis plicata	Taiwan, Thailand, Indo-China and Malesia to New Guinea.
Thrixspermum hystrix	Myanmer, Thailand and Malesia.
Trichoglottis cirrhifera	Thailand, Malaya and Java.
Vrydagzynea albida	Bangladesh, Myanmar, Thailand, Indo-China and Malesia.
Korthalsia echinometra	Myanmar and Malesia.
Aglaonema schottianum	Myanmar and Java.
A. simplex	Java.
A. simplex var. *malaccense*	Myanmar and Malaya.
Homalomena griffithii var. *ovata*	Malaya.
H. nutans	Malaysia.
Pothos macrocephalus	Malaysia.
Carex cryptostachys	S. China, Taiwan, Malaya, Philippines, New Guinea and Australia.
C. rafflesiana	Malaysia, Java, Philippines and Australia.
Mapania cuspidata var. *angustifolia*	Malaysia.
Centhotheca longilamina	Sri Lanka, Myanmar, Thailand, Malaya and Java.
Coelorachis glandulosa	Myanmar, Indo-China, Malaya, Java and Philippines.

Table VII
Species mentioned by Kurz (1875, 1876) from the island biosphere but not found in recent collections

Botanical name	Family
Apodytes andamanica	Olacaceae
Salacia platyphylla	Hipporcrateaceae
Semacarpus heterophyllus var. *pubescens*	Anacardiaceae
Desmodium heterocarpum (= *D. polycarpum*)	Fabaceae
Phanera ferruginea (= *Bauhinia ferruginea*)	Caesalpiniaceae
Albizia retusa (= *A. littoralis*)	Mimosaceae
Lumnitzera racemosa	Combretaceae
Adenia cordifolia (= *Modecca cordifolia*)	Passifloraceae
Heptapleurum ellipticum	Araliaceae
Adenosacme longifolia	Rubiaceae
Hedyotis racemosa	Rubiaceae
Blumea lanceolaria (= *B. myriocephala*)	Asteraceae
Sideroxylon attenuatum	Sapotaceae
Chionanthus palembanicus	Oleaceae
Merremia vitifolia (= *Ipomoea vitifolia*)	Convolvulaceae
Eranthemum succifolium	Acanthaceae
Justicia vasculosa	Acanthaceae
Excoecaria oppositifolia	Euphorbiaceae
Euphorbia atoto	Euphorbiaceae
Ficus macropoda	Moraceae
Korthalsia scaphigera	Arecaceae
Scindapsus pteropodus	Araceae

PHYTOGEOGRAPHY

Every natural phytogeographic province possesses a flora more or less unique to that area and its flora is an expression of its individuality. Such characteristic flora of a given phytogeographic province constitutes its unique floristic regime. According to Good (1974) and Takhthajan (1986) India along with the South-east Asia falls under the palaeotropical subkingdom and Indo-Malaysian subkingdom. Hooker (1906) in his treatise on phytogeographical divisions of India, included Andaman Islands and Myanmar together in the eighth division and Nicobar Islands together with Malay Peninsula from Kedah to Singapore in the nineth division. Several subsequent phytogeographic accounts of Indian subcontinent and its different regions were discussed by authors including Meher-Homji and Mishra (1973), Subramanyam and Nayar (1974), Mani (1974), Rao (1974) and Rau (1974). However, no serious attempt has been made so far on a composite phytogeography of Andaman and Nicobar Islands as a whole or in part. Ridley (1930) expressed the opinion that the Andaman and Nicobar Islands are undoubtedly continental, formerly connected with Myanmar and Sumatra, retaining the remnants of a more widely extended flora. Melville (1973) states that the land masses surrounding the Indian Ocean were formerly parts of the Gondwana continent during the Palaezoic and Mesozoic times. Thakhthajan (1986) in his phytogeographic classification of the World includes Andaman Islands as a province under Indo-chinese Region and Nicobar Islands under Malaysian region.

As suspected by earlier authors, the Great Nicobar flora has very close affinities to the Sumatran flora, which is predominantly Malaysian. At the same time certain striking Andaman-Myanmarese elements also occur which are not found in Indonesia or Malaysia. The fact that there is phytogeograhic affinities with such distant regions as New Guinea, Australia, New Caledonia and Polynesian Islands, as evidenced by the geographical distribution of several species, cannot be ignored.

From the data presented in table II, III and IV above, the following interesting features of the flora emerge.

1) Floristic affinities are predominently evident between Andaman Islands and India-Myanmar-Thailand on the north and Nicobar Islands and Malaysia-Indonesia on the south, rather than between Andaman and Nicobar groups of Islands.

2) Great Nicobar Biosphere shows no endemism at family level. The families Dipterocarpaceae, Simaroubaceae and Polygalaceae, though present in Andaman Islands and Malesia do not occur in this island.

3) Great Nicobar Island share more families common with Sumatra in Indonesia than with India-Myanmar-Thailand region.

4) The presence of many species common between Andaman Islands and Nicobar Islands is probably due to recent exchange and migration.

5) The presence of a significant number of endemic species, a number of rare taxa of limited distribution and only two endemic genera indicates long isolation of the island, though not long enough to produce many endemic genera.

6) The presence of widespread genera and species, of which the majority are mainland Asian and Malesian elements, also indicates that apart from continental connections, the role played by long distance dispersal and distribution is also responsible.

7) Out of the 722 species reported from this island, 78 species (ca 11 %) are endemic to Andaman and Nicobar Islands. The break-up of these endemics are: 13 species endemic strictly to the Great Nicobar Island, 22 species endemic to Nicobar group of Islands and 43 species endemic to the entire Andaman and Nicobar Islands. Among the species known from this island, 124 (ca 17%) species are Malesian, not found in mainland India nor in Andaman Islands, and the rest 598 species are widespread and distributed throughout South and Southeast Asia to Australia and Polynesian Islands.

Therefore, it leads to the conclusion that at family level as well as at species level the flora of Great Nicobar Biosphere is more allied to Malesia rather than to Andamans and mainland India-Myanmar-Thailand landmass. It also suggests ancient land connections between Andaman Islands and Myanmar in the north and between Nicobar Islands and Sumatra in the south, thereby facilitating easy migration of species between them. The presence of the deep ten-degree (longitude) channel separating Andaman and Nicobar groups of islands also indicates that there never was any possibility of a land connection between these two groups of Islands, thereby supporting the present day distinction between these two floras.

The following distribution types with their typical representatives were discovered in this island.

1) **Cosmopolitan and Pantropical genera:** *Ageratum, Argemone, Boerhavia, Cassia, Cyperus, Geophila, Guettarda, Ipomoea, Nephrolepis, Ocimum, Phyla, Phyllanthus, Scoparia, Sida, Solanum, Sophora, Stachytarpheta, Vigna,* etc.

2) **E. Himalayan-Assam genera:** *Burmannia, Euonymus, Lycianthus, Saurauria, Thelasis,* etc.

3) **Malesian genera:** *Aglaia, Anaxagorea, Appendicula, Argusia, Blumeodendron, Chilocarpus, Cyrtandra, Cyrtandromoea, Cypholophus, Dacryodes, Dichapetalum, Friesodelsia, Greenia, Indorouchera, Kibara, Luerssemia, Mastixia, Neodissochaeta, Neoscortechina, Ochthochodes, Otanthera, Parastemon, Phalera, Pisonia, Plocoglottis, Pometia, Pternandra, Reediella, Spathistenon, Stauranthera, Teijsmanniodendron, Timonius, Tinomiscium, Vandenboschia, Vrydagzynea,* etc.

4) **Peninsular Indian genera:** *Bentinckia, Burmannia, Calanthe, Corymborkis, Floscopa, Geodorum, Myxopyrum, Phyllochlamys,* etc.

5) **Endemic genera:** *Jainia* and *Sphyranthera.*

The above unique distribution patterns indicate that the flora of Andaman and Nicobar Islands forms one of the ancient connecting links between the floras of Indian and Malesian subcontinents.

ECONOMIC BOTANY

Ever since human race began, man depended mainly on plants and plant products for his essential requirements of food, shelter, fuel and clothing. The dwindling stock of non-renewable resources (fossil fuels) and shortage of food output to meet the increasing population, bring Economic Botany to the foreground among all human pursuits. Man has only just begun to take stock of the chemical and genetic possibilities in the plant kingdom. Therefore, we should seriously study the neglected or little known untested or unidentified plant species which may harbour chemicals useful medicinally or otherwise, that can bring further welfare to mankind. The tropical plants have contributed the majority of cultivated and medicinal species useful for mankind. However, there are still growing need for new plant products from the underexplored and unexplored areas of tropics which may yield more renewable resources for food, medicine, fuel and other needs of the ever increasing human population for their sustainable developments. Forest resources of humid tropical regions of Asia abound in such untapped natural resources. Great Nicobar Island is one of such area in India, showing rich biodiversity harbouring very many useful plant resources.

An inventory of such plant species with known uses occurring in this small tropical island is given below in tables VIII - XIV, with their presently known utilities and future potentialities. Table XII indicates that there are not many indigenous plants in this island with known medicinal importance, as can be expected due to the fact that the Andaman and Nicobar Islands were never approachable to the medicinal men and sanyasis of ancient India, who evolved the system of Ayurveda in India based mainly on plants from the mainland India and adjoining areas.

Table VIII
Species yielding major forest products
(i.e. timber, firewood, etc.)

Botanical name	Local or trade name
Adenanthera pavonina	Ywegyi
Alstonia kurzii	Chatian
Aglaia spectabilis	Lalchini
Anthocephalus chinensis	Kadamba
Aphanamixis polystachya	–
Artocarpus chama	Toungpeinne
A. gomeziana	Lakuch
Calophyllum inophyllum	Poon
Canarium euphyllum	Jungli doop
Carallia brachiata	–
Dysoxylum thyrsoideum	–
Elaeocarpus tuberculatus	–
Harpullia cupanioides	–
Heritiera littoralis	Sundri
Knema andamanica	Jungli Jaiphal
Lagerstroemia ovalifolia	Pyinma

Botanical name	Local or trade name
Lannea coromandelica	Nabbe
Litsea glutinosa	–
Mangifera camptosperma	Jungli Am
Planchonella longipetiolata	Lamba-pathi
Pometia pinnata	Thitkandu
Premna pyramidata	–
Pterocymbium tintorium	Papita
Sterculia alat	Letkok
Terminalia bialata	Safed jungli am
T. procera	Safed bambway

Table IX
Species yielding minor forest products

Botanical name	Uses
Areca catechu	Nuts for chewing as a stimulant, trunks for house construction.
Boehmeria nivea	Fibre.
Calamus andamanicus	Canes for baskets and furniture.
Canarium euphyllum	Gum for incense.
Daemonorps kurzianus	Canes for baskets and furniture.
Derris elliptica	Yields Rotenone
D. trifoliolata	-ditto-
Dinochloa andamanica	Bamboo stems for baskets, fishing rods, furniture and hut building.
D. scandens	-ditto-
Hibiscus tiliaceus	Fibre.
Nypa fruticans	Leaves for thatching houses, flower spikes for tapping toddy.
Piper betle	Leaves for chewing as a stimulant.
Planchonella longipetiolata	Matchwood

Botanical name	Uses
Phragmitis karka	For making mats, baskets, brooms and fences.
Rhizophora apiculata	Bark yields tannin, wood for making charcoal.
R. mucronata	-ditto-
Rhopaloblaste augusta	House construction.
Thespesia tiliaceus	Fibre.
Vanilla andamanica	Fragrant essence from fruits.

Table X
Species of potential ornamental value, suitable for introduction in gardens

Botanical name	Family	Habit
Aeschynanthus volubilis	Gesneriaceae	Epiphytic shrubs
Alangium javanicum	Alangiaceae	Trees
Alstonia kurzii	Apocynaceae	Trees
A. macrophylla	Apocynaceae	Trees
Astronia macrophylla	Melastomataceae	Tree
Cordia subcordata	Ehretiaceae	Trees
Crinum asiaticum	Amaryllidaceae	Herbs: lily-type
Cycas rumphii	Cycadaceae	Trees
Cyrtandromoea nicobarica	Scrophulariaceae	Shrubs
Dehaasia triandra	Lauraceae	Trees
Dracaena angustifolia	Agavaceae	Trees
Euonymus javanicus	Celastraceae	Scandent shrubs
Fagraea auriculata	Loganiaceae	Trees
F. racemosa	Loganiaceae	-ditto-
Flagellaria indica	Flagellariaceae	Climbers
Gardenia tubifera	Rubiaceae	Shrubs or trees

Botanical name	Family	Habit
Helicia serrata	Proteaceae	Trees
Jasminum acuminatissimum	Oleaceae	Straggler
Indorouchera griffithiana	Linaceae	Climbing shrubs
Ixora brunnescens	Rubiaceae	Trees or shrubs
I. kurziana	Rubiaceae	-ditto-
I. macrosiphon	Rubiaceae	-ditto-
Lagerstroemia ovalifolia	Lythraceae	Trees
Melastoma affine	Melastomataceae	Shrubs
Memecylon caeruleum	Memecylaceae	Shrubs or trees
Phalaenopsis speciosus	Orchidaceae	Epiphytic herbs
Phanera nicobarica	Caesalpiniaceae	Scandent shrubs
Podocarpus wallichianus	Podocarpaceae	Trees
Pomatocalpa wendlandorum	Orchidaceae	Epiphytic herbs
Radermachera pinnata	Bignoniaceae	Liana
Tabernaemontana crispa	Apocynaceae	Shrubs
Thunbergia laurifolia	Thunbergiaceae	Climbers
Zingiber zerumbet	Zingiberaceae	Herbs

Table XI
Wild relatives of cultivated plants

Botanical name	Cultivated relative
Areca catechu (Wild form)	Arecanut, betelnut
Mangifera camptosperma	Mango
Mangifera sp. (Wild form)	Mango
Musa sp. (Wild form)	Banana
Myristica elliptica	Nutmeg
Nephelium lappaceum	Litchi
Piper betle (Wild form)	Betel leaf
Vanilla andamanica	Vanilla

Table XII
Species of medicinal importance

Botanical name	Uses
Apama tomentosa	Leaves and roots in insect stings and snake bites.
Ardisia oxyphylla	Roots boiled in water and the decoction used for washing uterus after child birth.
A. solanacea	-ditto-
Aristolochia tagala	Plants used in bowel complaints.
Corymborkis veratrifolia	Juice of fresh leaves as febrifuge, in Malaria.
Costus speciosus	Roots used in snake bite and yields diosgenin.
Dioscorea glabra	Rhizomes yield diosgenin.
Myristica elliptica	Oil from seeds and pulp of bark applied on skin diseases.
Pericampylus glaucus	Antidote for snake poison.
Pongamia pinnata	Young stems chewed to reduce tooth-ache.
Rauvolfia sumatrana	Bark and roots contain an alkaloid rauwolscine used as cardiovascular depressant.
Sandoricum koetjape	Roots used in diarrhoea and dysentary.
Semecarpus kurzii	Sap from bark and oil from pericarp of fruits used for healing wounds.
Strychnos axillaris	Leaves used in skin diseases.
Zingiber zerumbet	Rhizome used as carminative and flavouring agent, given in dyspepsia.

Table XIII
Species of ethnobotanical importance
(used by the local tribes, Shompens and Nicobarese)

Botanical name	Purpose for which used
Aglaia spectabilis	Timber for canoes
Areca catechu	Leaves for thatching, nuts for chewing as stimulant, terminal bud edible and eaten raw.
Artocarpus chama	Timber for canoes, fruits and seeds as food.
Calamus andamanicus	Leaves for thatching, the hollow stem when cut provides safe drinking water.
Calophyllum inophyllum	Timber for canoes.
Capsicum frutescens	As condiment in food.
Carica papaya	Fruits as food.
Caryota mitis	Leaves for thatching.
Ceratopteris thalictroides	Young plants as vegetable.
Cocos nucifera	Fruits eaten, trunks for construction of huts and leaves for thatching, toddy taken from flower spikes.
Colocasia esculenta	Rhizome as food.
Dioscorea glabra	Rhizome as food.
Ficus brevicuspis	Inner bark used as cloth.
Mangifera camptosperma	Fruits eaten, raw or ripe.
Morinda citrifolia	Tender leaves eaten.
Musa sp.	Raw green fruits cooked and eaten.
Nicotiana tabaccum	Leaves as narcotic.
Nypa fruticans	Leaves for thatching, immature fruits often eaten.
Pandanus leram	Pulp of fruits form the staple food, after boiling and removing fibres.

Botanical name	Purpose for which used
P. tectorius	Leaves for thatching.
Piper betle	Leaves chewed as stimulant.
Pisonia umbellifera	Tender growing tips eaten.
Selaginella spp.	Roots eaten raw.
Sterculia alata	Timber used for canoes, bark used as cloth.
S. macrophylla	Timber used for canoes, bark used as cloth.
S. villosa	Timber used for canoes
Tacca leontopetaloides	Whole plant cooked and eaten as vegetable.
Terminalia catappa	Fruits edible and eaten.
Thespesia populnea	Young leaves cooked and eaten.
Xanthosma sagittifolium	Rhizome cooked and eaten.

Table XIV
Species from mainland being cultivated by settlers from mainland for their use

Botanical name	Local name or Hindi name	English name
Cereal crops :		
Oryza sativa	Dhan	Paddy
Zea mays	Makai	Maize
Vegetables :		
Abelmoschus esculentus	Bhendi	Lady's finger
Benincasa hispida	Chal kumra	Ash Gourd
Capsicum annum	Mirchi	Capsicum
Coccinia grandis	Kundri	Ivy Gourd
Colocasia esculenta	Kachu	Cocoyam
Cucumis sativus	Khira	Cucumber

Botanical name	Local name or Hindi name	English name
Cucurbita pepo	Lal Kumra,	Pumkin Khaddu
Lagenaria ciceraria	Lauki	Bottle gourd
Luffa acutangula	Torui	Ribbed gourd
L. cylindrica	Ghia torui	Sponge gourd
Manihot esculenta	Maliyar Alu, Malayala Alu	Cassava, Tapioca
Momordica charantia	Karela	Bitter gourd
Moringa oleifera	Sajinafali	Drumstick
Solanum melongena	Baigon	Brinjal
Trichosanthes anguina	Chichinga	Snake gourd
Vigna unguiculata	Lobia	Cow pea
Xanthosma sagittifolium	Ghuiyan	Taro
Beverages :		
Coffea arabica	Coffee	Coffee
Theobroma cocoa	Coco	Cocoa
Spices :		
Cinnamomum xeylanicum	Dalchini	Cinnamon
Myristica fragans	Jaiphal	Nutmeg
Piper nigrum	Kali mirchi	Black pepper
Syzygium aromaticaum	Laung	Clove
Fruit trees :		
Achras sapota	Chikku	Sapota
Anacardium occidentale	Kaju badam	Cashew nut
Ananus comosus	Ananas	Pineapple
Annona squamosa	Ata	Custardapple
Artocarpus integra	Kanthal	Jack fruit
Citrus aurantifolia	Nimbu	Lime
C. reticulata	Santra	Orange
Cocos nucifera	Nariyal	Coconut

Botanical name	Local name or Hindi name	English name
Mangifera indica	Aam	Mango
Musa sapientum	Kela	Banana
Psidium guajava	Amrud	Guava
Phyllanthus acidus	Harfarauri	Star Gooseberry
P. emblica	Amla	Myrobalan
Punica granatum	Dalim	Pomegranate
Tamarindus indica	Imli	Tamarind
Ziziphus mauritiana	Ber	Indian jujube

MAJOR THREATS

The rich floristic diversity of the island as elaborated above is under serious pressure from the activities of man, destroying the natural ecosystem at an alarming rate. It is extremely doubtfull whether we will be able to study the potential uses, medicinal or otherwise, of the rare and endemic species of this island, before the island is depleted of its rich natural resources by the harmful activities of man, unless we resort to very serious urgent action to protect its biodiversity. The major threats affecting the island ecosystem are summarized briefly below.

a) Population pressure by human settlements: As human population expands, the forests of the island are being rapidly and extensively cleared by human activities and ultimately changing the balance in the population-enviroment relationship. During the period 1970-1980, large scale settlements of mainlanders have come up in this island along the southern east coast, causing wide clearance inland evergreen as well as coastal littoral forests. It has been estimated that about 105 sq km of rich virgin forests (about 10 % of the forest area of this island) have been cleared for this purpose during the period.

b) Impact of grazing animals: The induction of settlers from mainland has also brought in a large population of grazing animals, i.e. goats, cattles and buffaloes. As the new settlement areas do not have any grazing ground, these animals are allowed to stray into the nearby virgin forests for grazing, thereby destroying the herbaceous and shrubby undergrowth as well as the germinating seedlings of large trees, causing slow but steady depletion of the rare plants.

c) Timber extraction: There is one saw mill in this island to meet the needs of timber for the settlers. To meet the local requirements, timber is being extracted from the forests near the settlement areas, causing further depletion of the natural plant resources. Due to various new developmental activities to cater to the needs of the settlers and Government constructions, the demand for timber is only increasing day by day. Since the local timber species of this island are not of very good quality, certain exotic species, like teak (*Tectona grandis*), Garjan (*Dipterocarpus* spp.), Andaman Padauk (*Pterocarpus dalbergioides*), etc., have been brought into this island and are being cultivated in large areas of plantations. The large scale clearance of virgin forests to clear the way for this monoculture cultivation of such exotic species which do not occur naturally in this island has resulted in very dangerous ecological imbalance. The results have been disastrous, the introduced ones did not do well, and the local flora got destroyed in very large areas. It is estimated that an area of 1267 hectares of virgin forests have been cleared for this purpose alone.

d) Extraction of minor forest products: Apart from timber, there are several minor forest products being extracted from the forests, usually from far deep inside the virgin forests, wherever they are available. Rattans available in these forests are of very good quality. They are being cut and brought to the headquaters town, Campbell Bay for manufacture of furniture items, which are in great deamand in the island as well as other islands and Port Blair town. Cutting down one clump of rattans involves destruction of several plants around and often some big trees on which they climb for support. The large leaves of Nypa palm (*Nypa fruticans*) resembling coconut leaf is often used for thatching purposes by the local people. Further the terminal bud of this palm, known as 'Palm Cabbage' is a delicacy for the Nicobarese tribals and the extraction of the growing tip causes complete death to the palm. As a result its population is fast depleting. The labourers brought by settlers trek deep into the forests for extraction of various minor forests products like honey, jungle fowl, wild pigs, betel leaves, arecanut, roots of *Pericampylus glaucus* for preparation of the brew, the 'handia', a local alcholic beverage, etc. These activities also cause disturbance in the delicate balance of the ecosystem.

e) Exotic weeds and animals: Several exotic weeds like *Eupatorium, Merremia, Mikania,* etc. have invaded this island and are causing extreme harm to the natural regeneration of the forests. Seeds of these weeds were introduced inadvertantly by the migrants, the ships and import of food grains from mainland. Similarly pigs and cattle introduced have been causing great destruction of the undergrowth in the forests.

CONSERVATION MEASURES

The regional unit of Botanical Survey of India at Port Blair, started in 1972, is deeply engaged in survey of the plant resources of the major unexplored islands. Great Nicobar Island, being the southernmost and largely unexplored, was given top priority. Under the Man and Biosphere Programme, the phytodiversity of this island was intensely studied from 1977 to 1982. As result a large collection data and plant materials (herbarium and liquid preserved specimens) were gathered and deposited at the regional herbarium at Port Blair. Several species were kept under cultivation in the exprimental garden near Port Blair. These data and collected materials were analysed and studied in detail and the results revealed the richness and uniqueness of the flora of this island and its importance for our country. Several new species and new records for India were discovered from these collections. The report (Anonymous 1989) prepared by the scientists (N.P. Balakrishnan, D.K. Hore, and R.P. Dwivedi), strongly recommended the immediate establishment of a Biosphere Reserve in this island, also specifically demarcated the core zones and buffer zones in a map. After considerable discussions with experts in the Ministry of Enviroment and Forests, the island was finally declared as a Biosphere Reserve in the year 1989. Except for the narrow coastal belt on the southern part of the east and west coasts, where human settlements are already existing, the remaining entire nothern portion and the central southern portion are now protected as Biosphere Reserve (Map 2). Thus it can be safely assumed that the phytodiversity of this island is now fairly well protected. However, in order to sustain this protection for future generations, it is necessary that we should not in any way enhance the developmental activities in the unreserved areas, so that the future population pressure would not nullify the conservation measures taken by the present generation.

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Three story forest canopy - at Indira Point.

Cyathea albosetacea - an endemic tree fern.

Dense fern vegetation in biosphere reserve.

Littoral vegetation - Nevy Dera.

Tacca leontopetaloides - staple food of Shompen tribe.

Pandanus leram var. *andamanensium* - a staple food of Shompen tribe.

Vanilla andamanica - an endemic wild relative of cultivated *Vanilla*.

Sonneratia caseolaris - mangrove tree.

GULF OF MANNAR BIOSPHERE RESERVE

P. Daniel
P. Umamaheswari

The Gulf of Mannar is situated between southeastern India and northwestern Sri Lanka. The Indian part of the gulf covers an area of about 10,500 sq. km (Anon., 1987). It is spread on the Indian side along longitude 78° 08'E 79° 30'E and latitude 8° 35'N 9° 25'N. This was declared as a biosphere reserve on 18th February, 1989 and is the first marine biosphere reserve in entire southeast Asia. It includes all the islands in the Gulf of Mannar and the sea thereabout. The mainland coast, located at the southern end of the East Coast, is about 350 km long running north-south in the districts of Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari in Tamil Nadu. Among the existing 23 islands two, namely, Hare or Pandian and Rameswaram are connected to the mainland while two islands, Vilanguchalli and Poovarsanpatti get exposed only during extremely low tides. The rest run like an arc in the Bay of Bengal from Pamban in Ramanathapuram district in the north to Tuticorin in the south (Table I) and together cover an area of about 625 ha. The biosphere reserve is rich in biological wealth and ecosystem diversity. The presence of a variety of natural resources such as seagrasses, seaweeds, coral reefs, pearl banks, chank beds, mangroves, coastal plant species, marine animals, birds etc. makes the biosphere reserve an important region for conservation.

A marine biosphere reserve has a 'core zone' which is surrounded by a 'buffer zone' for manipulative research and other scientific activities. Near to the 'buffer zone' is the 'utilisation zone' which provides marine resources to meet the basic needs of the local people. Table II provides the zonation in the Gulf of Mannar Biosphere Reserve.

The earliest work exclusively related to the region seems to be that of Iyengar (1927) who while exploring for algae made some observations on angiosperms on Kurusadai and Shingle Islands. Chacko *et al.* (1955) who studied the fauna of the region enumerated the angiosperms of Kurusadai Island. Srinivasan (1960) described the vegetation of Church Island off Tuticorin. Sundararaj and Nagaraj (1964, 1966) enumerated the

Table I
Islands of the Gulf of Mannar Biosphere Reserve

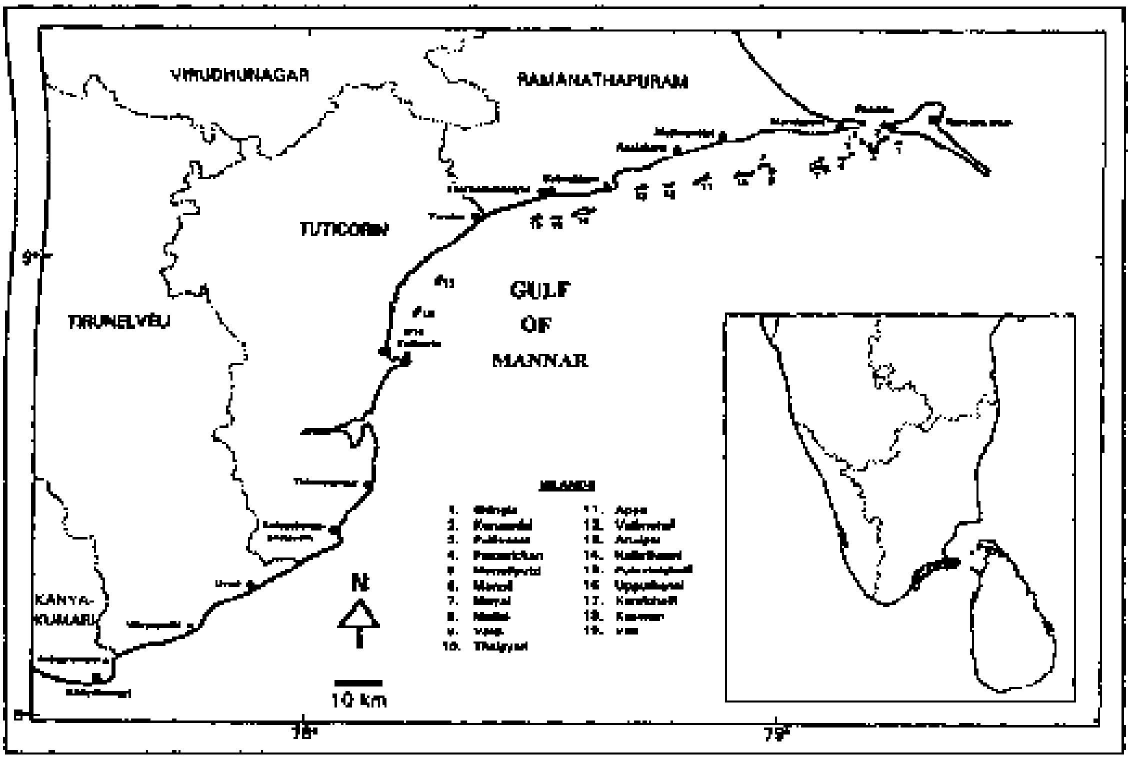
Sl.No.	Name of island	Approximate area	Distance from mainland
A.	**Mandapam group**		
1.	Shingle	12.69 ha	4 km from Pamban
2.	Kurusadai	65.80 ha	3 km from Pamban
3.	Pullivasal	29.95 ha	3 km from Mandapam Camp
4.	Pumarichan	16.58 ha	3 km from Mandapam Camp
5.	Manoliputti	2.34 ha	5 km from Mandapam Camp
6.	Manoli	25.90 ha	6 km from Mandapam Camp
7.	Muyal	129.00 ha	7 km from Mandapam Camp
8.	Rameswaram		(connected to the mainland)
B.	**Keelakarai group**		
1.	Mullai	10.20 ha	10 km from Keelakarai
2.	Valai	10.10 ha	10 km from Keelakarai
3.	Thalaiyari	75.15 ha	10 km from Keelakarai
4.	Appa	28.63 ha	8 km from Keelakarai
5.	Valimunai	6.72 ha	9 km from Keelakarai

Sl.no.	Name of island	Approximate area	Distance from mainland
6.	Anaipar	11.00 ha	9 km from Keelakarai
7.	Nallathanni	101.00 ha	2 km from Mundal
8.	Puluvinichalli	6.00 ha	18 km from Vembar
9.	Poovarasanpatti	0.50 ha (now submerged)	12 km from Keelakarai
C.	**Tuticorin group**		
1.	Upputhanni	22.94 ha	8 km from Vembar
2.	Karaichalli	16.46 ha (now only 12.70 ha)	15 km from Tuticorin
3.	Kaswari	19.54 ha (now only 15 ha)	7 km from Tuticorin
4.	Van	16.00 ha (now only 12 ha)	6 km from Tuticorin
5.	Kuttichalli	(reportedly submerged 30 years ago)	
6.	Vilanguchalli	0.95 ha (now submerged)	15 km from Tuticorin
7.	Hare (Pandian)	16.00 ha	(now connected to the mainland)

species of angiosperms of both Church (Van) and Hare Islands off Tuticorin as well as Kurusadai Island. Rao *et al.* (1963a,b, 1975) studied the coastal flora of Tamil Nadu and that of the Kurusadai (Mandapam) group of islands with an emphasis on ecology. The mainland coast of Ramanathapuram district as well as Kurusadai Island were explored by Ramachandran and Balasubramaniam (1991). Studies of most of the other authors involved only the mainland coast (Gamble, 1915-1936; Henry & Swaminathan, 1981; Hooker, 1872-1897; Lawrence, 1960; Nayar, 1959; Shankaranarayan, 1960). The seagrasses were studied by Ramamurthy *et al.* (1992). The more recent comprehensive reports on the biosphere reserve (Deshmukh and Venkataramani, 1994; Neelakantan, 1994) are with a special stress on the fauna. No efforts were made to study the flora of the biosphere reserve as a whole in the past. All the islands of the biosphere reserve were explored this time around for angiosperms including seagrasses. As the mainland coastal vegetation and the flora thereof have been dealt with at length by various authors earlier referred to as well as Rao (1974), Rao and Sastry (1972, 1974) and Rao *et al.* (1975) and more recently Nair and Vivekananthan (1983), they are not considered here.

Table II
Zonation in the Gulf of Mannar Biosphere Reserve
(as proposed by the State Forest Department,
vide Neelakantan, 1994)

1. Core zone			
	Anaipar	Kurusadai	Manoli
	Manoliputti	Palliyarmunai (Valimunai)	Pullivasal
	Pumarichan	Shalli (Puluvinichalli)	
2. Restoration zone			
	Appa	Karaichalli	Kaswari
	Mullai	Muyal	Nallathanni
	Poovarasanpatti	Shingle	Thalaiyari
	Upputhanni	Valai	Van
	Vilanguchalli		
3. Tourism zone			
	Muyal	Nallathanni	Van



Map of Gulf of Mannar Biosphere Reserve. Inset: Location in Peninsular India

VEGETATION AND FLORA

For convenience, based on the nearness of the mainland coast the islands are grouped into Mandapam, Keelakarai and Tuticorin groups (Table I). The sequence of the islands given below is after their location in the gulf from Rameswaram to Tuticorin.

Shingle Island

This island is mostly filled with dead corals and chanks along its shores. The soil here is mostly coralline. The vegetation is sparse with a few species of large shrubs and a number of herbs. The presence of *Suriana maritima* in good numbers and a few bushes of *Scaevola taccada* on the western side is a significant feature in that both are rare in the biosphere reserve. While mangrove species such as *Avicennia marina, Lumnitzera racemosa* and *Excoecaria agallocha* are scarce, *Pemphis acidula* is the dominant shrub especially on the eastern shore. The foreshore sandy habitat has *Atriplex repens, Cyperus bulbosus, Cyperus conglomeratus* subsp. *pachyrrhizus, Halopyrum mucronatum, Ipomoea pes-caprae, Launaea sarmentosa, Scaevola plumieri* etc. Some of the other species frequent are *Pandanus fascicularis* which forms two patches in the middle of the island, *Asparagus racemosus, Blumea obliqua, Phoenix pusilla, Phyllanthus maderaspatensis, Spinifex littoreus, Thespesia populnea, Vernonia cinerea, Vigna trilobata* etc. The parasitic climber *Cassytha filiformis* infests almost all plants on the island. One large shrub of *Calotropis gigantea* and a small tree of *Ficus benghalensis* were also found. Succulent halophytes like *Sesuvium portulacastrum*, *Suaeda maritima* and *S. nudiflora* are frequent in marshy areas on the eastern side. This island with an area of 12.69 ha has 44 species (Chart 1).

Kurusadai Island

This is the fourth largest island in the biosphere reserve. It is an important island in that it harbours the maximum number of species of mangroves, seagrasses, many rare species besides its unique and characteristic fauna. The vegetation is varied with different habitats such as foreshore sandy, inland sandy, salt marsh, mangrove, sand dune and maritime, in addition to a large *Pandanus* swamp in the middle. The foreshore sandy vegetation consists of *Atriplex repens, Cyperus* *conglomeratus* subsp. *pachyrrhizus*, *Halopyrum mucronatum*, *Ipomoea pes-caprae* along with the rare *Canavalia rosea*, *Scaevola plumieri* and *Sesuvium portulacastrum*. Inland sandy habitat harbours herbs like *Aerva lanata*, *Aloe vera*, *Cucumis melo*, *Enicostema axillare*, *Euphorbia indica*, *Hedyotis puberula*, *Leucas aspera*, *Phyllanthus maderaspatensis*, *Spermacoce ocymoides*, *Vigna trilobata* etc., grasses such as *Chloris barbata*, *Cymbopogon caesius*, *Dactyloctenium aristatum*, *Eragrostis amabilis*, *Trachys muricata* etc. and sedges such as *Bulbostylis barbata*, *Cyperus arenarius*, *C. compressus*, *C. pumilus*, *Fimbristylis cymosa* etc. *Commelina benghalensis*, *C. paleata* and *Cyanotis cristata* which usually grow in shades are frequent. The common climbers are *Asparagus racemosus*, *Coccinia grandis*, *Lablab purpureus*, *Momordica dioica* and the seasonal *Gloriosa superba*. *Cocculus hirsutus*, *Pergularia daemia*, *Solanum trilobatum*, *Tinospora cordifolia* and *Trichosanthes cucumerina* are occasional. A large number of palmyra palms (*Borassus flabellifer*) are present on the southern side. The common species in open sandy areas include *Aerva persica*, *Crotalaria retusa*, *Indigofera oblongifolia* and many grasses and sedges. Some of the common trees are *Dichrostachys cinerea*, *Pleurostylia opposita*, *Prosopis chilensis*, *Salvadora persica* var. *wightiana*, *Thespesia populnea* etc. Species like *Azima tetracantha*, *Caesalpinia bonduc*, *Dodonaea viscosa*, *Manilkara hexandra*, *Phoenix pusilla*, *Premna serratifolia* are frequent near sand dunes. *Spinifex littoreus* is the dominant species on sand dunes. *Calotropis gigantea* occasionally occurs in this habitat. While *Ipomoea violacea* is a frequent climber on many plants, *Cassytha filiformis* infests a number of species. In marshy habitat are present *Aleuropus lagopoides*, *Fimbristylis ferruginea*, *F. polytrichoides*, *Sporobolus tremulus*, *Typha angustata* and the rare *Fimbristylis triflora*. Succulent halophytes such as *Salicornia brachiata*, *Suaeda maritima*, *S. monoica* and *S. nudiflora* also occur. Mangroves consisting mostly of *Avicennia marina*, *Bruguiera cylindrica*, *Ceriops tagal*, *Rhizophora mucronata* etc. with the rare *Aegiceras corniculatum* occur on the northwestern shore. *Pemphis acidula* is a frequent associate of mangroves and protects parts of the northern and eastern shores. *Suriana maritima* forms a patch of about 20 plants on the southern shore. Many species such as *Breynia vitis-idaea*, *Cordia subcordata*, *Ehretia laevis*, *E. ovalifolia*, *Pavetta indica*, *Phyllanthus rotundifolius* and *Solanum pubescens* occur occasionally in different habitats.

The seagrasses *Cymodocea serrulata, Enhalus acoroides, Halodule pinifolia, H. uninervis, Halophila ovalis* and *Syringoidium isoetifolium* are common along the shore. With an area of 65.8 ha this island has 134 species (Chart 1).

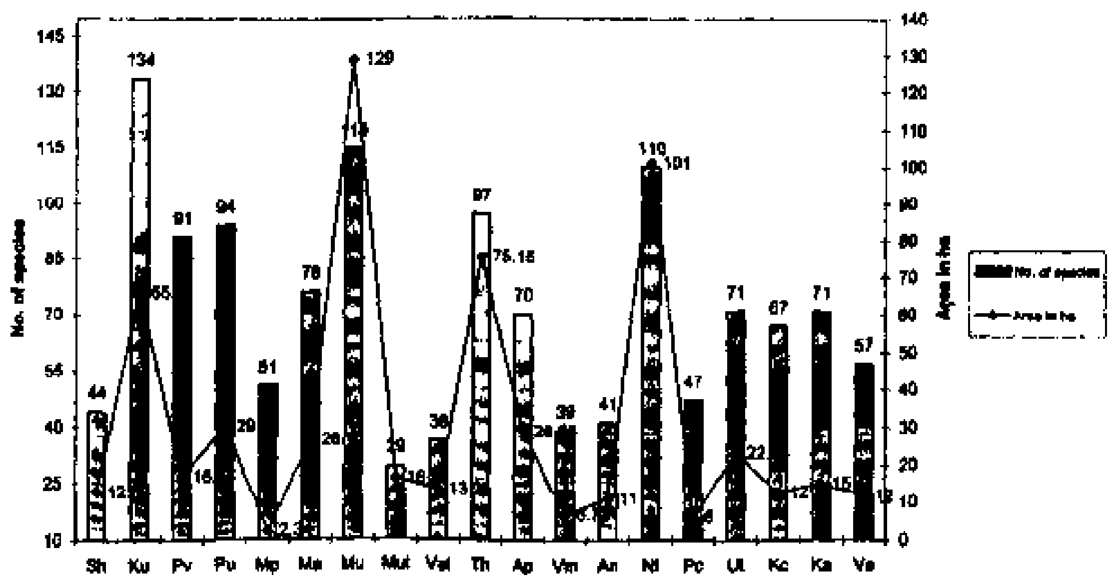


Chart 1: Area and no. of species on different islands of Gulf of Mannar Biosphere Reserve (GMBR)

Pullivasal Island

It harbours a good vegetation particularly mangroves associated with *Pemphis acidula* along the shores and in the muddy swamps and intertidal regions. The area between this island and Pumarichan Island is covered with luxuriant growth of seagrasses *Enhalus acoroides* and *Syringodium isoetifolium*. The shores are well protected from wave action by dense growth of *Pemphis acidula* in most places. Some of the common plants that occur in the inland woody zone include *Dichrostachys cinerea, Dodonaea viscosa, Lannea coromandelica, Pleurostylia opposita* and *Salvadora persica* var. *wightiana* among others. A few species like *Aerva persica, Indigofera oblongifolia, Clitoria ternatea, Crotalaria retusa, Suaeda maritima* and *Azima tetracantha* are abundant in certain places. Many herbs such as *Cleome viscosa, Commelina paleata, Enicostema axillare, Euphorbia indica, Hedyotis puberula, Launaea intybacea, Phyllanthus* spp., *Pupalia lappacea* var. *orbiculata, Spermacoce ocymoides, Vernonia cinerea* etc. are fairly common among grasses. While climbers like *Abrus precatorius, Asparagus racemosus* and *Clitoria ternatea* are frequent in some places, *Lablab purpureus* is the most common climber spreading on almost all plants. The other gregarious climber is *Ipomoea violacea* which is mostly found atop *Thespesia populnea*. Similarly the parasitic twiner *Cassytha filiformis* grows on trees like *Manilkara hexandra* and infests many plants including grasses vigorously. The foreshore sandy habitat has sand binders such as *Atriplex repens*, *Cyperus conglomeratus* subsp. *pachyrrhizus*, *Halopyrum mucronatum*, *Launaea sarmentosa*, *Scaevola plumieri*, *Sesuvium portulacastrum* etc. The common grasses and sedges that grow in the inner herbaceous zone include *Bulbostylis barbata* subsp. *pulchella*, *Cymbopogon caesius*, *Dactyloctenium aegyptium*, *Fimbristylis cymosa*, *Trachys muricata* etc. Species such as *Aloe vera*, *Cassia auriculata*, *Colubrina asiatica*, *Crinum defixum*, *Premna serratifolia*, *Sauropus bacciformis*, *Vicoa indica* and *Ziziphus xylopyrus* are less frequent in different parts of the island. Mangrove species present in the adjacent islands are common here too. Destruction of mangroves on this island in the hidden interior amounts to near-vandalism. A few plants of *Suriana maritima*, which is rare, occur on the southern side. A notable feature is that some of the rare plants like *Cordia subcordata*, *Tarenna asiatica*, *Heterostemma tanjorense* and *Wedelia biflora* grow well in some places. Among these *Wedelia biflora* is a very rare but potentially useful plant which according to a recent report contains useful agrochemicals that effectively control some of the most serious phytopathogens (Miles *et al*., 1993). This plant is restricted only to the southwestern shore of this island in the entire biosphere reserve. Seagrasses that occur along the shallow waters of the shores include *Halodule uninervis*, *Halophila ovalis* and *H. ovata*. There are no sand dunes on Pumarichan as well as Pullivasal Islands. This island has an area of 29.95 ha and 91 species (Chart 1).

Pumarichan Island

This island has its land connection with the nearby Pullivasal Island exposed during low tides. It is situated at the extreme left of and connected to Kurusadai Island by shallow waters during low tides. Both Pumarichan and Pullivasal have almost similar type of vegetation and species-composition. The characteristic feature of the two islands is that they have good mangroves along the muddy shores, tidal swamps and creeks and intertidal regions. Common trees include *Dichrostachys cinerea*, *Lannea coromandelica*, *Manilkara hexandra*, *Pemphis acidula*, *Pleurostylia opposita*, *Salvadora persica* var. *wightiana* and *Thespesia populnea*. Shrubby species such as *Azima tetracantha*, *Caesalpinia bonduc*, *Clerodendrum inerme, Phoenix pusilla, Premna serratifolia* and the tree *Cordia subcordata* etc. are less frequent. Presence of a good number of plants of *Suriana maritima* near mangroves along with *Pemphis acidula* and *Lumnitzera racemosa* on the eastern side is an interesting feature. More common climbers are *Coccinia grandis, Ipomoea violacea, Lablab purpureus* etc. and the frequent ones are *Asparagus racemosus, Cissus quadrangularis, Clitoria ternatea, Gloriosa superba, Momordica dioica, Pergularia daemia* etc. Mangrove species such as *Avicennia marina, Bruguiera cylindrica, Ceriops tagal, Excoecaria agallocha, Lumnitzera racemosa, Rhizophora mucronata* thrive well. Common species of seaward areas are *Atriplex repens, Cyperus arenarius, Cyperus conglomeratus* subsp. *pachyrrhizus, Halopyrum mucronatum, Ipomoea pes-caprae, Launaea sarmentosa, Scaevola plumieri* and *Sesuvium portulacastrum*. Herbs such as *Acalypha indica, Aerva lanata, Corchorus aestuans, Cucumis melo, Euphorbia indica, Hedyotis puberula, Leucas aspera, Phyllanthus maderaspatensis, Spermacoce ocymoides, Vernonia cinerea, Vicoa indica, Vigna trilobata* etc. are frequent among grasses and sedges like *Apluda mutica, Cymbopogon caesius, Cyperus bulbosus, Fimbristylis cymosa, Sporobolus maderaspatanus, S. virginicus, Trachys muricata* etc. The succulent halophytes *Suaeda maritima* and *S. monoica* often occur near pure populations of *Atriplex repens* in the foreshore sandy habitat. Species that are rare and restricted only to this island in the biopshere reserve are *Capparis sepiaria, Ehretia canarensis* and *Erthroxylum monogynum.* Similarly plants which are apparently absent include *Azadirachta indica, Calotropis gigantea, Ficus* spp., *Pandanus fascicularis, Prosopis chilensis, Spinifex littoreus* etc. With an area of 16.58 ha this island has 94 species (Chart 1).

Manoliputti Island

It is the smallest island in the biosphere reserve with an area of 2.34 ha but harbours 51 species (Chart 1). Mangroves and their associate species and sand binders present on the Manoli Island are also common here. The shores are protected by *Pemphis acidula* especially on the eastern side and less frequently with *Avicennia marina. Suaeda maritima* occurs as low shrubs. A feature shared by Manoli and Manoliputti Islands is the presence of *Excoecaria agallocha* in good numbers. The other common species are *Clerodendrum inerme, Crotalaria retusa, Enicostema axillare, Euphorbia indica, Ipomoea* *violacea, Lablab purpureus, Salvadora persica* var. *wightiana, Thespesia populnea, Vernonia cinerea* etc. Besides, herbs such as *Hedyotis corymbosa* and *Pentatropis capensis* are also frequent. *Sopubia delphiniifolia* and *Striga asiatica* are absent.

A small sandbar connecting Manoli and Manoliputti Islands is getting stabilized with plants like *Cyperus conglomeratus* subsp. *pachyrrhizus, Sesuvium portulacastrum, Suaeda maritima*, a few grasses and sedges, and seedlings of *Pemphis acidula*. It can connect the two islands if left undisturbed.

Manoli Island

With an area of about 26 ha this is the fourth largest among the Mandapam group and the seventh largest in the biosphere reserve. It has 76 species (Chart 1). The most striking feature is the presence of near-pure populations of robust *Suaeda maritima* attaining a height of *ca* 2 m in marshy places. *Pemphis acidula, Salvadora persica* var. *wightiana* and *Thespesia populnea* are the common trees. Mangroves with *Avicennia marina, Bruguiera cylindrica, Ceriops tagal, Excoecaria agallocha, Lumnitzera racemosa* and *Rhizophora mucronata* are common in swamps and intertidal regions. Herbaceous species in the interior include *Achyranthes aspera, Aerva persica, Blumea obliqua, Corchorus aestuans, Cucumis melo, Eclipta prostrata, Enicostema axillare, Euphorbia indica, Hedyotis puberula, Peplidium maritimum, Phyllanthus maderaspatensis, P. rotundifolius, Pupalia lappacea* var. *orbiculata, Sopubia delphiniifolia, Striga asiatica, Vernonia cinerea* etc. with grasses such as *Aleuropus lagopoides, Apluda mutica, Cymbopogon caesius, Sporobolus maderaspatanus* etc. *Atriplex repens, Cyperus conglomeratus* subsp. *pachyrrhizus, Halopyrum mucronatum, Launaea sarmentosa, Sesuvium portulacastrum* and *Spinifex littoreus* are the common sand binders on the eastern and western shores. The climbers *Asparagus racemosus, Cissus quadrangularis* and *Coccinia grandis* are common, and *Lablab purpureus* and *Ipomoea violacea* are abundant in the sandy interiors. *Clerodendrum inerme, Premna serratifolia* and the succulent halophytes *Arthrocnemon glaucum* and *Suaeda monoica* are less frequent. Seagrasses common along the shores are *Cymodocea serrulata* and *Halophila ovata*.

Muyal Island

It is the largest island in the biosphere reserve and has 115 species (Chart 1). A very large number of trees of *Borassus flabellifer* (palmyra palm) and *Cocos nucifera* (coconut palm), planted by the earlier private owners, occupy most parts of the island. On the northwestern side exists a considerably large swamp with tidal creeks and mangroves, mostly of *Avicennia marina* and *Lumnitzera racemosa* often associated with *Thespesia populnea* and *Salvadora persica* var. *wightiana* towards the interior. The mangroves have been degraded to a large extent due to felling as may be evident from the left over stumps. *Acacia planifrons* is the dominant tree on the western side. The northern and southern shores are protected by *Pemphis acidula* and sand binders such as *Sesuvium portulacastrum* which forms dense patches in certain areas with *Cyperus conglomeratus* subsp. *pachyrrhizus*, *Halopyrum mucronatum*, *Ipomoea pes-caprae* etc. *Spinifex littoreus* is a common sand dune stabiliser on the eastern side while *Indigofera oblongifolia* is the most common species on the northern side. Some of the herbs present in the middle zone include *Acalypha indica*, *Achyranthes aspera*, *Aerva lanata*, *Asparagaus racemosus*, *Cassia senna*, *Cissus quadrangularis*, *Coccinia grandis*, *Eclipta prostrata*, *Enicostema axillare*, *Gloriosa superba*, *Hedyotis puberula*, *Iphigenia indica*, *Phyllanthus maderaspatensis*, *Tylophora indica*, *Wattakaka volubilis* etc. Grasses such as *Dactyloctenium aegyptium*, *Sporobolus maderaspatanus*, *S. tremulus*, *Trachys muricata* and sedges such as *Bulbostylis barbata*, *Cyperus arenarius*, *C. bulbosus*, *C. stoloniferus*, *Fimbristylis cymosa*, *F. polytrichoides* etc. are very common and often occur in association with *Sopubia delphiniifolia* and *Striga asiatica*. Species frequent in the coconut groves are *Aerva persica*, *Blumea obliqua*, *Boerhavia diffusa*, *Corchorus aestuans*, *Cucumis melo*, *Dactyloctenium aristatum*, *Epaltes divaricata*, *Euphorbia* spp., *Leucas diffusa*, *Pedalium murex*, *Tridax procumbens*, *Vernonia cinerea* etc. Shrubby species like *Calotropis gigantea*, *Clerodendrum inerme*, *Opuntia dillenii*, *Premna serratifolia*, *Securinega leucopyrus* etc. and occasionally *Capparis zeylanica*, *Pleurostylia opposita* and *Ziziphus xylopyrus* occur a little interior in wet sandy localities. Herbs such as *Ammannia baccifera*, *Euphorbia indica*, *Lindernia crustacea*, *Peplidium maritimum*, *Phyllanthus rotundifolius*, *Sauropus bacciformis* etc. are frequent among grasses. A few large trees of *Ficus benghalensis* and *Azadirachta indica* are present on the eastern and norhtern sides. A number of trees of the latter and *Tamarindus indica* are present in the western interior. *Caesalpinia bonduc*, *Cordia obliqua*, *C. subcordata* and *Vitex trifolia* are rare. The climber *Ipomoea violacea* grows luxuriantly.

There are rabbits and peafowl on the island. The private owners in whose possession this island was until recently are said to have introduced them. Their interaction with plant species would form an interesting study.

The seagrasses *Halophila ovata* and *Syringodium isoetifolium* are frequent in the shallow waters along the shores.

Mullai Island

The area of this island is 10.20 ha which is reported to have increased to 16 ha as per 1994 satellite images (Deshmukh and Venkataramani, 1994) and has 29 species (Chart 1). It is mostly sandy and calcareous in some parts. The western side is connected with Valai Island by a *ca* 50 m long and 10 m wide sandy tract which is exposed during low tides. The most common species here include *Acacia planifrons*, *Lablab purpureus*, *Pemphis acidula*, *Salvadora persica* var. *wightiana*, *Scaevola plumieri*, *Sporobolus maderaspatanus*, *Thespesia populnea* etc. *Atriplex repens*, *Cyperus bulbosus*, *C. conglomeratus* subsp. *pachyrrhizus*, *Halopyrum mucronatum* and *Sesuvium portulacastrum* are frequent especially along the foreshore sandy habitat. *Cassia auriculata*, *Clerodendrum inerme*, *Crotalaria retusa*, *Dichrostachys cinerea* and *Indigofera oblongifolia* occupy the calcareous-sandy inner regions. The middle region with sandy soil supports herbs like *Enicostema axillare*, *Hedyotis puberula*, *Launaea intybacea*, *Pentapropis capensis*, *Vernonia cinerea*, *Vicoa indica*, *Vigna trilobata* etc. and a few grasses and sedges. There are neither sand dunes nor salt marshes. Mangroves are absent. Coral reefs and seaweeds grow well in the shallow waters along the shores.

Valai Island

The total area of 10.15 ha of the island is reported to have increased to 13.25 ha as per 1994 satellite image (Deshmukh and Venkataramani, 1994) and has 36 species (Chart 1). It is a linear island which runs parallel to the mainland. Some of the common trees here include *Acacia planifrons*, *Dichrostachys cinerea*, *Salvadora persica* var. *wightiana* and *Thespesia populnea*. Besides, species like *Clerodendrum inerme*, *Crotalaria retusa, Indigofera oblongifolia, Prosopis chilensis* are frequent in the inner sandy habitat. Herbs such as *Achyranthes aspera, Aerva lanata, Enicostema axillare, Hedyotis puberula, Vernonia cinerea, Vicoa indica, Vigna trilobata* etc. are quite common along with grasses like *Cymbopogon caesius, Eragrostis riparia, Eremopogon foveolatus, Sporobolus maderaspatanus* etc. Along the northern shores the dominant sand binders are *Cyperus conglomeratus* subsp. *pachyrrhizus, Halopyrum mucronatum, Scaevola plumieri* and *Spinifex littoreus* whereas on the southern side a dense population of *Pemphis acidula* mixed with *Avicennia marina* and *Atriplex repens* protects the shores from erosion. *Caesalpinia bonduc* occasionally occurs among bushes on the northern side. *Lablab purpureus* is the dominant climber, mostly climbing on *Salvadora persica* var. *wightiana* and *Thespesia populnea*.

The long sandy tract on the northern side connecting this island with Mullai Island is getting colonised by sand binders *Sesuvium portulacastrum* and *Scaevola plumieri*.

Thalaiyari Island

It is the second largest island in the Keelakarai group and third largest in the biosphere reserve and harbours 97 species (Chart 1). The most common species are *Pemphis acidula* and *Thespesia populnea*. Sand binders like *Atriplex repens, Cyperus conglomeratus* subsp. *pachyrrhizus, Halopyrum mucronatum, Scaevola plumieri, Spinifex littoreus* etc. often in association with *Apluda mutica* and *Eremopogon foveolatus* or *Ipomoea pes-caprae* protect the northern and western shores. Most of the island's shores are inhabited by *Pemphis acidula* which completely covers the eastern side. In the marshy inland habitats grasses and sedges such as *Cyperus squarrosus, Fimbristylis cymosa, Sporobolus maderaspatanus* etc. are common with herbs like *Sopubia delphiniifolia* and *Striga asiatica*. Other species in marshy habitats are *Ammannia baccifera, Blumea obliqua, Hedyotis corymbosa, Heliotropium spp., Lindernia minima, L. parviflora, Ludwigia perennis, Peplidium maritimum, Sauropus bacciformis, Salicornia brachiata, Spermacoce ocymoides* etc. Open areas are mostly occupied by *Aerva lanata, A. persica, Cleome viscosa, Corchorus fascicularis, Crotalaria retusa, Eclipta prostrata, Enicostema axillare, Euphorbia indica, Hedyotis puberula, Launaea intybacea, Pedalium murex, Pentatropis* *capensis, Phyllanthus maderaspatensis, Physalis minima, Stemodia viscosa, Tribulus lanuginosus, Vernonia cinerea, Vigna trilobata* etc. and grasses.

Species such as *Acacia planifrons, Clerodendrum inerme, Dichrostachys cinerea, Indigofera oblongifolia, Prosopis chilensis* and *Salvadora persica* var. *wightiana* are of frequent occurrence. A small patch of *Avicennia marina* with *Lumnitzera racemosa* and *Suaeda maritima* occurs on the northern part. *Lablab purpureus* is the common climber whereas *Coccinia indica, Ipomoea nil, Pergularia daemia* etc. are less frequent. Weedy herbs like *Amaranthus polygamus, Datura metel, Tribulus terrestris* etc. inhabit the interior damp sandy places. Species of rare occurrence include *Hedyotis pumila, Ipomoea coptica, Micrococca mercurialis* and *Polycarpaea spicata* which grows among grasses. *Enhalus acoroides* is the common seagrass that occurs along the shallow waters of the eastern shores.

Appa Island

This island lying north-south in two bits is connected by a sandbar under shallow waters. The predominant species on the northern bit is *Prosopis chilensis* followed by *Acacia planifrons*. *Thespesia populnea* and *Salvadora persica* var. *wightiana* are less frequent. The shores of the southern bit are full of dead corals and live coral reefs while that of the northern one are sandy with populations of *Prosopis chilensis*. There are no mangroves or their associate species. Herbs such as *Achyranthes aspera, Aerva lanata, A. persica, Aloe vera, Boerhavia diffusa, Cissus quadrangularis, Coccinia grandis, Hedyotis puberula, Pedalium murex, Pupalia lappacea* var. *orbiculata*, *Striga asiatica, Tephrosia maxima* and *Vernonia cinerea* along with grasses like *Dactyloctenium aegyptium, Eragrostis amabilis, Trachys muricata* and sedges such as *Cyperus arenarius, C. bulbosus* etc. are common throughout. The northern bit harbours *Ipomoea pes-caprae, Launaea sarmentosa, Scaevola plumieri, Sesuvium portulacastrum* and *Spinifex littoreus* whereas the southern bit has *Sesuvium portulacastrum* and *Scaevola plumieri*. *Bulbostylis barbata* subsp. *pulchella, Cyperus bulbosus, C. stoloniferus, Dactyloctenium aristatum, Eragrostis coarctata, Fimbristylis ferruginea, Mariscus squarrosus, Rikliella squarrosa, Tribulus lanuginosus* etc. are exclusive to the northern bit. Presence of a lonely *Moringa pterygosperma* tree and the rare grass *Eragrostis* *amabilis* var. *insularis* are the interesting taxa present in this part. The western elevated part of the southern bit has a vast expanse of grasses dominated by *Cenchrus setigerus* with a sprinkling of *Apluda mutica, Cymbopogon caesius, Gloriosa superba* and *Aloe vera* here and there. Species occuring only in the southern bit include *Alysicarpus rugosus* var. *styrasifolius*, *Calotropis gigantea, Cayratia trifolia, Crinum defixum, Indigofera colutea, Opuntia dillenii* and the rare herb, *Polycarpaea spicata*. Seagrasses that occur along the shores are *Cymodocea serrulata, Halophila ovalis* and *Syringodium isoetifolium*. With an area of 28.63 ha this island has 70 species (Chart 1).

Valimunai Island

Palliyarmunai is the other name for this island. In the foreshore occur *Cyperus arenarius, C. bulbosus, C. conglomerataus* subsp. *pachyrrhizus, Halopyrum mucronatum, Ipomoea pes-caprae, Scaevola plumieri, Sesuvium portulacastrum, Spinifex littoreus* etc. In the interior herbs such as *Boerhavia diffusa, Hedyotis puberula, Phyllanthus maderaspatensis, Pupalia lappacea* var. *orbiculata, Vernonia cinerea* etc. are frequent. Grasses such as *Cymbopogon caesius, Dactyloctenium aegyptium, Sporobolus maderaspatanus* and sedges like *Bulbostylis barbata, Cyperus arenarius* etc. also occur here. A few patches of *Aloe vera* are found. The parasitic herb *Cassytha filiformis*, and *Cissus quadrangularis* are common too. The more common species of the island are *Aerva persica, Coccinia grandis, Crotalaria retusa, Indigofera oblongifolia* and *Lablab purpureus*. Trees which are a little frequent include *Acacia planifrons, Lannea coromandelica, Prosopis chilensis, Salvadora persica* var. *wightiana* and *Thespesia populnea*. A few patches of *Pemphis acidula* occur on the western side. Notably large shrubs of *Cassia auriculata* are present on the eastern side. The climber *Wattakaka volubilis* is rare. This island with an area of 6.72 ha harbours 39 species (Chart 1).

Anaipar Island

The island is mostly surrounded by coral reefs. Trees are represented by *Acacia planifrons, Dichrostachys cinerea, Lannea coromandelica* and *Salvadora persica* var. *wightiana*. Large bushes of *Pemphis acidula* and *Prosopis chilensis* occur here and there. The foreshore sandy habitat harbours *Atriplex repens, Scaevola plumieri* and *Sesuvium portulacastrum* along with grasses and sedges. *Coccina grandis, Ipomoea pes-tigridis, I. violacea* and *Lablab purpureus* are the most common climbers whereas the parasitic climber *Cassytha filiformis* infests most herbs. Species that occur in the interior are *Aerva lanata, A. persica, Aloe vera, Asystasia gangetica, Boerhavia diffusa, B. erecta, Cardiospermum canescens, Cleome viscosa, Commelina benghalensis, Euphorbia indica, Hedyotis puberula, Pergularia daemia, Phyllanthus rotundifolius, Vernonia cinerea, Vigna trilobata* etc. Grasses like *Cymbopogon caesius, Dactyloctenium aegyptium, Sporobolus maderaspatanus* and sedges such as *Cyperus arenarius, C. bulbosus* etc. also grow well along with these herbs. A few bushy populations of *Clerodendrum inerme* occur on the eastern side. With an area of 11 ha this island harbours 41 species (Chart 1).

Nallathanni Island

This is just 2 km away from the mainland coastal village of Mundal near Valinokkam in Ramanathapuram district. It is the largest island in the Keelakarai group and the second largest in the biosphere reserve and harbours 110 species (Chart 1). *Azadirachta indica, Borassus flabellifer, Delonix elata, Ficus benghalensis, Lannea coromandelica, Moringa pterygosperma, Pongamia pinnata, Tamarindus indica* are the planted trees. Most part of the island is occupied by large number of palmyra and coconut palms. The western side is dominated by *Acacia planifrons, Thespesia populnea* and *Prosopis chilensis*. Vegetation on sand dunes with *Acacia planifrons* and *Borassus flabellifer* is reminiscent of that of the mainland coast. The eastern side is rich in sand binders such as *Ipomoea pes-caprae, Spinifex littoreus* and occasionally *Atriplex repens, Cyperus conglomeratus* subsp. *pachyrrhizus* and *Halopyrum mucronatum*. Species like *Aerva persica, Calotropis gigantea, Citrullus colocynthis, Hedyotis graminifolia, Euphorbia rosea, Phyllanthus maderaspatensis* etc. occur near sand dunes. *Boerhavia diffusa, Cenchrus ciliaris, Chloris barbata, Cyperus bulbosus, Hedyotis puberula, Iphiginea indica, Leucas aspera, Pedalium murex, Sida cordifolia, Trachys muricata, Vernonia cinerea* etc. are common in the inner sandy regions. In coconut groves *Achyranthes aspera, Aerva lanata, Ammannia baccifera, Corchorus aestuans, Cucumis melo, Eclipta prostrata, Euphorbia rosea, Hedyotis graminifolia, Launaea intybacea, Phyllanthus amarus, Physalis minima, Polygala erioptera, Spermacoce hispida, Vigna trilobata* etc. along with grasses and sedges such as *Brachiaria ramosa, Cyperus pumilus, Dactyloctenium aristatum, Setaria verticillata, Sporobolus maderaspatanus* etc. are common. While climbers like *Cissus quadrangularis* and *Coccinia grandis* are common here, *Cocculus hirsutus* and *Wattakaka volubilis* are occasional. Species frequent in the inland herbaceous zone include *Cleome viscoa, Crotalaria retusa, Indigofera colutea, Jatropha glandulifera* etc. In marshy areas *Cyperus stoloniferus, Fimbristylis cymosa, F. ferruginea* and *Sporobolus tremulus* are common whereas *Bulbostylis barbata, Cymbopogon caesius, Eragrostis amabilis, E. coarctata* etc. are frequent in dry sandy areas. *Acrachne henrardiana*, the endemic grass, is of rare occurrence on sandy soil under shade particularly that of *Acacia planifrons*. *Fimbristylis triflora* is pretty common on sandy soil in the interior. *Solanum virginianum* is rare. A few plants of *Ziziphus mauritiana* and *Clerodendrum inerme* occur on the eastern and southeastern sides respectively. Other species that are extremely rare are *Atalantia racemosa, Ehretia ovalifolia, Hydrophylax maritima* and *Polycarpaea spicata*. This is the only island that has potable water now. The absence of *Lablab purpureus* which is profuse in almost all islands of the Mandapam group is striking.

There is a temple on the island which is visited by the local village folks frequently. The rituals at the temple include goat sacrifice as well.

There are rabbits and peafowl on the island introduced by earlier private owners. Bulbs of *Cyperus bulbosus* are reportedly a staple food of the peafowl. Nothing is known about the interaction of these animals with plants.

Puluvinichalli Island

This is the smallest (6 ha) island in the Keelakarai group and has 47 species (Chart 1). The northern shores are occupied by *Cyperus conglomeratus* subsp. *pachyrrhizus, Halopyrum mucronatum, Launaea sarmentosa, Scaevola plumieri, Sesuvium portulacastrum* etc. The inner herbaceous habitat has *Aerva persica, Asystasia gangetica, Boerhavia diffusa, Cyperus arenarius, C. rotundus, Dactyloctenium aegyptium, Hedyotis puberula, Phyllanthus maderaspatensis, Sporobolus virginicus, Vernonia cinerea* etc. *Lablab purpureus, Coccinia grandis* and *Cissus quadrangularis* are the common climbers. One large bush of *Clerodendrum inerme* in association with *Pupalia lappacea* var. *orbiculata* was found on the northern side. Some of the common trees of the mainland such as *Azadirachta indica*, *Prosopis chilensis* and *Tamarindus indica* along with *Thespesia populnea* also occur.

Absence of mangroves and associated species, salt marsh plants and sand dune stabilizers like *Spinifex littoreus* is a characteristic feature of this island.

Upputhanni Island

The low-lying southern side of the island is coralline while others are sandy. There is a large swamp almost in the middle with numerous stunted bushes of *Avicennia marina* along the fringes extending into the sea on the southern side. On the southwest raised sandy tract occur robust bushes of *Arthrocnemon glaucum* in association with *Suaeda maritima*. Trees are represented by *Azadirachta indica*, *Prosopis chilensis*, *Tamarindus indica* and *Thespesia populnea* which are rare. Sand binders such as *Cyperus arenarius*, *C. conglomeratus* subsp. *pachyrrhizus*, *Ipomoea pes-caprae*, *Scaevola plumieri* and *Sesuvium portulacastrum* are found on the northern and eastern sandy shores. Inland vegetation is dominated by herbs like *Achyranthes aspera*, *Aerva persica*, *Asystasia gangetica*, *Coccinia grandis*, *Enicostema axillare*, *Pedalium murex*, *Phyllanthus maderaspatensis*, *Spermacoce hispida*, *Tribulus terrestris*, *Vernonia cinerea* etc. and grasses and sedges like *Bulbostylis barbata*, *Cymbopogon caesius*, *Dactyloctenium aegyptium*, *Eragrostis amabilis*, *E. coarctata* etc. *Hedyotis puberula*, *Hydrophylax maritima* and *Leucas mollisma* are not uncommon. *Aloe vera* is frequent in association with *Achyranthes aspera*, *Aerva persica* and *Azadirachta indica*. Climbers like *Coccinia grandis* and *Pergularia daemia* dwell on *Azadirachta indica* and *Clerodendrum inerme*. *Crotalaria medicaginea* var. *herniarioides* is frequent and occurs on the western and eastern sides with *Gisekia pharnaceoides* and *Indigofera linnaei*. The sandy eastern shore is dominated by *Cardiospermum canescens* in association with *Aerva persica*, *Asystasia gangetica* and *Pupalia lappacea* var. *orbiculata*. Shrubs like *Clerodendrum inerme* and *Calotropis gigantea* are frequent.

Notable feature is the occurrence of about 30 plants of *Atalantia racemosa* with a near-globose crown of *ca* 1 m and an almost invisible trunk. *Leucas anandaraoana* is a new species described from this island (Umamaheswari and Daniel 1999). With an area of 22.94 ha this island harbours 71 species (Chart 1).

Karaichalli Island

In the foreshore sandy habitat sand binders such as *Cyperus conglomeratus* subsp. *pachyrrhizus, Halopyrum mucronatum, Scaevola plumieri* and *Sesuvium portulacastrum* usually dominate. *Atriplex repens* and *Launaea sarmentosa* are also frequent. Species like *Aerva persica, Blumea obliqua, Cassia italica, Cleome viscosa, Crotalaria retusa, Croton bonplandianum, Cucumis melo, Enicostema axillare, Euphorbia rosea, Hedyotis puberula, Indigofera oblongifolia, Phyllanthus maderaspatensis, Spermococe hispida, Trianthema triquetra, Vernonia albicans, Vigna trilobata* etc. are common. *Cymbopogon caesius* and *Eremopogon foveolatus* are common in the interior. *Cadaba fruticosa, Caralluma adscendens* and *Jatropha glandulifera* which usually occur in association with *Aloe vera, Cardiospermum canescens* and *Cissus quadrangularis* are rare. *Suaeda maritima* and *S. monoica* are also rare.

The coralline habitat of the southern side harbours *Aloe vera, Cissus quadrangularis, Cardiospermum canescens, Suaeda maritima, Prosopis chilensis, Ziziphus mauritiana* etc.

The seagrasses *Halodule pinifolia* and *Syringodium isoetifolium* are quite common in that they are washed ashore in plenty. The common tree species present almost all over the island is *Salvadora persica* var. *wightiana*. This island has an area of 12.7 ha and 67 species (Chart 1).

Kaswari Island

This island which originally had an area of about 19 ha has lost one fourth of its area due to removal of coral reefs, seaweeds, and other human interference and consequent erosion (Neelakantan, 1994), and has 71 species (Chart 1). The vegetation is sparse with less number of species. The foreshore habitat has sedges like *Cyperus arenarius, C.*

conglomeratus subsp. *pachyrrhizus* and other herbs like *Atriplex repens, Launaea sarmentosa, Ipomoea pes-caprae, Sesuvium portulacastrum, Spinifex littoreus* etc. *Scaevola plumieri* is abundant almost throughout the island. Species like *Crotalaria retusa, Enicostema axillare, Vernonia cinerea, Vigna trilobata* along with common sedges and grasses like *Bulbostylis barbata* subsp. *pulchella, Cyperus stoloniferus, Fimbristylis ferruginea, Cymbopogon caesius, Eremopogon foveolatus* and *Sporobolus maderaspatanus* are frequent. *Opuntia dillenii* which usually occurs in association with the rare *Indigofera oblongifolia* is also rare.

Around the swamp on the southern side occur shrubs of *Avicennia marina* and *Arthrocnemon glaucum* in association with *Atriplex repens, Suaeda maritima* and *S. monoica. Pemphis acidula*, which is part of this association, is rare.

Seagrasses such as *Halodule pinifolia, Halophia stipulacea,* and *Syringodium isoetifolium* were found washed ashore in plenty. *Halophila stipulacea* was collected on this island for the first time.

Van Island

This is the smallest (12 ha) island in the Tuticorin group and was known as the Church Island by earlier workers. It has 57 species (Chart 1). The vegetation is very sparse with less number of species. Sand binders like *Cyperus conglomeratus* subsp. *pachyrrhizus* and *Halopyrum mucronatum* are common along the shores often in association with *Sesuvium portulacastrum* and *Scaevola plumieri* which is the most common species here. Only a few bushes of *Salvadora persica* var. *wightiana* occur on the eastern and southern sides. On the western and northern sides a few patches of trees of *Prosopis chilensis* are present. *Clerodendrum inerme* forming two large patches is found on the southwestern side. Herbs such as *Aerva lanata, Crotalaria retusa, Enicostema axillare, Hedyotis puberula, Indigofera oblongifolia, Tribulus terrestris, Vernonia cinerea* and *Vigna trilobata* are frequent in the interior mostly in association with grasses and sedges like *Cenchrus ciliaris, Cymbopogon caesius. Eremopogon foveolatus. Sporobolus maderaspatanus, S. tremulus, Bulbostylis barbata* subsp. *pulchella, Fimbristylis cymosa* etc. *Atriplex repens* and *Launaea sarmentosa* are found occasionally along with *Scaevola plumieri*. Succulent halophytes like *Suaeda maritima, S. monoica* and *Arthrocnemon glacum* are frequent on the southern shores. A few bushes of *Aloe vera* occur in association with *Salvadora persica* var. *wightiana* on the southeastern side. A good number of plants of *Cressa cretica* which is rare on islands was found on the sandy tracts of the southern side. *Pentatropis capensis* in association with *Sporobolus tremulus* was also common here. *Cissus quadrangularis*, found on *Salvadora persica* var. *wightiana*, is not common. *Halopyrum mucronatum* is in its robust form here.

The presence of stunted form of *Salvadora persica* var. *wightiana* which is otherwise a tree is a characteristic feature of the islands of the Tuticorin group.

Some of the more common seagrasses along the shores are *Cymodocea serrulata, Halophila ovalis* and *Syringodium isoetifolium*.

Mangroves

Until a few years ago mangroves were considered to be destroyable wastelands and there has been massive destruction of mangrove forests of southern Asia and the Pacific for wood chips used by rayon and other industries (Vannucci, 1991). These characteristic littoral forests form a complex and unique ecosystem as an essential part of coastal environment. Mangroves play an important role in land-building, stabilising seashores and preventing soil erosion besides being the habitat for a wide variety of organisms associated with this ecosystem. Mangrove trees are a significant source of fuel and also used for construction and industrial purposes (Groombridge, 1992).

Mangroves of the Gulf of Mannar Biosphere Reserve deserve more attention since they are fast-dwindling due to natural as well as man-made disturbances. The species diversity of mangroves is moderately rich in the Mandapam group of islands whereas in other areas of the biosphere reserve usually one and rarely two species, *viz*., *Avicennia marina* and *Lumnitzera racemosa* occur. The most common mangroves are *Avicennia marina, Ceriops tagal* and *Rhizophora mucronata*. *Bruguiera cylindrica* and *Lumnitzera racemosa* are frequent on the Mandapam group of islands. *Rhizophora apiculata* and *Aegiceras corniculatum* are rare. While the former species is restricted to a single backwater creek in Pamban, the latter is restricted to Kurusadai Island. *Excoecaria agallocha*, one of the economically and medicinally very important mangrove species, occurs only on the Mandapam group of islands. It is rare on the mainland coast. *Avicennia marina* is abundant both along the mainland coast particularly beyond Keelakarai towards south as well as on many islands. However, only stunted populations are common around Tuticorin which become extremely stunted around Punnakayal further south. Kurusadai Island harbours the maximum number of six species which may indicate the diversity of habitat/ecosystem there. Destruction of the mangroves on some of the islands like Muyal and Pullivasal is indeed systematic.

Seagrasses

These specialised marine angiosperms inhabit tidal and subtidal zones of shallow and sheltered localities of seas, gulfs, bays, backwaters, lagoons and estuaries. They are found to grow either homogenously or heterogenously in mixed populations forming thick and dense meadows on muddy, sandy and clayey soils of the sea and coral rubble bottoms (Ramamurthy *et al.*, 1992). Seagrasses support a large number of marine organisms which directly or indirectly depend on them. Besides, they help reduce surface erosion in sedimentation areas and check ocean currents and maintain active nutrient cycles especially of phosphorus, nitrogen and sulphur. More importantly, they are relished by many endangered and extinct-prone marine animals. For instance, the seacow, *Dugong dugong*, one of the most endangered marine mammals, is reported to prefer pastures of *Halodule uninervis* (Anon., 1987). A variety of products such as paper, chemicals, fertilizers etc. can also be produced from harvested seagrasses (*vide* Phillips & McRoy, 1980). Direct human consumption of seagrasses as food has also been reported (Turner & Bell, 1963). In all 13 species belonging to 6 genera occur throughout the biosphere reserve. Plants of *Cymodocea serrulata, Halodule pinifolia, H. uninervis, Halophila ovalis, H. ovata* and *Syringodium isoetifolium* are found abundantly washed ashore both along the mainland coast as well as that of many of the islands. *Enhalus acoroides* with its large leaves harbours various marine micro-flora and -fauna. It is common along the shores of Kurusadai, Pumarichan, Pullivasal and Thalaiyari Islands. *Halophila stipulacea*, collected around Kaswari Island and *Halodule wrightii*, around Manoli Island, are rare in the biosphere reserve.

PLANT DIVERSITY

Though the plant diversity in the biosphere reserve may not be that rich compared to that of oceonic islands, the presence of a number of species of seagrasses and a variety of vegetation like foreshore sandy, inland herbaceous, inland closed woody, mangrove, swamp, salt marsh, sand dune etc. on the islands endow the biosphere reserve with good diversity in ecosystems. Such a diversity and a rich floristic and faunistic wealth, geographic and allied features make these islands ideal natural laboratories.

The biosphere reserve as a whole harbours *ca* 269 species of angiosperms with 203 species of dicots and *ca* 66 monocots. Of these 42 are trees, 33 shrubs, 173 herbs and 21 are climbers which include *Cassytha filiformis*, the only parasite.

Plant diversity in arid environments is low compared with that of most other biomes. Yet the number of species in a given area is not necessarily a good measure of either their functional or economic importance (Belal and Springuel, 1996). The situation in the Gulf of Mannar Biosphere Reserve seems to corroborate this conclusion. Economically important plants abound in the region. Table III lists plants of known medicinal uses. Eight species that are endemic to peninsular India occur in the biosphere reserve as well. Besides, a number of species are identified as rare (Table IV).

Another 36 species endemic to peninsular India occur on the mainland coast some of which might get dispersed to the islands in future. Among those identified as rare, species such as *Canavalia rosea*, *Cenchrus setigerus*, *Cordia diffusa*, *Crotalaria medicaginea* var. *herniarioides*, *Dactyloctenium aristatum*, *Dalbergia horrida*, *Dipcadi montanum* var. *madrasicum*, *Fimbristylis triflora*, *Hydrophylax maritina*, *Lindernia minima*, *Melhania cannabina*, *Polycarpaea spicata*, *Rhynchosia velutina*, *Scaevola taccada*, *Suriana maritima* and *Wedelia biflora* are rare elsewhere too as may be evident from holdings at MH.

Table III
Medicinal plants
(Ambasta, 1986; Warrier *et al.*, 1994 - 1996; Anon., 1996; Tripathi *et al.*, 1996).

Botanical name	Family
Abrus precatorius	Fabaceae
Acalypha indica	Euphorbiaceae
Achyranthes aspera	Amaranthaceae
Aerva lanata	Amaranthaceae
Aloe vera	Liliaceae
Ammannia baccifera	Lythraceae
Asparagus racemosus	Liliaceae
Azadirachta indica	Meliaceae
Boerhavia diffusa	Nyctaginaceae
Borassus flabellifer	Arecaceae
Caesalpinia bonduc	Caesalpiniaceae
Calotropis gigantea	Asclepiadaceae
Carissa carandas	Apocynaceae
Cassia auriculata	Caesalpiniaceae
C. occidentalis	Caesalpiniaceae
C. senna	Caesalpiniaceae
Cayratia trifolia	Vitaceae
Cissus quandragularis	Vitaceae
Citrullus colocynthis	Cucurbitaceae
Cleome gynandra	Cleomaceae
C. viscosa	Cleomaceae
Clitoria ternatea	Fabaceae
Coccinia grandis	Cucurbitaceae
Cocculus hirsutus	Menispermaceae
Cocos nucifera	Arecaceae
Colubrina asiatica	Rhamnaceae
Corchorus aestuans	Tiliaceae

Botanical name	Family
C. fascicularis	Tiliaceae
Cressa cretica	Boraginaceae
Crotalaria retusa	Fabaceae
Cucumis melo	Cucurbitaceae
Cyperus rotundus	Cyperaceae
Datura metel	Solanaceae
Dichrostachys cinerea	Mimosaceae
Diplocyclos palmatus	Cucurbitaceae
Dodonaea viscosa	Sapindaceae
Eclipta prostrata	Asteraceae
Emila sonchifolia	Asteraceae
Enicostema axillare	Gentianaceae
Evolvulus alsinoides	Convolvulaceae
Euphorbia thymifolia	Euphorbiaceae
Ficus benghalensis	Moraceae
F. religiosa	Moraceae
Gloriosa superba	Liliaceae
Hedyotis corymbosa	Rubiaceae
H. herbacea	Rubiacreae
Hibiscus tiliaceous	Malvaceae
Indigofera tinctoria	Fabaceae
Iphigenia indica	Liliaceae
Ipomoea alba	Convolvulaceae
I. coptica	Convolvulaceae
I. nil	Convolvulaceae
I. pes-caprae	Convolvulaceae
Jatropha glandulifera	Euphorbiaceae
Lannea coromandelica	Anacardiaceae
Leucas aspera	Lamiaceae
Lycopersicon esculentum	Solanaceae
Manilkara hexandra	Sapotaceae

Botanical name	Family
Moringa pterygosperma	Moringaceae
Mukia maderaspatana	Cucurbitaceae
Pandanus fascicularis	Pandanaceae
Pedalium murex	Pedaliaceae
Pergularia daemia	Asclepiadaceae
Phoenix pusilla	Arecaceae
Phyllanthus amarus	Euphorbiaceae
P. maderaspatanus	Euphorbiaceae
Physalis minima	Solanaceae
Pongamia pinnata	Fabaceae
Sapindus emarginatus	Sapindaceae
Sarcostemma acidum	Asclepiadaceae
Scutia myrtina	Rhamnaceae
Securinega leucopyros	Euphorbiaceae
Sida cordifolia	Malvaceae
Solanum trilobatum	Solanaceae
S. virginianum	Soplanaceae
Spermacoce hispida	Rubiaceae
Syzygium cumini	Myrtaceae
Tamarindus indica	Caesalpiniaceae
Tephrosia purpurea	Fabaceae
Thespesia populnea	Malvaceae
Tribulus terrestris	Zygophyllaceae
Trichosanthes cucumerina	Cucurbitaceae
Tylophora indica	Asclepiadaceae
Typha angustata	Typhaceae
Vernonia cinerea	Asteraceae
Vitex trifolia	Verbenaceae
Wedelia biflora	Aseraceae
Ziziphus mauritiana	Rhamnaceae

Table IV
Endemic and rare species

Botanical name	Family
Acrachne henrardiana	Poaceae [Endemic]
Aegiceras corniculatum	Myrsinaceae
Atalantia racemosa	Rutaceae
Caesalpinia bonduc	Caesalpiniaceae
Canavalia rosea	Fabaceae
Caralluma adscendens	Asclepiadaceae [Endemic]
Cardiospermum canescens	Sapindaceae
Cenchrus setigerus	Poaceae
Cordia diffusa	Boraginaceae [Endemic]
C. obliqua	Boraginaceae
C. subcordata	Boraginaceae
Crotalaria medicaginea var. *herniarioides*	Fabaceae
Cyperus rotundus	Cyperaceae
Dactyloctenium aristatum	Poaceae
Dalbergia horrida	Fabaceae [Endemic]
Dipcadi montanum var. *madrasicum*	Liliaceae [Endemic]
Eremopogon foveolatus	Poaceae
Erythroxylum monogynum	Erythroxylaceae
Excoecaria agallocha	Euphorbiaceae
Fimbristylis triflora	Cyperaceae
Halodule wrightii	Potamogetonaceae
Halophila stipulacea	Hydrocharitaceae
Halosarcia indica	Chenopodiaceae
Hedyotis graminifolia	Rubiaceae
Heterostemma tanjorense	Asclepiadaceae
Hydrophylax maritima	Rubiaceae
Leucas anandaraona	Lamiaceae [Endemic]
L. diffusa	Lamiaceae

Botanical name	Family
Lindernia minima	Scrophulariaceae [Endemic]
Melhania cannabina	Sterculiaceae [Endemic]
Phyllanthus rotundifolius	Euphorbiaceae
Polycarpaea spicata	Caryophyllaceae
Premna serratifolia	Verbenaceae
Pupalia lappacea var. *orbiculata*	Amaranthaceae
Rhizophora apiculata	Rhizophoraceae
Rhynchosia velutina	Fabaceae
Sapindus emarginatus	Sapindaceae
Sarcostemma acidum	Asclepiadaceae
Scaevola taccada	Goodeniaceae
Sopubia delphiniifolia	Scrophulariaceae
Sporobolus virginicus	Poaceae
Suriana maritima	Surianaceae
Tylophora indica	Asclepiadaceae
Vitex trifolia	Verbenaceae
Wattakaka volubilis	Asclepiadaceae
Wedelia biflora	Asteraceae

FACTORS AFFECTING THE FLORA

Throughout the biosphere reserve biodiversity and ecosystems are getting affected due to a number of direct as well as indirect factors involving human interference as well as natural calamities such as gales, cyclones, storms and consequent floods. A few factors are particularly important and immediate action needs to be taken to conserve the ecosystems.

In many areas the problem of encroachment along the seashore is acute. Rapid industrialisation and conversion of mangroves and other coastal habitats for aquaculture farms in the vicinity of the biosphere reserve cause extensive damage to the marine environment. Besides, the increase in area of salt pans along the coasts, which appears to be a direct consequence of many salt-based industries, is a serious problem threatening the vegetation in the region. Felling of trees on the mainland coast and mangroves on the islands for short-term economic gains takes precedence over long-term benefits which have both economic and environmental value. Species such as *Avicennia marina, Ceriops tagal, Pemphis acidula, Lumnitzera racemosa, Pleurostylia opposita* and *Rhizophora mucronata* are being targetted for fuelwood and other purposes. The magnitude of destruction on the Pullivasal Island may indicate that extraction of wood here has been going on for quite sometime. Human interference in the form of island based drift-net, stake-net and wall-net fishing operations resorted to by fishermen throughout the year affect the growth of seagrasses and other marine organisms. Another threat to the biodiversity is the large scale removal of natural resources like coral reefs, mangroves and seaweeds (such as species of *Gelidium, Gracilaria, Sargassum* etc.) for industrial use. Extraction of seaweeds and heaps of extracted corals on the mainland coast are not an infrequent sight. Soil erosion witnessed in a number of places on the mainland coast as well as that of the islands seems to be a result of such multiple factors. A very recent press report says that the Gulf of Mannar coast particularly in Tirunelveli district has been for the last two years subjected to illegal sand-mining for garnet extraction for export. The mining has been so severe that it has considerably reduced the shrimp catch in the nearby seas and seawater has penetrated for about 6 km into the land making the rice fields and drinking water wells saline. However, the more undesirable immediate tangible fallout has been the eruption of avoidable tension among groups of people in the otherwise peaceful places like Periathalai, Uvari, Perumanal etc. It seems that it is the social tension that compelled the district administration to recommend to the state government the immediate banning of the sand-mining with a suggestion for detailed studies by scientists on the threats posed by it.

Apart from this pollution from the industries has its own adverse effects. This is more intense especially around Tuticorin. This port city is highly industralised so much so it is not what it was a few decades ago. With the new 1000-crore controversial copper smelting plant, another 1500-crore oil refinery to be installed in the near future and the optimistic anticipation of enormous foreign investment in more industries and the already expanded port getting expanded further as a result, Tuticorin is not going to be what it is in a couple of decades. Such an unplanned and fast industrialization is highly unlikely to be conducive to the existence of the already affected marine biota around this place.

The consequence of these causal factors is not only habitat destruction but also loss of islands as such. Three islands have aleady submerged and a few existing ones are facing rapid erosion. Many species have either become rare or disappeared from the known areas of their occurrence. Mention may be made of Kurusadai Island where species earlier reported such as *Acanthus ilicifolius*, *Excoecaria agallocha*, *Maytenus emarginata* (Chacko *et al.*, 1955; Rao *et al.*, 1963a) and *Tournefortia argentea* (Sundararaj & Nagarajan, 1966), and *Polycarpaea spicata* have never been re-collected. Similarly species such as *Bruguiera gymnorrhiza*, *Capparis tenera*, *Catunaregam spinosa*, *Derris trifoliata*, *Ehretia microphylla*, *Maba buxifolia* and *Tamarix dioica* reported to occur in different parts of Rameswaram (Rao *et al.*, 1963b) have no recent collections. *Polycarpaea diffusa*, originally described from Tuticorin by Wight, has never been collected in the type locality. Likewise *Bonamia evolvuloides*, *Najas malesiana*, *Dalbergia horrida* and *Polycarpaea spicata* have never been collected around Tuticorin after Wight.

SUGGESTIONS FOR CONSERVATION

The biosphere reserve, as pointed out by Deshmukh and Venkataramani (1994), is located in an underdeveloped and economically backward region. The conservation of the existing biodiversity involves protection of different habitats and ecological niches not only on the islands but along the entire mainland coast as well. Shingle Island of the Mandapam group is remarkable in that it now harbours a large number of plants of *Suriana maritima* in addition to a few of *Excoecaria agallocha* and *Scaevola taccada*. All these species are rare in the biosphere reserve. This indicates that the islands may have better vegetation after regeneration if left undisturbed. Another important habitat is Pamban where along the backwaters at Kundhukal a reasonably large swamp with five species of mangroves exists. *Avicennia marina* attains large size here giving a majestic appearance. The mangroves need to be conserved with due consideration for the flora and fauna.

There is an urgent need to protect the ecosystems of the biosphere reserve which are getting threatened due to pollution from industries. The pollution from the thermal plant at Tuticorin has a telling effect in its vicinity. Replanting of mangrove species in suitable places after studying the factors governing optimal development should be given due consideration. Many organisms of economic importance and potentially useful species are interdependent. Hence, immediate steps need to be taken to check human interference such as illicit firewood collecting, seaweed collecting, coral mining and different types of fishing operations on and around many of the islands. The existing islands off Tuticorin are likely to face the serious problem of submergence if these causal factors continue to operate unabated.

Biotechnological approaches through *in vitro* clonal propagation and crop preservation methods can be undertaken for conserving rare and threatened plants of the biosphere reserve. Standardising agronomic practices for domestication of wild food, fodder, fuel and medicinal plants would protect the genetic diversity and also improve the economy of the local people. Remote sensing technology may be employed to monitor the changes in the vegetational and geographical pattern in the biosphere reserve.

It should be convincingly highlighted to the local people that all ecosystems and biogeochemical cycles are interlinked and should be protected and exploited judiciously. In other words, educate the people on the importance of conserving the natural resources and protecting the environment so that they willingly participate in conservation. Unless this is achieved the confrontation and hostility between the locals and the biosphere reserve management is going to be never-ending and the much talked about conservation would remain an unattainable goal.

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Scaevola taccada

Canavalia rosea and *Ipomoea pes-caprae*

Rhizophora mucronata (foreground) and *Avicennia marina* trees in the background.

Aegiceras corniculatum - rare.

A view of mangroves.

Destruction of mangroves.

Cymodocea serrulata - common seagrass.

A mangrove swamp.

Destruction of mangroves - another view.

Acacia planifrons and *Borassus flabellifer*
- an association on sand dunes.

Hydrophylax maritima - rare.

Atalantia racemosa - rare.

KANCHANJUNGA BIOSPHERE RESERVE

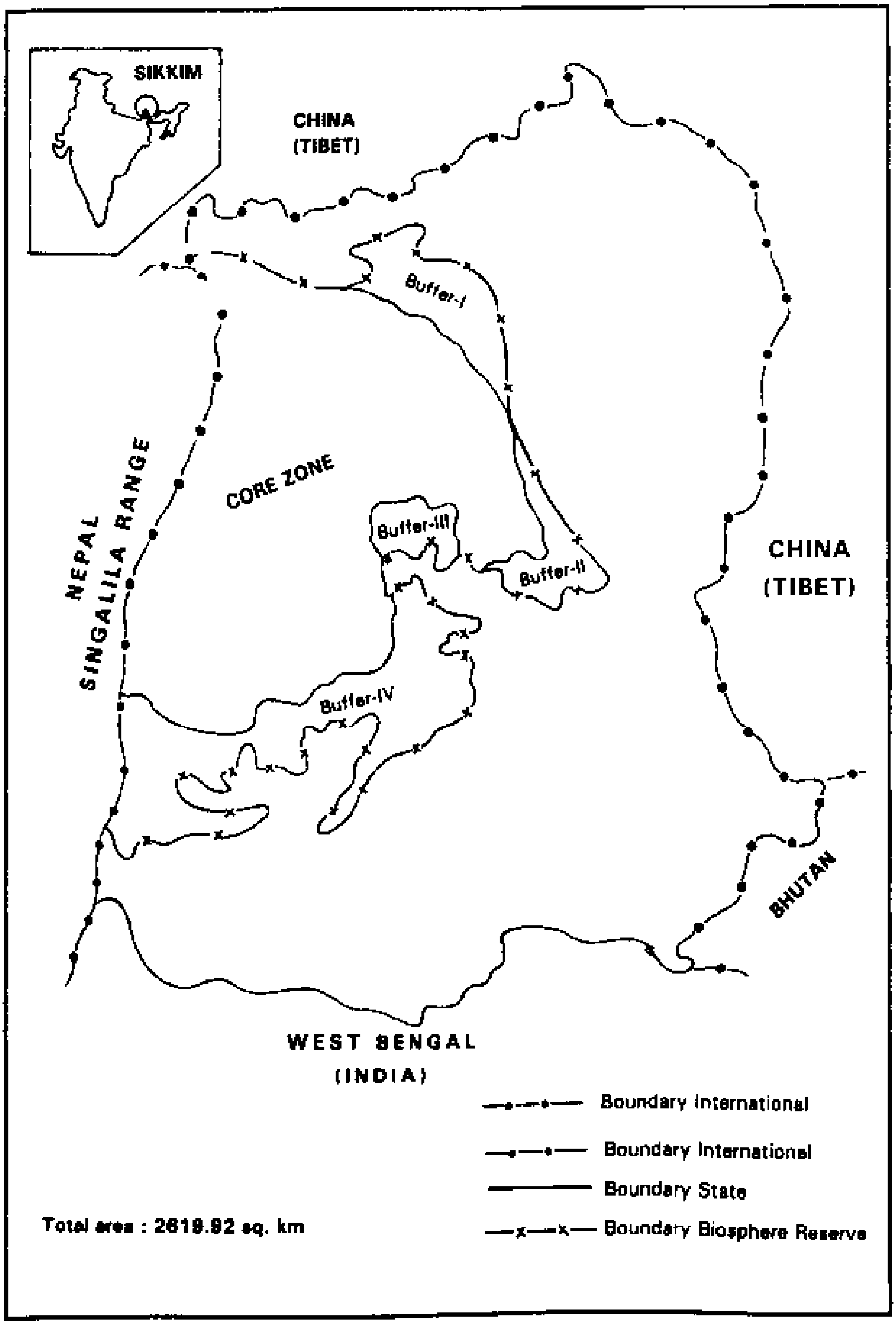
Debabrata Maity
A.S. Chauhan

Kanchanjunga Biosphere Reserve was established on February 7th, 2000 to conserve the unique biodiversity of the area. The biosphere reserve covering a total area of 2619.92 sq. km, lies between 27° 15' 27° 57' N latitude and 88° 02' 88° 40' E longitude in North and West districts of Sikkim state. It has a core zone and 4 buffer zones covering an area of 1784.00 sq. km and 835.92 sq. km respectively. The biosphere reserve has the boundary of notified Kanchanjunga National Park and Lungnakla in the north and Tista river in the east, to the south it includes the boundary of various reserved forests of south and west forest divisions of the state and to the west, it is bounded by the Singalila range which forms the international boundary between Indian state Sikkim and Nepal. It also has a short stretch of international boundary with China in the north-west corner of the state.

Topography and climate

The topography of the biosphere reserve is quite varied. Mountains are the most important feature and their elevations range from *ca* 1220 to 8550 m with almost no flat piece of land any where. The snow-clad mountains, the lower hills covered with dense evergreen forests, many rivers and rivulets cascading down from the rocky heights and rippling through the green expanse of the valleys constitute a magnificent and eye inspiring panorama. Zemu chu, Thomphyan chu, Phuthung chu, Rangyong chu, Prek chu, Umran, Rukel, Rimbi are the main river systems in the biosphere reserve. The largest glacier of the state, the Zemu is present within the biosphere reserve. Besides, few other glaciers like Tholung, Thangsing etc. are also the source of water for many perennial rivers.

Due to great altitudinal variations, the climate of the biosphere varies from place to place. It is burning summer at the foot hills and freezing chills in winter at high mountains. The weather is pleasent during spring (March-May) and autumn (September-November). The biosphere reserve experiences a wide range of humidity which rises up to 95% during the



Map : Kanchanjunga Biosphere Reserve rainy season (June- July). The rainfall also varies from 2000 to 5000 mm per year.

The biosphere reserve has least biotic interference as there are only two small eco- villages. Tsoka one of the two villages, belongs to Tibetan community with a population of 90 in an allotted area of 13 acres. It was treated as a part of the ecosystem. The other small village is of retired army personnel of Nepalese community (Gurung), settled in an area of 10 acres of land. The biosphere reserve is also surrounded by other rural villages which belong to other communities like Lepchas, Bhutias and Nepalese. About 75% of house holds are considered to be poor and they directly or indirectly depend on the biosphere reserve for their livelihood. The rural economy of the area is of mixed type and mostly depends on agriculture, horticulture and animal husbandary.

VEGETATION

Kanchanjunga Biosphere Reserve is one of the richest phytodiversity centre in Sikkim himalaya. Due to its unique geographical position, the vegetation of the biosphere reserve has invasion of many foreign elements as well as endemic species. The vegetation of biosphere reserve can broadly be grouped into subtropical, temperate and alpine forest types.

Subtropical forests

Subtropical forests occur up to an altitude of *ca* 1800 m. These are mainly mixed type of forests, comprising of *Macaranga denticulata*, *Alnus nepalensis*, *Castanopsis tribuloides*, *Rhododendron arboreum*, *Alangium chinense*, *Maesa chisia*, *Malus sikkimensis*, *Ficus semicordata*, *Toricellia tiliifolia*, *Schima wallichii*, *Saurauia nepaulensis*, etc. as tree species. Predominant shrubs here are *Dichroa febrifuga*, *Oxyspora paniculata*, *Melastoma malabathricum*, *Buddleja asiatica*, *Edgeworthia gardneri*, *Rubus ellipticus*, *Mussaenda roxburghii*, etc. Many climbing species of *Piper*, *Smilax*. *Tetrastigma*, *Rhaphidophora*, etc. are also common in these forests. Dominant herbs found in the biosphere belong to species like *Persicaria capitata*, *Houttuynia cordata*, *Gnaphalium affine*, *Eupatorium odoratum*, *Gynura pseudo-china*, *Ranunculus diffusus*, *Notochaete hamosa*, *Drymaria villosa*, *Sagina japonica*, *Elatostema lineolatum*, *Plantago erosa*, *Crassocephalum crepidioides*. *Hydrocotyle asiatica*, *Achyranthes bidentata*, *Oxalis corniculata*, *Oxalis griffithii*, *Galinsoga parviflora*, *Bidens pilosa*, etc.

Temperate forests

These forests are confined between 1800 and 3500 m altitude and can be further divided in to (a) broad leaved temperate forests and (b) coniferous forests. The important tree species of broad leaved forests are *Acer campbellii*, *Exbucklandia populnea*, *Alnus nepalensis*, *Betula utilis*, *Malus sikkimensis*, *Lithocarpus pachyphylla*, *Engelhardtia spicata*, *Quercus* spp., *Enkianthus deflexus*, *Pieris formosa*, *Lyonia ovalifolia*, *Rhododendron grande*, *Magnolia campbellii*, etc. Shrubby vegetation is quite dense and diverse and comprises of *Berberis aristata*, *B. insignis*, *Buddleja colvilei*, *Hypericum hookerianum*, *Sambucus adnata*, *Philadelphus tomentosus*, *Mahonia nepaulensis*, *Gaultheria* spp., etc.

The temperate zone is also characterized by presence of numerous interesting species of climbers like *Ceropegia pubescens*, *Aristolochia griffithii*, *Clematis montana*, *C. acuminata*, *C. buchananiana*, *Dicentra scandens*, *Holboellia latifolia*, etc. Similarly, dominant herbaceous species in these forests are represented by *Aconogonum molle*, *Bistorta vaccinifolia*, *Koenigia nepalensis*, *Euphorbia sikkimensis*, *Pilea anisophylla*, *Gaultheria trichophylla*, *Agapetes incurvata*, *Panax pseudo-ginseng*, *Rubus fragarioides*, *Arisaema nepenthoides*, *A. griffithii*, *A. jacquemontii*, *A. propinquum*, *Smilacina oleracea* f. *acuminata*, *Roscoea purpurea*, *Hedychium* spp., etc. Many herbaceous species of *Begonia* and *Impatiens* grow along the banks of rivers, rivulets and other moist places. Some dominant species are *Impatiens bicolor*, *I. longipes*, *I. spirifer*, *I. sulcata*, *Begonia flaviflora*, *B. josephii*, etc.

A few insectivorus species like *Drosera peltata*, *Utricularia brachiata*, *U. wallichiana*, *U. multicaulis*, etc. are also found in moist and shady places.

The coniferous species are one of the important constituents of the temperate vegetation. The common species found here are *Larix griffithii*, *Cupressus corneyana*, *Abies spectabilis*, *Tsuga dumosa* and an important medicinal plant *Taxus wallichiana*. *Cryptomeria japonica*. introduced long ago has now naturalized and flourshing well within the biosphere reserve.

Alpine forests

These forests occur between *ca* 3500 and 5000 m altitude. At low altitudes usually shrubby species of *Berberis, Vaccinium, Rhododendron, Cotoneaster, Salix, Ribes*, etc. grow profusely. At higher elevations the vegetation comprises of alpine moorland where tree growth is completely arrested and bushes form dense clumps. Some predominant alpine species found are *Rheum acuminatum*, *Rheum nobile*, *Primula capitata*, *P. obliqua*, *P. minutissima*, *P. sikkimensis*, *Rhododendron ciliatum*, *R. anthopogon*, *R. lepidotum*, *Cassiope fastigiata*, *Parnassia nubicola*, *Rhodiola himalensis*, *R. imbricata*, *Corydalis juncea*, *Nardostachys grandiflora*, *Saussurea gossypiphora*, *Meconopsis paniculata*, *Caltha palustris*, *Potentilla coriandrifolia*, *P. peduncularis*, *Cypripedium himalaicum*, *Pododphyllum hexandrum* and species of *Aconitum, Bryocarpum, Cassiope, Gentiana, Corydalis, Saxifraga, Sedum*, etc.

Three species of gymnosperms are also found in this zone, of these *Juniperus recurva* and *J. squamata* are very common, whereas *Ephedra gerardiana* occurs at few places.

FLORISTIC DIVERSITY

Kanchanjunga Biosphere Reserve exhibits enormous floristic diversity which is presently under investigation. There are diverse species of Rhododendrons, Orchids, medicinal plants, horticultural plants, taxa of ethnobotanical importance, rare and endangered species. The diversity is also further enriched by the presence of numerous species of adjacent and distant regions. In the present state of knowledge, the biosphere comprises about 1225 species of angiosperms distributed under 490 genera and 120 families. These figures may change in due course of time when remaining surveys and studies are completed. The present status of different groups of vascular plants, a conspectus of families showing number of genera and families and families showing maximum diversity in biosphere reserve are presented (Tables I-V) below.

Table I
Status of different groups of vascular plants

Group	Family	Genera	Species
ANGIOSPERMS	120	490	1225
Dicots	(105)	(379)	(1030)
Monocots	(15)	(111)	(195)
GYMNOSPERMS	5	9	10
PTERIDOPHYTES	22	37	57

Table II
A conspectus of families showing number of genera and species

Family	Genera	Species
DICOTYLEDONS		
Ranunculaceae	8	33
Magnoliaceae	2	5
Schisandraceae	1	1
Menispermaceae	3	4
Berberidaceae	4	4
Podophyllaceae	1	1
Lardizabalaceae	1	1
Papaveraceae	2	6
Fumariaceae	2	20
Brassicaceae	17	36
Violaceae	1	5
Polygalaceae	1	1
Caryophyllaceae	9	38
Tamaricaceae	1	9
Theaceae	2	3

Family	Genera	Species
Actinidiaceae	1	1
Saurauiaceae	1	1
Stachyuraceae	1	1
Malvaceae	1	1
Sterculiaceae	1	1
Geraniaceae	1	7
Oxalidaceae	1	3
Balsaminaceae	1	12
Rutaceae	5	6
Burseraceae	1	1
Aquifoliaceae	1	1
Celastraceae	1	2
Rhamnaceae	2	3
Vitaceae	1	2
Sapindaceae	1	1
Aceraceae	1	6
Sabiaceae	2	2
Coriariaceae	1	1
Fabaceae	18	32
Caesalpiniaceae	2	2
Rosaceae	15	69
Saxifragaceae	5	34
Grossulariaceae	1	5
Philadelphaceae	1	2
Hydrangeaceae	2	3
Parnassiaceae	1	4
Droseraceae	1	1
Haloragaceae	2	3
Melastomataceae	4	5

Family	Genera	Species
Onagraceae	3	10
Samydaceae	1	1
Cucurbitaceae	5	5
Begoniaceae	1	3
Apiaceae	9	21
Araliaceae	4	7
Cornaceae	1	1
Alangiaceae	1	1
Caprifoliaceae	5	32
Sambucaceae	1	3
Rubiaceae	12	18
Valerianaceae	2	4
Dipsacaceae	4	4
Asteraceae	48	123
Campanulaceae	4	8
Lobeliaceae	1	3
Vacciniaceae	1	7
Ericaceae	9	42
Monotropaceae	1	1
Diapensiaceae	1	1
Primulaceae	6	42
Myrsinaceae	2	4
Symplocaceae	1	4
Oleaceae	1	1
Asclepiadaceae	5	8
Buddlejaceae	1	3
Gentianaceae	7	33
Boraginaceae	8	21
Convolvulaceae	1	1

Family	Genera	Species
Cuscutaceae	1	2
Solanaceae	3	6
Scrophulariaceae	10	44
Orobanchaceae	1	1
Lentibulariaceae	2	4
Gesneriaceae	8	14
Acanthaceae	1	1
Verbenaceae	2	2
Lamiaceae	13	19
Plantaginaceae	1	4
Amaranthaceae	4	4
Chenopodiaceae	2	3
Phytolaccaceae	1	1
Polygonaceae	9	34
Aristolochiaceae	1	2
Piperaceae	2	8
Lauraceae	4	5
Thymelaeaceae	2	6
Loranthaceae	2	4
Santalaceae	3	3
Balanophoraceae	1	1
Euphorbiaceae	6	8
Urticaceae	7	11
Cannabaceae	1	1
Moraceae	2	2
Juglandaceae	1	1
Betulaceae	3	13
Fagaceae	1	2
Salicaceae	2	8

Family	Genera	Species
MONOCOTYLEDONS		
Orchidaceae	32	51
Zingiberaceae	5	12
Haemodoraceae	2	4
Iridaceae	1	1
Amaryllidaceae	2	6
Hypoxidaceae	1	1
Liliaceae	17	25
Smilacaceae	1	2
Commelinaceae	2	3
Juncaceae	2	15
Araceae	3	13
Najadaceae	2	2
Eriocaulaceae	1	1
Cyperaceae	9	13
Poaceae	31	46
PTERIDOPHYTES		
Huperziaceae	1	1
Lycopodiaceae	2	2
Selaginellaceae	1	2
Equisetaceae	1	1
Plagiogyriaceae	1	1
Gleicheniaceae	1	1
Dicranopteridaceae	1	1
Loxogrammaceae	1	1
Polypodiaceae	7	12
Cryptogrammaceae	1	1
Pteridaceae	1	4

Family	Genera	Species
Hemionitidaceae	1	3
Vittariaceae	1	2
Monachosoraceae	1	1
Pteridiaceae	1	1
Lindsaeaceae	2	2
Thelypteridaceae	1	1
Aspleniaceae	1	1
Athyriaceae	1	3
Peranemtaceae	1	1
Dryopteridaceae	4	12
Nephrolepidaceae	1	1
Oleandraceae	1	1

Table III
Dominant families

Family	Genera	Species
Asteraceae	48	123
Rosaceae	15	69
Orchidaceae	32	51
Poaceae	31	46
Scrophulariaceae	10	44
Ericaceae	9	42
Primulaceae	6	42
Caryophyllaceae	9	38
Brassicaceae	9	38
Polygonaceae	9	34

KBR = Kanchanjunga Biosphere Reserve.

Table IV
Largest families of dicots by number of species

Family	KBR	Sikkim
Asteraceae	123	310
Rosaceae	69	138
Scrophulariaceae	44	112
Ericaceae	42	65
Primulaceae	42	94
Caryophyllaceae	38	51
Brassicaceae	38	78
Polygonaceae	34	76
Saxifragaceae	34	63
Ranunculaceae	33	99

Table V
Largest families of monocots by number of species

Family	KBR	Sikkim
Orchidaceae	51	494
Poaceae	46	271
Liliaceae	25	75
Juncaceae	15	36
Araceae	13	40
Cyperaceae	13	147
Zingiberaceae	12	52
Amaryllidaceae	6	6
Haemodoraceae	4	12
Commelinaceae	3	22

KBR = Kanchanjunga Biosphere Reserve.

Fungi

The humid climate of the reserve provides suitable habitats for rich growth of fungal flora. They are found almost every where starting from the foot hills to the higher elevations in the hills. During rainy season many edible fungi are collected by local communities and used as substitute for vegetable. Sometimes some species are dried and stored for use in future. Some of the edible fungi belong to different genera are *Agaricus, Polyporus, Clavaria, Boletus, Lycoperdon,* etc.

Besides, some deadly poisonous fungi are also found. *Rossula tinctoria* -a source of rossuline, and *Amanita* sp. a source of amanitin also occur in the biosphere reserve. Some other fungi collected so far from the reserve belong to genera are *Calocybe, Coprinus, Clitocybe, Flammula, Lentinus, Mycena, Mutinus, Panus, Peziza, Marasmius, Tremella* and *Xylaria.*

Lichens

In general lichens are poorly studied in the country. The biosphere exhibits rich lichen diversity. All growth forms, the crustose, foliose and fruticose types are found almost in all climatic zones. However, they are more predominant in subtropical and temperate zones. Some lichen species found in the biosphere reserve are *Peltigera dolichorrhiza, Solorina crocea, Nephroma helveticum, Lobaria pseudopulmonaria, L. kurokawae, L. discolor* var. *discolor, L. retigera, Sticta nylanderiana, Parmelia adangescens, Parmotrema nilgherrense, P. mellisii, P. tinctorum, P. subtinctorium, Parmelina wallichiana, P. aurulenta, Plastismatia erosa, Hypogymnia vittata* , *Leptogium azureum, Collema furfuraceum, Coccocarpia erythroxylii, Cladonia furcata, C. chlorophaea, Usnea baileyi* , *U. longissima, Stereocaulon paradoxum,* etc.

Pteridophytes

Pteriodophytic flora of the biosphere is also rich and diverse. Pteriodophytes occur on the slopes of rocky mountains from subtropical to alpine areas but more predominant in temperate zone. Some common pteridophytes met in the biosphere reserve are *Asplenium ensiforme, Lepisorus leiopteris, Pyrrosia flocculosa, P. mollis, Polypodiastrum argutum, Phymatopteris erythrocarpa, Phymatosorus cuspidatus, Polypodioides amoena, Lepisorus angustus, L. nudus, Microsorium membranaceum, Arthromeris wallichiana, Coniogramme subcordata, C. cautata, Diplazium frondosum, Polystichum lentum, P. semifertile, Pteris wallichiana, P. biaurita, P. critica, P. aspericaulis, Gleichenia* *gigantea*, *Nephrolepis cordifolia*, *Sphenomeris chinensis*, *Loxogramma involuta*, *Selaginella monospora*, *S. involvens*, *Dicranopteris liniaris* var *montana*, *Palhinhea cernua*, etc. In alpine areas two species of Dryopteridaceae viz *Dryopteris berbigera* and *Polystichum prescottianum* are very common.

ENDEMIC TAXA

The endemic taxa are those which are confined to a small area. These species due to certain specific habitat conditions and barriers may remain within the region and could not spread beyond their confines. North eastern region being a center of active speciation harbours large number of endemic taxa. As far as Kanchanjunga Biosphere Reserve is concerned, the endemic species are mainly confined to the regions of Zemu, Llonakh, Lachen valleys, etc. Some of the endemic taxa found in Sikkim Himalaya and other north-eastern states are also flourishing well within the biosphere reserve and are appended in the table VI.

THREATENED SPECIES

Sikkim Himalaya has been identified as one of the important "Hot Spot" of the country. However, this rich plant diversity is threatened due to various natural and biotic factors. While incidences of flood, earth quakes, land slides, biological factors such as natural competition between species etc. have contributed to some extent to alteration of vegetation types. It is the man made threats such as distruction of natural habitats for agriculture, mining, urbanisation, grazing and over exploitation of germ plasm etc. are responsible for the rapid transformation of land scape in the region. Consequently, the population of several taxa have been depauperised considerably and some of the native plants are under great danger. A list of such taxa is given in the table VII.

ETHNOBOTANY

The tribal communities have a good knowledge of wild plants. They are dependent on the natural resources for their food, shelter, medicines, fodder, insecticides, etc. They live in the fringe areas of the biosphere reserve. Some ethnobotanically important species used by them are provided in the tables from VIII to XVI.

Table VI
Endemic species from other parts found in the Kanchanjunga Biosphere Reserve

Botanical name	Family	Locality	Altitude in meters	Habit
a. From Sikkim Himalaya				
Hypericum filicaule	Hypericaceae	Zema-II to Jakthang	3300	Herb
Lonicera magnibracteata	Caprifoliaceae	Thila	3800-4100	Shrub
Codonopsis foetens	Campanulaceae	Llonakh valley, Thila	4000-4300	Herb
Gentiana prainii	Gentianaceae	Kishong	4000	Herb
Listera alternifolia	Orchidaceae	Zema - II	3100	Herb
b. From N.E. India				
Abies densa	Pinaceae	Jakthang- Tholung	3600- 3800	Tree
Agapetes incurvata	Ericaceae	Bakhim	2800	Epiphytic shrub
Betula utilis	Betulaceae	Tholung - Kishong	3500	Tree
Larix griffithii	Pinaceae	Zema-II- Jakthang	3300	Tree
Meconopsis grandis	Papaveraceae	Thila, Kishong	4000-4200	Herb
Rhododendron ciliatum	Ericaceae	Dzongri	4200	Scrub

Botanical name	Family	Locality	Altitude in meters	Habit
Rhododendron grande	Ericaceae	Bakhim- Tsoka Tholung-Kishong	2700-3000	Tree
Rhododendron wightii	Ericaceae	Tsoka-Dzongri	3700-3900	Small Tree
Rubus fragarioides	Rosaceae	Tsoka, Phedang, Jakthang, Tholung-Kishong	3300-4200	Herb

Table VII
Rare and threatened plants

Botanical name	Family	IUCN category	Locality	Altitude in m.	Habit
Aconitum ferox	Ranunculaceae	EN	Kishong	4000	Herb
Aconitum heterophyllum	Ranunculaceae	EN	Kishong Pachpokhri	3800 4100	Herb
Arisaema echinatum	Araceae	LR	Lachen	3000	Herb
Arisaema griffithii	Araceae	VU	Zemi - II	2700-3000	Herb
Aristolochia griffithii	Aristolochiaceae	VU	Lachen	3000	Climber
Balanophora involucrata	Balanophoraceae	CR	Karchi	2900	Herb
Bryocarpum himalaicum	Primulaceae	LR	Zema II to Jakthang	3500	Herb
Campylandra aurantiaca	Liliaceae	EN	Yoksum - Bakhim, Bey - Tholung	2100	Herb
Codonopsis foetens	Campanulaceae	EN	Muguthang	4300	Herb
Cypripedium himalaicum	Orchidaceae	EN	Thila-Jakthang	4200	Herb
Ephedra gerardiana var. *sikkimensis*	Ephedraceae	EN	Phimla	4250	Shrub
Gentiana prainii	Gentianaceae	CR	Kishong	4000	Shrub

Botanical name	Family	IUCN category	Locality	Altitude in m.	Habit
Hypericum filicaule	Hypericaceae	EN	Zema-II to Jakthang	3300	Herb
Listera alternifolia	Orchidaceae	CR	Thila	3800 -4100	Shrub
Lonicera magnibracteata	Caprifoliaceae	CR	Zema - II	3100	Herb
Nardostachys grandiflora	Valerianaceae	CR	Dzongri	4000	Herb
Panax pseudo-ginseng	Araliaceae	LR	Lachen-Jakthang Tholung-Kisong	3000 4000	Herb
Podophyllum hexandrum	Podophyllaceae	EN	Thila- Jackthang	3400	Herb
Rheum nobile	Polygonaceae	EN	Dzongri, Kishong, Thela	4200 4400	Herb
Rhododendron anthopogon	Ericaceae	VU	Dzongri, Thela, Kishong	4100 4200	Scrub
Rhododendron setosum	Ericaceae	VU	Dzongri, Thela, Kishong	4200	Scrub
Taxus wallichiana	Taxaceae	VU	Karchi	3000	Tree

CR: Critically endangered: EN: Endangered; VU: Vulnerable; LR: Lower risk

Table VIII
Medicinal plants

Botanical name	Family	Vernacular name	Parts used	Disease/ailments
Abies densa	Pinaceae	Gobresalla Chanden Kung Dumsing	Oleoresin	Toothache
Abroma augusta	Sterculiaceae	Kapsi (N) Chuli (L)	Bark	Menstrual disorder
Achyranthes aspera var. *porphyristachya*	Amaranthaceae	Apangpati(N)	Leaf	Cut and wounds
Artemisia nilagirica	Asteraceae	Titapati (N) Teil (L)	Leaf	Nasal bleeding, benemicidal and skin treatment
Astilbe rivularis	Saxifragaceae	Bokeokhati (N)	Bark of root	Bodyache, menstrual disorder
Begonia spp.	Begoniaceae	Chimcharch (L)	Leaf and petiole	Stomachache
Berberis wallichiana	Berberidaceae	Chitrokanra (N)	Fruit	Madness of dog
Bergenia purpurascens	Saxifragaceae	Pakhanbed (N)	Rhizome and	Bodyache and wounds, Peyogokhum (L) Stem throat pain
Boenninghausenia albiflora	Rutaceae	Sambupati (N)	Leaf	Mild eafraction milking cows

Botanical name	Family	Vernacular name	Parts used	Disease/ailments
Buddleja asiatica	Buddlejaceae	Sonpati (N)	Leaf	Headache
Cajanus cajan	Papilionaceae	Raharh (N)	Leaf	Loose motion
Capsella bursapastoris	Brassicaceae	Tori (N)	Leaf	Vomiting
Centella asiatica	Apiaceae	Golpat (N)	Leaf	Lever disorder
Cissampelos pareira var. *hirsuta*	Menispermaceae	Taamarkey (N)	Stem	Stomach, liver disorder
Clematis montana	Ranunculaceae	Simegrah (N)	Stem	Stomach complaints of cattle
Clematis nepaulensis	Ranunculaceae	Pinasey jhar (N)	Green stem	Headache and nasal snoring
Codonopsis viridis	Campanulaceae	Aniomukh (L)	Leaf	Infant diahorrea
Commelina benghalensis	Commelinaceae	Kaanay (N)	Watery latex	Conjunctivitis
Costus speciosus	Costaceae	Betlauri (N) Roo-pa-Tong (L)	Rhizome	Urinary disorder and food poisoning
Cuscuta reflexa	Cuscutaceae	Binajari (N) Mamkam (N)	Stem	Irregular menstrual secretion
Cyathula prostrata	Amaranthaceae	Luga kara (N)	Shoot	Joints sprain

Botanical name	Family	Vernacular name	Parts used	Disease ailments
Cynodon dactylon	Poaceae	Dhubiagas (N)	Shoot	Excessive seminal discharge
Cynoglossum zeylanicum	Boraginaceae	Selay pati (N)	Root	Constipation and gastric problems
Datura innoxia	Solanaceae	Dhaturo (N)	Leaf, seed	Skin disease, antiseptic in cuts and wounds
Dioscorea bulbifera	Dioscoreaceae	Ghar Tarul (N)	Root	Expel and to Kill worms
Drymaria diandra	Caryophyllaceae	Wounioo (N)	Leaf	Cut and wounds
Elatostema platyphyllum	Urticaceae	Dambrunchoem (B)	Leaf	Gastric disorder
Elsholtzia blanda	Lamiaceae	Niraypato (N)	Leaf	Pneumonia
Engelhardtia spicata	Juglandaceae	Mouwha (N) Shykhyok-kung (L)	Green bract	Stomach ailments and throat pain
Equisetum diffusum	Equisetaceae	Sinbera (N)	Shoot	Body pain
Eurya japonica	Theaceae	Jhingoni (N)	Root	Muscle pain and boils
Fagopyrum esculentum	Polygonaceae	Phapar (N)	Leaf	Stomach ailments and constipation
Geranium nepalense	Geraniaceae	Gajal jhar (N)	Root	Stomach disorder

Botanical name	Family	Vernacular name	Parts used	Disease ailments
Houttuynia cordata	Saururaceae	Gandhdya jhar (N)	Leaf	Gastric disorder
Hedera nepalensis	Araliaceae	Ivy (N)	Leaf	Purgative
Hedyotis scandens	Rubiaceae	Kalelahara (N)	Root Shoot	Jaundice, gastric disorder
Hemiphragma heterophyllum	Scrophulariaceae	Kank mala (N) Mala Jhar (S) Ulak-rikh (L)	Fruit	Throat pain and tonsilitis
Hoya lanceolata	Asclepiadaceae	Aulay Khari (N)	Root	Cold sickness
Jasminum nepalense	Oleaceae	Tirpot lahara (N)	Young stem	Nasal pain
Juglans regia	Juglandaceae	Okhar (N) Taga (S) Kal kung (L)	Nut	Rheumatism
Knoxia sumantrensis	Rubiaceae	Bille jhar (N)	Root and leaf	Medicinally important
Leucosceptrum canum	Lamiaceae	Gurbish (N)	Necteriferous scale	Eye irritation due to cold
Leycesteria glaucophylla	Caprifoliaceae	Tiplay jhar (N)	Fruit	Hair falls
Lobelia angulata	Lobeliaceae	Firupot (L)	Fruit	Mother health care after child birth
Lyonia ovalifolia	Ericaceae	Angery (N)	Leaf	Skin treatment
Mallotus philippensis	Euphorbiaceae	Sindhuray (N)	Bark	Liver depression

Botanical name	Family	Vernacular name	Parts used	Disease ailments
Maesa rugosa	Myrsinaceae	Loketesising (B)	Bark	Joint pain
Melastoma malabathricum	Melastomataceae	Lotey (N)	Flower	Foot sores of cattles
Nardostachys grandiflora	Valerianaceae	Jatamansis (N)	Root	Fever and gastric disorder
Orchis latifolia	Orchidaceae	Panch anguli (N)	Tuber	Cuts, wounds, and sexual disease
Osbeckia nepalensis	Melastomataceae	Latttey (N)	Leaf and flower	Foot sores of cattles
Panax pseudo-ginseng	Araliaceae	Gingsang (N)	Root	Sexual impotency and gastric disorder
Peperomia tetraphylla	Piperaceae	Piplay pati (N)	Leaf	Fever
Persicaria microcephala	Polygonaceae	Kukur thotnay (N) Jalgasi (S)	Leaf	Cattle dysentry
Piper argyrophyllum	Piperaceae	Pipla (N) Pantigum (B)	Fruit	Stomach ailments
Plantago lanceolata	Plantaginaceae	Auley chiroto (N)	Leaf	Septic wounds and sores
Plantago erosa	Plantaginaceae	Auley chiroto (N)	Leaf	Sores and boils
Podophyllum hexandrum	Podophyllaceae		Rhizome	Cancer

Botanical name	Family	Vernacular name	Parts used	Disease ailments
Potentilla indica	Rosaceae	Bhnuiaisayloo (N)	Fruit	Throat pain
Pteris biaurita	Pteridaceae	Thade (N) wounioo	Leaf	Cuts and wounds
Quercus lamellosa	Fagaceae	Guras (N) Lal chimal (S)	Petal	Blood dysentery
Rubia cordifolia	Rubiaceae	Majeto (N) Yhyena (L)	Root	Astringents incuts and wounds
Rumex nepalensis	Polygonaceae	Halhaley (N) Palhu(L) Isomo (S)	Rhizome	Food poisoning, cuts and wounds
Sambucus adnata	Sambucaceae	Charivang (N)	Fruit	Toothache
Sarcopyramis nepalensis	Melastomataceae	Angurkathi (N)	Leaf	Constipation
Schima wallichii	Theaceae	Chilawna (N) Sambrung (L) Kung	Fruit	Dendruff
Siegesbeckia orientalis	Asteraceae	Mong Rip (L)	Leaf	Sores
Smilacina oleracea	Liliaceae	Khirowla (N)	Root	Headache
Spilanthes acmella	Asteraceae	Zangoo mukh (L)	Inflorescence	Toothache
Taxus wallichiana	Taxaceae	Gobra sallaa (N)	Leaf	Cancer
Thunbergia lutea	Acanthaceae	Bokey lahara (N)	Latex	Cut and wounds

Botanical name	Family	Vernacular name	Parts used	Disease ailments
Thysanolaena maxima	Poaceae	Amliso (N) Pusore (L) Sabsiful (S)	Root	Boils, sores and gastric problems
Trichosanthes tricuspidata	Cucurbitaceae	Indrani lahara (N) Tungkung (L)	Root Stem Seed	Food-poisoning, snake bite and rheumatism
Zanthoxylum acanthopodium	Rutaceae	Bokey timbur (N)	Fruit	Tooth decaying

B = Bhutia; L = Lepcha; N = Nepalese; S = Sherpa

Table IX
Edible plants

Botanical name	Family	Local name	Parts used
Aconogonum campanulatum var. *campanulatum*	Polygonaceae	Thotnay(N) Achorh(L)	Sapling Shoot
Aconogonum molle	Polygonaceae		Young stem & leaf
Agapetes serpens	Vacciniaceae	Janglikhurshani (N)	Flower
Alnus nepalensis	Betulaceae	Uttis(N)	Fibrous root
Arisaema griffithii	Araceae		Tuber
Arisaema propinquum	Araceae	Thoa(N)	Tuber
Bauhinia purpurea	Caesalpiniaceae	Tanki(N)	Flower
Bidens biternata	Asteraceae	Kuroo(N)	Tender leaf
Bergenia ciliata	Saxifragaceae	Kuroo(N)	Tender leaf
Buddleja asiatica	Buddlejaceae	Sunpati(N)	Leaf
Campylandra aurantica	Liliaceae	Nakima(N)	Inflorescence
Castanopsis hystrix	Fagaceae	Dhalne Katus(N) Kaso tatal Kuno(L)	Fruit
Castanopsis tribuloides	Fagaceae		Fruit

Botanical name	Family	Local name	Parts used
Docynia indica	Rosaceae		Fruit
Elatostema platyphyllum	Urticaceae	Dambrumchoem(B)	Leaf
Elatostema sessile	Urticaceae	Gogluto(N)	Leaf
Elsholtzia blanda	Lamiaceae	Mirehpati(N)	Seed
Equisetum diffusum	Equisetaceae	Assalibisali(L)	Rhizome
Fagopyrum esculentum	Polygonaceae	Fapar(N)	Shoot
Ficus roxburghii	Moraceae	Nevara(N)	Fruit
F. semicordata	Moraceae		Fruit
Fragaria indica	Rosaceae	Bhuiaisalo(N)	Fruit
Fragaria nubicola	Rosaceae		Fruit
Gaultheria fragrantissima	Ericaceae	Jathyroid(S)	Fruit
Gaultheria griffithiana	Ericaceae	Thelexifal(N)	Axillary bud
Gaultheria trichophylla	Ericaceae	Kaloaisloo(N)	Fruit
Girardinia diversifolia	Urticaceae	Bhangra sisnoo(N)	Flower
Hemiphragma heterophyllum	Scrophulariaceae	Maljhar(N)	Fruit
Heracleum wallichii	Apiaceae	Chimping(N)	Fruit
Heracleum nepalense	Apiaceae	Chimping(N)	Fruit
Holboellia latifolia	Lardizabalaceae	Gulpha(N)	Seed
Hydrocotyle javanica	Apiaceae	Golpata(N)	Leaf

Botanical name	Family	Local name	Parts used
Juglans regia	Juglandaceae	Okahar(N)	Nut
Lobelia angulata	Lobeliaceae	Firupat(N)	Fruit
Mahonia nepaulensis	Berberidaceae	Chutro(N)	Flower
Malus sikkimensis	Rosaceae	-	Fruit
Nephrolepis cordifolia	Nephrolepidaceae	Paniamla(N)	Tuber
Podophyllum hexandrum	Podophyllaceae	-	Fruit
Prunus cerasoides	Rosaceae	Pinayoo(N)	Fruit
Prunus communis	Rosaceae		Fruit
Rhaphidophora glauca	Araceae		Young steam
Rheum nobile	Polygonaceae	Kachu(N)	Whole plant
Rubus ellipticus	Rosaceae	Rookhansilo(N)	Fruit
Rumex nepalensis	Polygonaceae	Halhalay(N) Palu(L)	Tender shoot
Saurauia nepaulensis	Saurauiaceae	Gogun(N)	Flower
Smilacina oleracea	Liliaceae	Khirowla(N)	Leaf
Stellaria media	Caryophyllaceae	Ricather(N)	Shoot
Streptopus simplex	Liliaceae	Sargomukh(L)	Fruit
Tetrastigma serrulatum	Vitaceae	Sileylahara(N)	Fruit
Viburnum erubescens	Caprifoliaceae	Asarch(N)	Fruit

Table X
Plants used as fodder

Botanical name	Family	Local name
Alangium chinense	Alangiaceae	
Boehmeria scabrella	Urticaceae	
Castanopsis tribuloides	Fagaceae	
Dichroa febrifuga	Hydrangeaceae	
Edgeworthia gardneri	Thymelaeaceae	
Elatostema platyphyllum	Urticaceae	
Exbucklandia populnea	Hamamelidaceae	
Ficus semicordata	Moraceae	
Gaultheria hookeri	Ericaceae	Jathyohoid(L)
Hoya lanceolata	Asclepiadaceae	Auley Khari(N)
Impatiens graciliflora	Balsaminaceae	Gagkleto
Lecanthus peduncularis	Urticaceae	Ghogey(N)
Leucosceptrum canum	Lamiaceae	Gurbish(N)
Macaranga denticulata	Euphorbiaceae	Rookh(N) Naybara
Malus sikkimensis	Rosaceae	
Osbeckia nutans	Melastomataceae	Thulo anghari(N)
Oxyspora paniculata	Melastomataceae	Kaloangrey(N)
Prunus carmesina	Rosaceae	Cherry kung(N)
Prunus cerasoides	Rosaceae	Paiyon(N)
Piper argyrophyllum	Piperaceae	Piplepati (N)
Rubus ellipticus	Rosaceae	Rookh ansiloo(N)
Rumex nepalensis	Polygonaceae	Halhaley(N)
Saurauia nepaulensis	Saurauiaceae	Gagun(N)
Sorbus ursina	Rosaceae	
Tetrastigma serrulatum	Vitaceae	Siley lahara(N)
Thunbergia coccinea	Acanthaceae	

Table XI
Dye yielding plants

Botanical name	Family	Local name	Parts used	Colour
Dichora febrifuga	Hydrangeaceae	Kaligal (N)	Bark	Dark Blue
Juglans regia	Juglandaceae	Okhar	Bark (N)	Straw Ghee colour
Rheum nobile	Polygonaceae	Chhucha (B)	Rhizome, Leaf	Yellow
Rubia cordifolia	Rubiaceae	Maketo (N)	Stem and root	Orange
Rumex nepalensis	Polygonaceae	Halhalay (N)	Tuberous root	Golden straw

Table XII
Fibre yielding plants

Botanical name	Family	Local name	Parts used
Bauhinia vahlii	Caesalpiniaceae	Tanki(N)	Bark
Boehmeria macrophylla	Urticaceae	Taksoor(N)	Bark
Cissampelos pareira	Menispermaceae	Palue(N)	Twig
Daphne bholua	Thymelaeaceae	Kagoti (N)	Bark
Edgeworthia gardneri	Thymelaeacee	Orgeli(N)	Bark

Table XIII
Poisonous plants

Botanical name	Family	Local name	Parts used
Aconitum ferox	Ranunculaceae	Bikhuma(N)	Root
Aconitum laciniatum	Ranunculaceae	Kalo Bikhuma(N)	Root
Aconitum spicatum	Ranunculaceae	Bikh(N)	Root
Lyonia ovalifolia	Ericaceae		Leaf
Pieris formosa	Ericaceae	Ballu(N)	Leaf
Schima wallichii	Theaceae	Chilaunay(N)	Leaf

Table XIV
Plants of superstition/ religious ceremony

Botanical name	Family	Local name	Parts used
Artemisia nilagirica	Asteraceae	TitapatiIN)	Twig and Leaf
Fagopyrum esculentum	Polygonaceae	Faper(N)	Seed
Juncus spp.	Juncaceae	Babio(N)	Shoot
Luculia gratissima	Rubiaceae	Dohri(N)	Flower
Rhododendron anthopogon	Ericaceae	Chimal(N)	Leaf

Table XV
Plants used as a source of aromatic odour

Botanical name	Family	Parts used
Cryptomeria japonica	Taxodiaceae	Twig
Juniperus recurva	Cupressaceae	Twig
Juniperus squamata	Cupressaceae	Twig
Rhododendron anthopogon	Ericaceae	Leaf and stem

Table XVI
Plants for construction/furniture/fuel wood

Botanical name	Family	Local name
Abies densa	Pinaceae	
Alnus nepalensis	Betulaceae	Utis(N)
Castanopsis hystrix	Fagaceae	Dhalnay Katus(N)
Cryptomeria japonica	Pinaceae	Dhupi(N)
Juglans regia	Juglandaceae	Okhar(N)
Macaranga denticulata	Euphorbiaceae	
Tsuga dumosa	Pinaceae	

Ornamental plants

A large number of wild ornamental plants occur in the biosphere reserve. Local people successfully introduce these wild plants in their gardens. They have a great potential for utilization as horticultural species. The angiosperms are usually accepted for their beautiful flowers. Some of these are Magnolias (Magnoliaceae), Orchids (Orchidaceae), Primulas (Primulaceae), Hedychiums (Zingiberaceae), Rhododendrons (Ericaceae), Potentilas (Rosaceae), Impatiens (Balsaminaceae), Begonias (Begoniaceae), some pteridophytes such as *Adiantum*, *Vittaria*, *Pyrrosia*, *Asplenium*, *Selaginella*, *Nephrolepis*, etc.

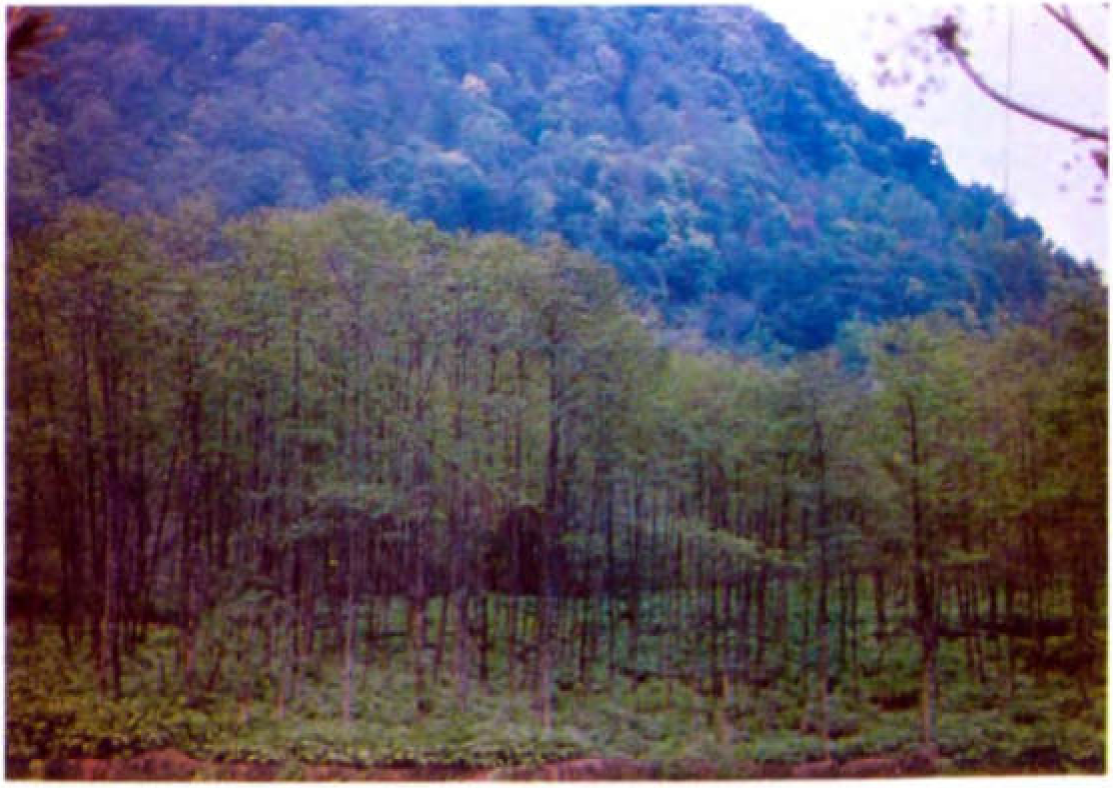
THREATS

The common threats to the phytodiversity of biosphere reserve could be broadly classified into two groups i.e. natural and man made. The natural causes responsible for depletion of certain species are landslides, natural competition between species, lack of natural propagation, diseases and forests fires, etc. The man made threats responsible for deterioration and dwindling of plant resources are rapid urbanization, large scale collection of timber and fire wood by the people inhabiting in fringes as well as within the reserve. Their demands, to some extent, are sustainable but over exploitation leads to deterioration of oak and coniferous forests in western parts of the reserve. The grazing by domestic animals is another cause responsible for depletion and erosion of the flora. There is need to carryout scientific study on carrying capacity of high altitude grazing lands and to put rotational grazing practice. Interestingly, the sub-alpine and alpine regions are very rich for large number of useful plants in general and medicinal herbs in particular. Some of these medicinal herbs viz. *Aconitum* spp., *Dactylorhiza hatagirea, Nardostachys grandiflora, Panax psedo-ginseng, Picrorhiza scrophulariflora, Podophyllum hexandrum, Quercus lamellosa* and aromatic plants like *Juniperus recurva, Rhododendron anthopogon*, etc. have been over exploited to such an extent that certain taxa need immediate protection. Besides, in the west Sikkim, tourism is a big attraction for domestic and foreign tourist. All the tourism related activities as well as development of network of roads for transportation purposes also have quite adverse effects on forests of this reserve.

CONSERVATION

The flora of Kanchanjunga biosphere reserve is comparatively undisturbed and has virgin patches of evergreen, broad leaved temperate and coniferous forests as well as rich alpine vegetation. There is an urgent need towards conservation of rare, threatened and endemic taxa as enumerated in tables VI and VII. Besides, *in situ* and *ex situ* conservation measures have also to be adopted through biotechnology and multiplication in botanic gardens. Commercially exploited medicinal herbs should also be cultivated to reduce the pressure on wild populations. The local medicine men who practice traditional systems of medicine should be encouraged to cultivate these herbs in their kitchen gardens, to serve the dual purpose of conservation and public awareness. There is also a need to educate the tourist and the people about the fragile nature of Himalayan ecosystem. Therefore, all activities leading to environmental degradation should be strictly dealt with. Some of these affects have already been nullified by progressive social and legislative measures undertaken by the central and state governments. However, public awareness about the conservation of floristic wealth particularly of biosphere reserve and other protected areas is necessary. Recently a voluntary organization Kanchanjunga Conservation Committee (KCC) has already started functioning for the cause of conservation in Yuksum area. Similarly some more sincere Non Government Organizations (NGOs) have to come forward to educate the masses, for proper and effective conservation of plant diversity of this reserve.

A view of Llonak valley.



Cardamom plantation - an economic crop of the biosphere reserve.

Magnolia campbellii

Saussurea obvallata - Brahmakamal.

Rheum nobile - used as vegetable.

Aristolochia griffithii - rare and threatened.

Listera alternifolia - endemic to Sikkim Himalaya.

Rhododendron grande

Rhododendron lepidotum - an alpine scrub.

Podophyllum hexandrum - a medicinal herb.

Cypripedium himalaicum - rare and endangered.

Excessive grazing.

Destruction of forests.

Xanthoria elegans - a yellow dye producing lichen.

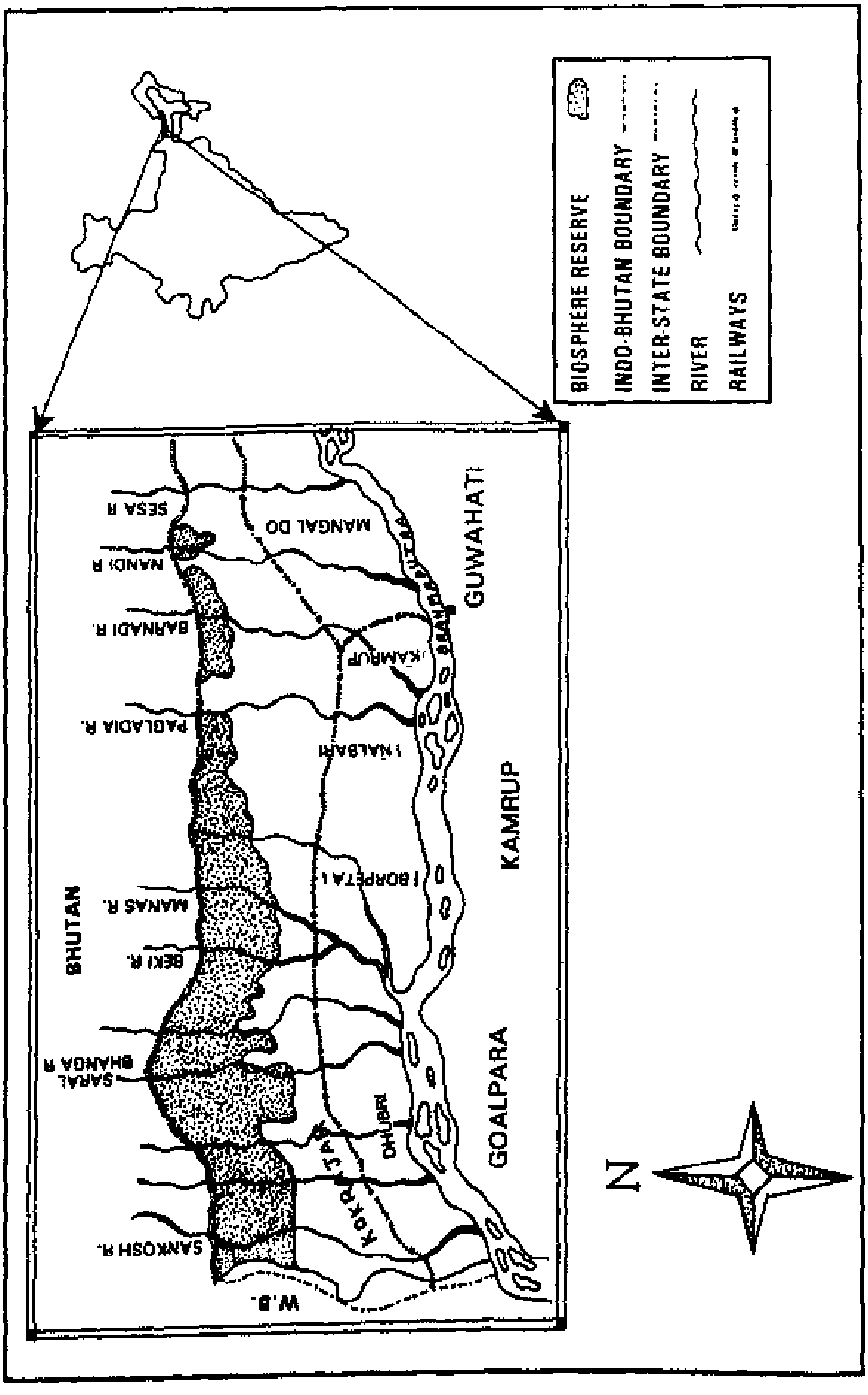
MANAS BIOSPHERE RESERVE

P.K. Hajra
A.K. Baishya

Manas Biosphere Reserve is located along the Himalayan foothills on the north of the Brahmaputra valley in Assam. In a strategy for conservation of the rich biological diversity of the region, Manas Tiger Reserve was declared as biosphere reserve on 14th March, 1989. The erstwhile Manas Wildlife Sanctuary established in the year 1928 was declared as Tiger Reserve in 1973 that forms the core area of the biosphere reserve. The biosphere lies between 26°30' to 27°0' N longitude and 90°15' to 90°30' E latitude. It consists of linear forest belt. The broadest portion is about 50 km wide in the west and gradually narrowing in the east. The total area of the biosphere reserve is 2,837 sq. km and encompasses 22 reserved forests under 5 Forest Divisions in Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamrup and Darrang districts of Assam. The core zone extends to 391 sq. km area of continuous forest belt, its western boundary is the river Sankosh in Kokrajhar district and the eastern boundary is up to river Pagladia in Nalbari district of Assam. The buffer zone however, extends up to the river Nandi in Sonitpur district and consists of two or three forest patches. The northern boundary forms part of the international border with Bhutan and the mixed forest belt is continuous with that of Bhutan hills. In the south the reserve is bounded by the cultivated areas and unclassed reserved forests. With the progressive settlement of tribal villages over the years these areas are purely under paddy cultivation resulting in the fragmentation of the buffer zone.

There is one forest village with approximate population of 2,500 people in the core area of the biosphere reserve, while in the buffer area there are more than 104 forest villages. In the manipulation zone there are around 200 forest villages with approximate population of 67,000 people. The people inhabited in these villages mostly belong to the ethnic communities and mostly depend on the reserve for their livelihood.

The terrain is flat alluvial land with a slope from north to south. The average elevation varies from 85 to 110 m above sea level. Numerous turbulent rivers arising from the Bhutan hills flow through the reserve. A few important ones are, Manas, Beki, Jongrong, Gyati, Garuchera, Rabang and Pagladia.



Map : Manas Biosphere Reserve

The climate is warm and humid. Maximum temperature rises upto 37°C in the summer months and the minimum temperature falls upto 6°C in the winter month. The average rainfall in the area is *ca* 4000 mm per year.

VEGETATION

The vegetation of the biosphere reserve can be classified into 5 (five) types.

1. Alluvial grasslands

Grasslands of the reserve represent the secondary vegetation. Extensive patches of grasslands are found in the western part of the reserve. They also occur in open areas at other places. The common grass species are *Apluda mutica, Brachiaria distachya, Capillipedium assimile, Chrysopogon aciculatus, Cynodon dactylon, Cyrtococcum accrescens, Digitaria ciliaris, D. longiflora, Echinochloa colona, Eleusine indica, Erianthus longisetosus, Hemarthria protensa, Imperata cylindrica, Neyraudia reynaudiana, Pogonatherum rufobarbatum, Polytoca digitata, Rottboellia cochinchinensis, Saccharum procerum, S. spontaneum, Themeda villosa* and several species of the genera *Eragrostis, Panicum* and *Paspalum*.

The grasslands are characterized by the occurrence of several scattered tall trees and shrubs, such as *Bombax ceiba, Dillenia indica, D. pentagyna, Phyllanthus emblica, Ziziphus mauritiana* and species of *Clerodendrum, Grewia, Leea, Mussaenda* and *Premna*.

The overall grassland vegetation is degraded due to several biotic and abiotic factors such as repeated flood, forest fire and excessive cattle grazing.

2. Tropical semi-evergreen forests

These forests occur mainly along the Indo-Bhutan boundary of the reserve and along the northern parts of Barnadi, Khalinduar, Balipara and Sonai-rupai sanctuary. The trees in these forests are very tall with their close canopy. The floristic composition is diverse. The common tall trees in these forests are *Artocarpus chama, Aphanamixis polystachya, Anthocephalus chinensis, Dysoxylum binectariferum, Kayea assamica,* *Kadsura heteroclita, Gynocardia odorata, Hydnocarpus kurzii, Mesua ferrea, Mangifera sylvatica, Michelia champaca, Magnolia pterocarpa, Phoebe attenuata, Syzygium cumini, S. formosum, S. oblatum,Tetrameles nudiflora, Magnolia hodgsonii, Vatica lanceaefolia, etc.* The second storey of the vegetation comprises of species like *Aglaia spectabilis, Actinodaphne obovata, Bauhinia purpurea, Dillenia indica, Garcinia cowa, Ficus racemosa, F. rumphii, Lagerstroemia parviflora, Mallotus philippensis,* etc.

Woody lianas like *Derris vestita, Entada pursaetha,* etc. are very common.

The undergrowth of these forests is very rich and diverse. Species like *Adhatoda zeylanica, Clerodendrum indicum, C. viscosum, Coffea bengalensis, Holmskioldia sanguinea, Leea alata, Phlogacanthus thyrsiflorus, Rauvolfia serpentina, Piper diffusum,* etc. are very common and form the ground floor dense, lush and green. *Alpinia nigra, Costus speciosus, Tacca laevis* and several species of *Calamus* and wild *Musa* form thickets in slightly moist and shady places.

3. Tropical moist and dry deciduous forests

This is the commonest vegetation types and is found in south-west and eastern parts of the reserve comprising of Kachugaon, Batabari, Subankhata, Nauduar, Balipara and part of Daranga reserve forests. The common tree species in these forests are *Haldina cordifolia, Aesculus assamica, Albizia odoratissima, A. procera, Anthocephalus chinensis, Bombax ceiba, Butea monosperma, Callicarpa arborea, Careya arborea, Cassia fistula, Cordia dichotoma, Duabanga grandiflora, Macaranga denticulata, Oroxylum indicum, Radermachera gigantea, Sterculia villosa, Sapium baccatum, Terminalia bellirica, T. chebula, Trewia polycarpa,* etc.

Micromelum integerrimum, Phyllanthus emblica, Rhamnus nepalensis, Ziziphus mauritiana and *Z. fueniculosa* often grow together and form extensive patches in certain areas of Batabari and Subankhata reserve forests.

Among the lianas and climbers, *Bauhinia vahlii, Combretum roxburghii, Dioscorea bulbifera, D. pentaphylla, Stephania japonica, Thunbergia grandiflora, Uncaria sessilifructus,*etc. are very common.

The undergrowth is rather poor. Species like *Artemisia nilagirica*, *Buddleja asiatica*, *Cassia occidentalis*, *Clerodendrum viscosum*, *Flemingia strobilifera*, *Grewia eriocarpa*, *Maesa indica*, etc. are the common shrubs and herbs forming the ground vegetation.

4. Riparian fringe forests

This type of vegetation is met with along the various river banks in the reserve. A few species of larger trees form a narrow fringe along the water courses. These trees are of semi evergreen type. They stand widely spaced with smaller trees and shrubs between and often with coarse grass mainly *Saccharum* spp. The common trees are *Aesculus assamica*, *Alstonia scholaris*, *Bischofia javanica*, *Bridelia retusa*, *Litsea salicifolia*, *Macaranga denticulata*, *Polyalthia simiarum*, *Trema orientalis* and several species of *Ficus*.

4. Swamps

In addition to river banks and beds, there are numerous pools and puddles in the reserve, which abounds in a variety of aquatic flora. The common plants in these wetlands are, *Arundo donax*, *Azolla pinnata*, *Ceratophyllum demersum*, *Cyperus brevifolius*, *Eichhornia crassipes*, *Lasia spinosa*, *Limnophila heterophylla*, *L. sessiliflora*, *Monochoria hastata*, *Nymphaea nouchali*, *Nymphoides cristatum*, *Ottelia alismoides*, *Polygonum posumbu*, *Typha elephantina*, *Vallisneria spiralis*, etc. *Ipomoea carnea* subsp. *fistulosa* is one of the most obnoxious weed forming extensive thickets in the marshy land.

FLORISTIC DIVERSITY

Jain and Hajra (1975), Kataki and Barua (1989) and Hajra and Jain (1996) studied the flora of Manas Biosphere Reserve in detail. Iswar Barua (1992), while preparing for his Ph.D. thesis entitled *'Systematic studies of the Angiosperms of Kamrup district, Assam'* carried out several floristic surveys and recorded more than 500 species from the biosphere area. Baishya (1998) has also analysed the floristic status of the Manas Tiger Reserve.

The flora of Manas Biosphere Reserve is rich both in luxuriance and species diversity. A perusal on the flora reveals that in the present state of knowledge the angiosperms are represented by 591 species belonging to 372 genera and 111 families (Table-1). Out of which, the dicots are represented by 429 species distributed in 279 genera and 94 families whereas, the monocots are represented by 162 species belonging to 93 genera and 17 families. The ratio between the genera to species of the angiosperm is 1: 1.6 while the ratio between the monocots to dicots is 1: 2.5. Hajra and Jain (1996) estimate the ratio of monocots to dicots as 1:2.8 on the combine flora of Manas and Kaziranga National Park. It shows that the dicots are more dominant over the monocots in Manas Biosphere Reserve.

Table I
Statistics of the flora

Plant group	No.of families	No. of genera	No.of species
ANGIOSPERMS	111	372	591
Dicots	(94)	(279)	(429)
Monocots	(17)	(93)	(162)
PTERIDOPHYTES	17	21	30
GYMNOSPERMS	1	1	1

Comparison of the angiosperm families shows that the family Poaceae is the most dominant family in the flora of Manas Biosphere Reserve with 64 species belonging to 35 genera, followed by Fabaceae and Orchidaceae, etc. Table-II provides a glimpse on the comparison within the dicots and monocots. Extensive grasslands in the biosphere reserve provide habitat for a wide spectrum of grass genera. The most dominant genera are *Panicum* (6 spp.), *Arundinella, Digitaria* and *Paspalum* with 5 spp. each, *Oplismenus, Pogonatherum, Saccharum*, etc. with 3 spp. each, *Brachiaria, Cyrtococcum, Eragrostis, Setaria, Sporobolus*, etc. with 2 spp. each, while *Phacelurus, Vetiveria*, etc. are with 1 species each. There are at least 7 species of bamboos belonging to the genera *Bambusa* and *Dendrocalamus* in the biosphere reserve.

The second largest family is Leguminosae (*s.l.*), which includes Caesalpiniaceae, Papilionaceae and Mimosaceae. *Desmodium* is the most dominant genus with 10 species followed by *Crotalaria* (5 spp.). *Bauhinia* and *Cassia* with their colourful flowers represented by 4 species each. The timber species *Albizia* and *Dalbergia* are represented by 2 species each. The genus *Butea* with majestic scarlet flowers is another genus with 2 species widely spread in the drier areas. Among the woody lianas, extensive *Entada* and *Mezoneurum* are represented by single species each.

The family Orchidaceae is represented by 35 species including 3 varieties belonging to 20 genera. Most dominant genus within the family is *Dendrobium* with 6 species followed by *Zeuxine* with 3 species and 2 varieties. It is interesting to find that more than 50% of the total orchid flora of Kamrup district occurs in the biosphere reserve. Barua (2000) recorded 65 orchid species from the district.

The family Euphorbiaceae is represented by 34 common species, that occurs almost everywhere in semievergreen forests of Assam. 29 species represent either trees or shrubby life form while 5 species are herbaceous. The genera like, *Antidesma, Bridelia, Croton, Glochidion, Phyllanthus, etc.* are some of the most widely distributed species in the area.

Asteraceae represented by 31 species belonging to 21 genera. Most of the species grow either as undergrowth in the forests or in open wastelands. The genera like *Blumea, Lactuca* and *Senecio* are represented presently by 3 species each, while *Bidens, Mikania* and *Sonchus* are represented by 2 species each. Remaining 15 genera are represented by a solitary species in each. Further surveys would reveal more species in future.

Rubiaceae is a family consisting of large tree genera like *Anthocephalus* to thorny small trees like *Meyna* and *Randia.* They are represented by single species in each. *Mussaenda and Paederia* both have 2 species in each. Most diverse genera in the family is the herbaceous genus *Hedyotis*, which is represented by 4 species.

The sedge family Cyperaceae occurs most gregariously in all the situations. The diversified genus *Cyperus* is represented by 15 species. The genus is the most dominant among all the genera in the reserve. *Carex* and *Fimbristylis* are represented by single species in the family.

Table II
Dominant families

Angiosperms			Dicotyledons			Monocotyledons		
Families	Gen.	Spp.	Families	Gen	Spp.	Families	Gen.	Spp.
Poaceae	35	64	Leguminosae (*s.l*)	26	54	Poaceae	35	64
Leguminosae (*s.l*)	26	54	Euphorbiaceae	20	34	Orchidaceae	20	35
Orchidaceae	20	35	Asteraceae	21	31	Cyperaceae	4	16
Euphorbiaceae	20	34	Rubiaceae	12	17	Zingiberaceae	8	11
Asteraceae	21	31	Verbenaceae	8	14	Commelinaceae	7	11
Rubiaceae	12	17	Acanthaceae	11	13	Dioscoreaceae	1	6
Cyperaceae	4	16	Moraceae	5	13	Liliaceae	3	3
Verbenaceae	8	14	Lamiaceae	10	10	Hydrocharitaceae	2	2
Acanthaceae	11	13	Lauraceae	6	10	Araceae	2	2
Moraceae	5	13	Urticaceae	6	10	Pontederiaceae	2	2

Table III
Dominant genera

Angiosperms		Dicotyledons		Monocotyledons	
Genera	No. of spp.	Genera	No. of spp.	Genera	No. of spp.
Cyperus	15	*Desmodium*	10	*Cyperus*	15
Desmodium	10	*Ficus*	9	*Dendrobium*	8
Ficus	9	*Polygonum*	7	*Panicum*	6
Dendrobium	8	*Crotalaria*	6	*Commelina*	5
Polygonum	7	*Phyllanthus*	5	*Dioscorea*	5
Crotalaria	6	*Piper*	5	*Arundinella*	5
Panicum	6	*Grewia*	5	*Digitaria*	5
Commelina	5	*Bauhinia*	4	*Paspalum*	5
Dioscorea	5	*Cassia*	4	*Zingiber*	4
Arundinella	5	*Clerodendrum*	4	*Zeuxine*	3

Verbenaceae is represented by 14 species belonging to 8 genera. The genus *Clerodendrum*, that occurs mostly along roadside and open places represented by 4 species and *Premna* with 3 species. The genus *Gmelina* occurs sporadically, and mostly planted by the forest department as a valuable timber species.

Acanthaceae is another herbaceous shade loving family represented by 13 species belonging to 11 genera, followed by Moraceae with similar number of species. The genus *Ficus* with 9 tree species exhibits maximum diversity and occurs gregariously throughout the reserve.

The dominance at the generic level both for dicots and monocots is shown in the table III.

An analysis of the flora of Manas Biosphere Reserve, on the basis of the above statistics, shows that maximum number of genera are represented by single species and a very few genera are represented by more number of species (Table IV).

Table IV
Analysis of the flora

	Angiosperms	Dicotyledons	Monocotyledons
Genera with 1 species	253	187	66
Genera with 2 species	66	53	13
Genera with 3 species	26	23	3
Genera with 4 species	10	8	2
Genera with 5 or more species	14	5	9

GYMNOSPERMS

There is no indigenous species of gymnosperms in Manas Biosphere Reserve. *Gnetum montanum* is the only representative of this group rarely found in the semi evergreen forests.

PTERIDOPHYTES

Pteridophytes are represented by 30 species belonging to 21 genera and 17 families. However, the number of species will increase if thorough survey of the group is undertaken.

ENDEMIC PLANTS

The following 4 endemic species have been recorded from the biosphere reserve area (Table V).

Table V
Endemic plants

Name of species	Family
Curcumorpha longiflora	Zingiberaceae
Echinocarpus assamicus	Elaeocarpaceae
Paspalum longifolium var. *lorirhachis*	Poaceae
Parakaempferia synantha	Zingiberaceae

UTILITARIAN ASPECT OF THE FLORA

The biosphere reserve abounds in many economically important wild plants. Although most of the tree species are becoming very rare due several biotic and abiotic factors prevailing in the region, a few such species have been enumerated in the table VI.

THREATS AND CONSERVATIONS

Several factors, mostly biotic and natural calamities have affected the Manas Biosphere Reserve. Due to rapid population growth there are pressures on the protected areas for livelihood. This type of population related threats are of global concern and Manas is not an exception. This has aggrieved the situation further due to ethnic conflict in the state and the most wonderful World Heritage Site, Manas Biosphere Reserve has become threatened.

Natural calamity in the region is an uncontrollable problem. Degradation of habitats because of devastating flood is one of the factors for the loss of biodiversity.

Insufficient infrastructure is yet another major problem that requires the attention of the policy makers for proper maintenance and management

Table VI
Wild economic plants of Mans Biosphere Reserve

Botanical name	Family	Parts used	Medicine	Edible fruits	Vegetable	Timber	Fibre	Fish poison	Insecticide	Fodder
Abelmoschus manihot var. *pungens*	Malvaceae	Bark	-				+			
Adhatoda zeylanica	Acanthaceae	Leaves, roots	+		+					
Artemisia nilagirica	Asteraceae	Leaves, roots	+							
Casearia vareca	Flacourtiaceae	Fruits	+							
Cassia fistula	Caesalpiniaceae	Fruits, roots	+					-		
Cissampelos pareira	Menispermaceae	Leaves, roots	+							
Cleome gynandra	Capparaceae	Leaves, roots, seeds	+							
Costus speciosus	Zingiberaceae	Roots	+							
Crateva unilocularis	Capparaceae	Bark, wood, leaves	+			+				+

Botanical name	Family	Parts used	Medicine	Edible fruits	Vegetable	Timber	Fibre	Fish poison	Insecticide	Fodder
Cynodon dactylon	Poaceae	Roots	+							
Dillenia indica	Dilleniaceae	Fruits, wood	+	+	+	+				
Dioscorea alata	Dioscoreaceae	Tuber	+							
D. bulbifera	Dioscoreaceae	Tuber	+		+					
D. pentaphylla	Dioscoreaceae	Tuber	+							
Sloanea sterculiacea var. *assamica*	Elaeocarpaceae	Wood				−				
Flacourtia jangomas	Flacourtiaceae	Leaves, fruits	+	+						
Garcinia cowa	Clusiaceae	Fruits	+	+		+				
G. xanthochymus	Clusiaceae	Fruits	+							
Gmelina arborea	Verbenaceae	Leaves, wood	−			+				
Gnetum montanum	Gnetaceae	Whole plant		+				-		
Hodgsonia macrocarpa	Cucurbitaceae	Fruits	+							
Hiptage benghalensis	Malpighiaceae	Leaves	+						+	
Homonoia riparia	Euphorbiaceae	Roots	+							

Botanical name	Family	Parts used	Medicine	Edible fruits	Vegetable	Timber	Fibre	Fish poison	Insecticide	Fodder
Kydia calycina	Malvaceae	Leaves, bark	+				+			
Lasia spinosa	Araceae	Leaves, roots	+	+	+					
Magnolia pterocarpa	Magnoliaceae	Wood				+				
Morus australis	Moraceae	Fruits		+						
Nymphaea pubescens	Nymphaeaceae	Root	+							
Oroxylum indicum	Bignoniaceae	Root bark, leaves, seeds	+							
Phyllanthus emblica	Euphorbiaceae	Fruit	+	+						
Polyalthia simiarum	Annonaceae	Wood				+				
Polygala chinensis	Polygalaceae	Roots	+							
Portulaca oleracea	Portulacaceae	Whole plant	+		+					
Randia spinosa	Rubiaceae	Bark, Roots	+						+	
Rauvolfia serpentina	Apocynaceae	Roots	+							

Name of the Species	Family	Parts used	Medicine	Edible fruits	Vegetable	Timber	Fibre	Fish poison	Insecticide	Fodder
Rorippa indica	Brassicaeae	Whole plant	+							
Stellaria media	Caryophyllaceae	Whole plant	+							
Stephania japonica	Menispermaceae	Roots	+							
Sterculia urens	Sterculiaceae	Wood-sap	+			+				
Streblus asper	Moraceae	Leaves, fruits	+							
Tamarix dioica	Tamaricaceae	Young twig	+							
Triumfetta rhomboidea	Tiliaceae	Whole plant	+							
Urena lobata	Malvaceae	Roots	+							

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Swapna Prabhu

Nokrek Biosphere Reserve - core zone.

Swapna Prabhu

Citrus plantation - buffer zone.

Swapna Prabhu

Citrus medica

Swapna Prabhu

Citrus indica

Jhuming - a view.

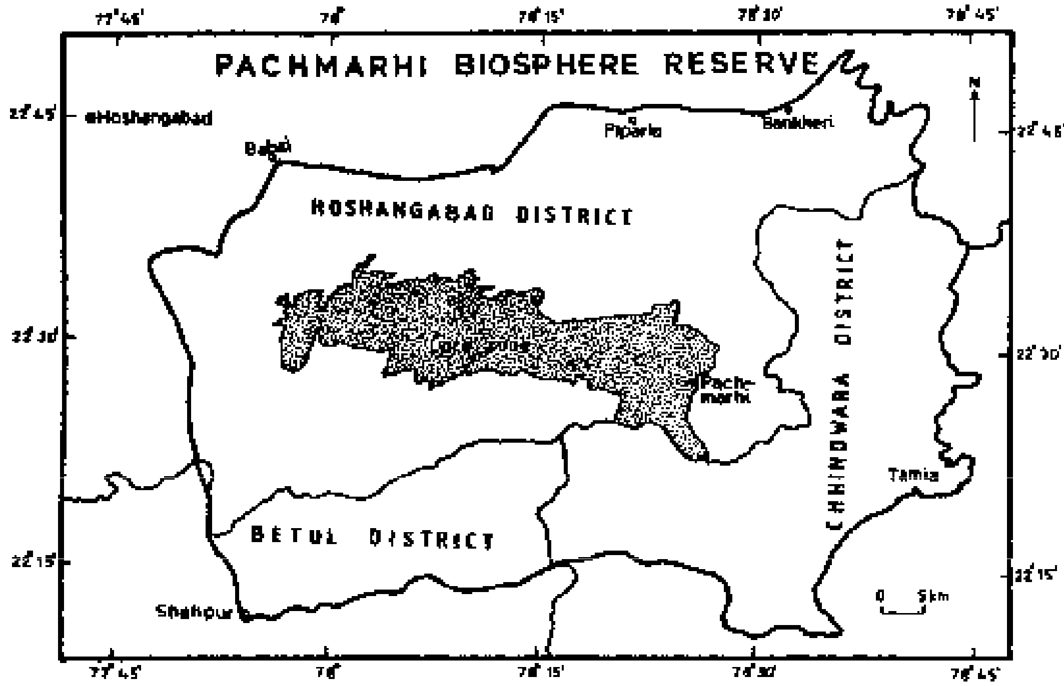
Jhum cultivation - another view.

PACHMARHI BIOSPHERE RESERVE

K.K. Khanna
V. Mudgal

Pachmarhi Biosphere Reserve established on 3rd March, 1999 is situated in Satpura hill ranges between 20°10' 22°50' N latitude and 77°45' 78°50' E longitude. It is the only hill resort in Madhya Pradesh that attracts tourists as well as botanists. The biosphere reserve falls under three districts of Madhya Pradesh viz., Hoshangabad (2971.59 sq. km under tehsils Hoshangabad and Sohagpur), Betul (568.13 sq. km under tehsil Betul) and Chhindwara (1386.56 sq. km under tehsils Chhindwara and Amarwada). The total area of biosphere reserve is 4926.28 sq. km. Maximum area of the biosphere reserve falls under Hoshangabad district, (60.32%) followed by Chhindwara (28.15%) and Betul (11.53%) districts. It is interesting to note that the biosphere reserve includes three wildlife conservation units viz., Satpura National Park (585.17 sq. km), Bori Sanctuary (485.72 sq. km) and Pachmarhi Sanctuary (417.78 sq. km). The Satpura National Park forms the core zone of the reserve while rest of the areas including Bori and Pachmarhi sanctuaries form the buffer zone. On the other hand, some of the areas like, degraded and wastelands, aquatic regions and agricultural lands have been included under restoration zone.

The general configuration of the area is hilly, undulating terrain and at certain places having deep narrow gorges (Pachmarhi plateau). The altitude varies from 320 to 1352 m above msl. Some of the important hill peaks are Dhupgarh (1352 m), Mahadeo (1328 m) and Chauragarh (1312 m). Due to altitudinal and latitudinal locations, the reserve remains much away from the dust storms and heat waves of Indo-Gangetic plain and thus, the climate is comparatively cooler than the rest of the districts of Madhya Pradesh. January and February are the coldest months with 8°C as the average minimum temperature while the hottest months are May and June with 40°C as the average maximum and 22°C as the average minimum temperature. The area experiences pre-monsoon showers at the end of May and monsoon from July to August which diminishes by October. The average annual rainfall is about 2000 mm while the dew continues up to March. Obviously the relative humidity is highest during July and August and the lowest in April and May. Due to high annual rainfall coupled with



Map : Pachmarhi Biosphere Reserve

high relative humidity and suitable temperature, the reserve harbours diverse and luxuriant growth of flora, typical of tropical type.

A review of literature reveals that Captain Forsyth was the first botanical explorer who surveyed the area in 1862. Following Forsyth (1871), a number of botanists visited the area and made important contributions to the flora of the region. They were Stewart and Brandis (1874), Hole (1904), Witt (1908), Haines (1916), Rao and Narayanaswami (1960), Kapoor and Yadav (1962), Joseph (1963), Panigrahi and Arora (1965), Panigrahi and Verma (1965), Panigrahi and Prasad (1966), Panigrahi *et al.* (1966), Panigrahi and Singh (1967), Ram Lal and Panigrahi (1967), Shukla and Panigrahi (1967), Tiwari (1954, 1955, 1957, 1963), Tiwari and Maheshwari (1963, 1964, 1965), Saxena (1973), Bir and Kumari (1982), Mukherjee (1984), Oommachan and Masih (1992), Kumar (1997), Mudgal *et al.* (1997), Singh *et al.* (2001), Khanna *et al.* (2001).

The total forest cover in the reserve is 3213.32 sq. km with 1364.56 sq. km agricultural land, 122.01 sq. km wasteland, 204.3 sq. km under water bodies and 22.09 sq. km built up land. Moreover, the closed forest accounts for 2739.48 sq. km while open and degraded forests comprise of 264.49 and 136.03 sq. km respectively with forest blank of 73.32 sq. km. According to Champion and Seth (1968) the entire forests of biosphere reserve can be broadly categorized into three major types viz., tropical moist deciduous forests, tropical dry deciduous forests and central Indian subtropical hill forests. The first two major types are further divided into three sub types in each, while last type is undivided. Thus, total seven forest types met in Pachmarhi Biosphere Reserve are discussed below.

South Indian moist teak forests

This type of forest is characterized by high moist teak forest and commonly 30 - 36 m or more in height. It is found in Bori valley and steep slopes on west of Pachmarhi plateau. The dominant species is *Tectona grandis* which is associated with *Terminalia alata, Diospyros melanoxylon, Buchanania lanzan, Pterocarpus marsupium, Schleichera oleosa, Careya arborea, Gardenia latifolia, Ougeinia oojeinensis, Bridelia retusa*, etc. The common herbs are *Rungia pectinata, Euphorbia hirta, Asparagus racemosus, Blepharis maderaspatensis, Achyranthes aspera, Apluda mutica, Dichanthium* *annulatum, Eragrostis tremula, Themeda quadrivalvis, Heteropogon contortus,* etc. In areas where bamboos are found, the ground flora comprises *Ichnocarpus frutescens, Sida acuta, Hemidesmus indicus, Elephantopus scaber, Celosia argentea, Pavonia repanda,* etc.

South Indian slightly moist teak forests

This type of forest occurs in the western part of Bori reserve. Though, the dominating species is teak (*Tectona grandis*) but the density of teak is lesser than the previous forest type.

South Indian moist mixed deciduous forests

These forests are almost similar to moist teak bearing forests except in the composition of teak which is occasionally present along with other associates. The associates are *Pterocarpus marsupium, Terminalia alata, T. bellirica, Anogeissus latifolia, Dalbergia latifolia, Lannea coromandelica, Lagerstroemia parviflora, Emblica officinalis.* The ground vegetation comprises *Asparagus racemosus, Elephantopus scaber, Abrus precatorius, Adiantum spp.*, etc. *Dendrocalamus strictus* appears on the slopes of hillocks but it is not uniform in the area. These forests are localized in small patches in Rampur and Bhatori of Betul forest division, Bhadbur in Hoshangabad forest division and part of Chhindwara forests.

Southern tropical dry teak forests

The forests of Matkuli, part of Pachmarhi Wildlife Sanctuary, Bankheri and Paraspani belong to this type. The main species is teak which is associated with *Anogeissus latifolia, Terminalia alata, Diospyros melanoxylon, Cassia fistula, Dalbergia latifolia, Butea monosperma, Haldina cordifolia, Mitragyna parvifolia, Bridelia retusa, Nyctanthes arbor-tristis, Woodfordia fruticosa, Helicteres isora, Indigofera cassioides, Carissa spinarum, Holarrhena pubescens, Lantana camara*, etc. Some of the common grasses are *Apluda mutica, Eragrostis tenella, Eragrostis viscosa, Heteropogon contortus*, etc.

Southern tropical dry mixed deciduous forests

The forest of this sub group is almost similar to dry teak deciduous forests but it differs mainly in floristic composition, where some typical species are more conspicuous. Thorny plants are common in the localities subjected to heavy grazing. The main associates are *Chloroxylon swietenia, Buchanania lanzan, Lagerstroemia parviflora, Mimusops hexandra, Hardwickia binata, Acacia catechu, Wrightia tinctoria, Albizia lebbeck, Flacourtia indica, Trema orientalis, Grewia tiliifolia, Lannea coromandelica*. The common shrubs are *Helicteres isora, Carissa carandas, Ziziphus oenoplia, Acacia pennata, Lantana camara*, etc. The common herbs are *Leucas montana, Vernonia cinerea, Pentanema indica, Crotalaria linifolia, Andrographis paniculata, Sida acuta*, etc. Some epiphytes and parasites which are found in these forests are *Vanda tessellata, Viscum articulatum* and *Dendrophthoe falcata*.

Northern dry peninsular sal forests (High level sal)

This type of forest covers the area of Pachmarhi plateau, extending towards eastern boundaries of the biosphere reserve. On the plateau, the growth of the sal is stunted. At places, *Mangifera indica* occurs in wild. The common herbs and shrubs found in these localities are *Pentanema indica, P. cernua, Vernonia cinerea, Ageratum conyzoides, Justicia* spp., *Blepharis maderaspatensis, Strobilanthes* spp., *Andrographis paniculata, Peristrophe bicalyculata, Themeda quadrivalvis, Cymbopogon martinii, Chloris dolichostachya, Eragrostis atrovirens*, etc.

Central Indian subtropical hill forests

This type of forest occurs on the hill top of Pachmarhi plateau. The forests in such localities are of inferior type and trees have short trunk. The trees occur in these forests are *Syzygium cumini, Terminalia alata, Anogeissus pendula, Emblica officinalis, Cassia fistula, Trema orientalis, Bombax ceiba, Litsea glutinosa, Kydia calycina, Ficus racemosa, Bridelia retusa, Terminalia chebula, T. bellirica, Mimusops hexandra, Anogeissus pendula, Ficus hispida*, etc. The common shrubs are *Berberis hainesii, B. lycium, Sophora interrupta, Lantana camara, Euphorbia royleana, Colebrookea oppositifolia,* etc., while the common herbs are *Leucas lanata, Andrographis paniculata, Sida acuta, Euphorbia hirta, Asparagus racemosus,* etc. On the other hand, *Dioscorea* spp. are also found at certain places.

FLORISTIC DIVERSITY

The status and analysis of various angiospermic families occurring in the biosphere reserve have been presented in table I. A total of 947 species under 516 genera belonging to 111 families occur in the area. A comparison of the status of various families of the biosphere reserve with Madhya Pradesh indicates that the number of genera and species in families like, Magnoliaceae, Cochlospermaceae, Dipterocarpaceae, Geraniaceae, Droseraceae, Saxifragaceae, Begoniaceae, Buddlejaceae, Proteaceae, Costaceae, Strelitziaceae is same. In certain families like Dilleniaceae, Berberidaceae, Violaceae, Tiliaceae, Linaceae, Oxalidaceae, Balsaminaceae, Leeaceae, Moringaceae, Crassulaceae, Onagraceae, Passifloraceae, Molluginaceae, Stylidiaceae, Ebenaceae, Menyanthaceae, Cuscutaceae, Lentibulariaceae, Chenopodiaceae, Loranthaceae, Musaceae, Cannaceae, Dioscoreaceae and Eriocaulaceae the genera occurring in the reserve are same as in Madhya Pradesh, but the number of species are less than Madhya Pradesh while in rest of the families, the number of genera and species occurring in the reserve are less than Madhya Pradesh.

The data further indicate that the families represented by a single genus and a single species in the reserve are Dilleniaceae, Annonaceae, Cochlospermaceae, Dipterocarpaceae, Bombacaceae, Malpighiaceae, Geraniaceae, Moringaceae, Myrsinaceae, Ebenaceae, Proteaceae, Santalaceae, Salicaceae, Costaceae, Cannaceae, Hypoxidaceae and Strelitziaceae. It is interesting to note that Cochlospermaceae, Leeaceae, Moringaceae, Begoniaceae, Stylidiaceae, Ebenaceae, Buddlejaceae, Menyanthaceae, Cuscutaceae, Cannaceae and Eriocaulaceae which are represented by a single genus in India also occur in the biosphere reserve. It is worthwhile to mention that the flora of the biosphere reserve includes four monogeneric families of the world viz., Leeaceae, Moringaceae, Cuscutaceae and Cannaceae.

Table I
A conspectus of families showing number of genera and species in Pachmarhi Biosphere Reserve and Madhya Pradesh

Family	Genera		Species	
	Pachmarhi Biosphere Reserve	Madhya Pradesh	Pachmarhi Biosphere Reserve	Madhya Pradesh
(1)	(2)	(3)	(4)	(5)
Ranunculaceae	3	6	4	9
Dilleniaceae	1	1	1	3
Magnoliaceae	2	2	2	2
Annonaceae	1	5	1	8
Menispermaceae	2	5	2	6
Berberidaceae	1	1	2	3
Papaveraceae	1	3	2	4
Brassicaceae	5	11	5	19
Capparaceae	1	5	4	20
Violaceae	2	2	2	4
Cochlospermaceae	1	1	1	1
Flacourtiaceae	2	4	3	7
Polygalaceae	1	2	3	18
Caryophyllaceae	3	7	3	11
Dipterocarpaceae	1	1	1	1
Malvaceae	6	16	14	52
Bombacaceae	1	5	1	6
Sterculiaceae	5	11	6	18
Tiliaceae	3	3	16	29
Linaceae	2	2	2	4
Malpighiaceae	1	4	1	5
Geraniaceae	1	1	1	1
Oxalidaceae	2	2	6	7

(1)	(2)	(3)	(4)	(5)
Balsaminaceae	1	1	3	4
Rutaceae	4	11	7	20
Burseraceae	2	4	2	4
Meliaceae	4	8	4	9
Celastraceae	2	3	2	7
Rhamnaceae	4	5	8	13
Vitaceae	3	6	5	14
Leeaceae	1	1	3	5
Sapindaceae	2	8	2	10
Anacardiaceae	5	7	5	8
Moringaceae	1	1	1	2
Fabaceae	39	73	109	264
Caesalpiniaceae	7	13	20	44
Mimosaceae	6	14	17	52
Rosaceae	5	6	8	12
Saxifragaceae	1	1	1	1
Crassulaceae	1	1	1	3
Droseraceae	1	1	2	2
Combretaceae	3	5	12	17
Myrtaceae	4	5	6	16
Lecythidaceae	1	2	1	3
Melastomataceae	3	4	3	7
Lythraceae	4	6	7	17
Onagraceae	1	1	3	5
Passifloraceae	1	1	1	2
Cucurbitaceae	7	15	10	33
Begoniaceae	1	1	2	2
Cactaceae	1	2	1	5
Molluginaceae	2	2	3	5

(1)	(2)	(3)	(4)	(5)
Apiaceae	7	17	12	24
Araliaceae	1	2	1	4
Rubiaceae	16	33	22	74
Asteraceae	37	81	58	153
Stylidiaceae	1	1	1	2
Campanulaceae	3	4	4	9
Plumbaginaceae	1	2	1	3
Primulaceae	2	3	3	6
Myrsinaceae	1	2	1	6
Sapotaceae	3	4	4	5
Ebenaceae	1	1	1	7
Oleaceae	2	5	6	20
Apocynaceae	6	15	9	24
Asclepiadaceae	10	19	13	29
Loganiaceae	3	4	4	6
Buddlejaceae	1	1	2	2
Gentianaceae	4	6	8	17
Menyanthaceae	1	1	1	2
Boraginaceae	6	8	10	30
Convolvulaceae	3	10	10	45
Cuscutaceae	1	1	2	5
Solanaceae	4	11	9	27
Scrophulariaceae	13	26	25	69
Lentibulariaceae	1	1	7	14
Gesneriaceae	2	4	2	4
Bignoniaceae	9	17	9	18
Pedaliaceae	1	2	1	2
Acanthaceae	23	38	41	103
Verbenaceae	11	18	14	35
Lamiaceae	14	20	25	62

(1)	(2)	(3)	(4)	(5)
Nyctaginaceae	1	4	2	7
Amaranthaceae	8	13	11	27
Chenopodiaceae	1	1	1	3
Polygonaceae	3	4	5	18
Lauraceae	1	5	1	7
Proteaceae	1	1	1	1
Loranthaceae	3	3	4	7
Santalaceae	1	2	1	2
Euphorbiaceae	18	29	42	96
Urticaceae	5	10	7	17
Ulmaceae	2	3	2	6
Moraceae	3	6	19	33
Salicaceae	1	2	1	2
Orchidaceae	14	33	26	88
Zingiberaceae	5	7	8	23
Costaceae	1	1	1	1
Musaceae	2	2	2	3
Strelitziaceae	1	1	1	1
Cannaceae	1	1	1	3
Hypoxidaceae	1	2	1	2
Agavaceae	4	7	6	12
Dioscoreaceae	1	1	7	15
Liliaceae	6	10	8	14
Commelinaceae	6	7	13	29
Arecaceae	1	6	3	8
Araceae	6	12	6	18
Eriocaulaceae	1	1	5	22
Cyperaceae	8	11	41	133
Poaceae	57	102	103	257

Table 2 indicates that out of total 111 families in the biosphere reserve, 95 families belong to dicotyledons (85.58%) while 16 families belong to monocotyledons (14.42%). Out of total 516 genera, 401 genera are of dicotyledons (77.71%) while 115 genera are of monocotyledons (22.29%). Likewise, out of 947 species, 715 species belong to dicotyledons representing 75.5%, while 232 species belong to monocotyledons representing 24.5% of the the total species. An analysis of data further indicates that the proportion of monocotyledons to dicotyledons is 1 : 3.08 while genera to species is 1:1.8.

Table II
Number and percentage of families, genera and species of angiosperms

Group	Families		Genera		Species	
	No.	% of total	No.	% of total	No.	% of total
DICOTYLEDONS	95	85.58	401	77.71	715	75.5
Polypetalae	(54)	(48.64)	(173)	(33.52)	(345)	(36.43)
Gamopetalae	(28)	(25.22)	(180)	(34.89)	(273)	(28.83)
Monochlamydeae	(13)	(11.72)	(48)	(9.3)	(97)	(10.24)
MONOCOTYLEDONS	16	14.42	115	22.29	232	24.5
Total	**111**		**516**		**947**	

The ten dominant families in Pachmarhi biosphere reserve showing maximum diversity and their comparison with Madhya Pradesh have been presented in tables III and IV. An analysis in the terms of number of species at family level indicates that family Fabaceae shows maximum diversity in the reserve. It is followed by Poaceae, Asteraceae, Euphorbiaceae, Acanthaceae, Cyperaceae, Orchidaceae, Scrophulariaceae, Lamiaceae and Rubiaceae. A comparison with the data of Madhya Pradesh indicates that the first three families viz., Fabaceae, Poaceae and Asteraceae also stand in the same rank in Madhya Pradesh while the status of other families is different. It is interesting to note that the ten dominant families of the biosphere reserve comprise 492 species i.e. 51.95% of the total species occurring in the reserve while remaining 101 families with a total of 455 species constitute 48.05%.

Table III
Ten dominant families showing maximum species diversity in Pachmarhi Biosphere Reserve and Madhya Pradesh

Family	Pachmarhi Biosphere Reserve No. of species	Family	Madhya Pradesh No. of species
Fabaceae	109	Fabaceae	264
Poaceae	103	Poaceae	257
Asteraceae	58	Asteraceae	153
Euphorbiaceae	42	Cyperaceae	131
Acanthaceae	41	Acanthaceae	103
Cyperaceae	41	Euphorbiaceae	96
Orchidaceae	26	Orchidaceae	88
Scrophulariaceae	25	Rubiaceae	74
Lamiaceae	25	Scrophulariaceae	69
Rubiaceae	22	Lamiaceae	62

Table IV
Ten dominant families showing maximum generic diversity in Pachmarhi Biosphere Reserve and Madhya Pradesh

Family	Pachmarhi Biosphere Reserve No. of genera	Family	Madhya Pradesh No. of genera
Poaceae	57	Poaceae	102
Fabaceae	39	Asteraceae	81
Asteraceae	37	Fabaceae	73
Acanthaceae	23	Acanthaceae	38
Euphorbiaceae	18	Rubiaceae	33
Rubiaceae	16	Orchidaceae	33
Lamiaceae	14	Euphorbiaceae	29
Orchidaceae	14	Scrophulariaceae	26
Scrophulariaceae	13	Lamiaceae	20
Verbenaceae	11	Asclepiadaceae	19

On the other hand, at generic level the family Poaceae exhibits maximum number of genera in the reserve as well as in Madhya Pradesh (Table IV). In the biosphere reserve it is followed by Fabaceae, Asteraceae, Acanthaceae, Euphorbiaceae, Rubiaceae, Lamiaceae, Orchidaceae, Scrophulariaceae and Verbenaceae.

Table V further indicates that the genus *Cyperus* shows maximum diversity in the biosphere and is represented by 25 species. It is followed by *Euphorbia* (17 spp.), *Ficus* (14 spp.), *Crotalaria* and *Indigofera* (13 spp. each), *Desmodium* (10 spp.), *Cassia* (9 spp), *Acacia* and *Lindernia* (8 spp. each), *Commelina, Dioscorea, Fimbristylis, Ipomoea, Justicia, Leucas, Utricularia* (7 spp. each), etc.

Table V
Genera showing maximum diversity

Genera	Family	No. of species
Cyperus	Cyperaceae	25
Euphorbia	Euphorbiaceae	17
Ficus	Moraceae	14
Crotalaria	Fabaceae	13
Indigofera	Fabaceae	13
Desmodium	Fabaceae	10
Cassia	Caesalpiniaceae	9
Acacia	Mimosaceae	8
Lindernia	Scrophulariaceae	8
Commelina	Commelinaceae	7
Dioscorea	Dioscoreaceae	7
Fimbristylis	Cyperaceae	7
Ipomoea	Convolvulaceae	7
Justicia	Acanthaceae	7
Leucas	Lamiaceae	7
Utricularia	Lentibulariaceae	7

Diversity of the biosphere is also enriched by the presence of 28 monotypic genera. They are *Chloroxylon, Soymida, Schleichera, Limonia, Lablab, Haldina, Blumeopsis, Ougeinia, Pongamia, Woodfordia, Caesulia, Hemidesmus, Rotula, Nicandra, Millingtonia, Oroxylum, Spathodea, Carvia, Colebrookea, Tamarindus, Ricinus, Gloriosa, Allmania, Ravenala (cultivated), Apluda, Diectomis, Pseudosorghum* and *Thysanolaena*. Besides, some genera represented in India by a single species are also found in the reserve. They are *Cissampelos, Waltheria, Aegle, Dodonaea, Diplocyclos, Centella, Blainvillea, Centipeda, Eclipta, Lagascea, Siegesbeckia, Tridax, Holarrhena, Rotula, Petalidium, Duranta, Tectona, Sebastiana, Costus* and *Floscopa.*

The biosphere reserve also covers some areas of high altitude in the state. An estimate from these areas indicates that *ca* 206 species belonging to 72 families are found at and above 1200 m altitude. Some such species are *Clematis heynei, Berberis lycium, Hibiscus lobatus, Firmiana colorata, Grewia asiatica, Cassine glauca, Crotalaria albida, Diospyros melanoxylon, Zornia gibbosa, Pimpinella heyneana, Vernonia divergens, Ceropegia hirsuta, Wrightia tinctoria,* etc. It is interesting to note that species like *Trachyspermum stictocarpum, Senecio bombayensis, Leucas zeylanica, Plectranthus rugosus, Glochidion johnstonei, Goodyera procera, Malaxis acuminata, Nervilia prainiana, Peristylus stocksii, Curcuma decipiens, Remusatia vivipara* are confined to high altitude areas of the reserve and are not reported from other parts of the state.

PHYTOGEOGRAPHY

Since the biosphere reserve occupies more or less central position in the country, it has a number of plants common with Western and Eastern Himalayas. The state of Madhya Pradesh is surrounded in the north-west by Rajasthan, in the west by Gujarat and in the south by Maharashtra and Andhra Pradesh. The biosphere reserve has a number of elements also common with Rajasthan, Gujarat, Maharashtra and southern India.

Plants common with Western Himalaya

Clematis roylei, Berberis asiatica, Casearia graveolens, Sida cordata, Bombax ceiba, Sterculia villosa, Impatiens balsamina, *Garuga pinnata, Toona ciliata, Celastrus paniculatus, Crotalaria albida, Indigofera cassioides, Pueraria tuberosa, Zornia gibbosa, Bauhinia vahlii, Acacia pennata, Rubus ellipticus, Terminalia alata, Diplocyclos palmatus, Centella asiatica, Schefflera venulosa, Catunaregam spinosa, Conyza stricta, Emilia sonchifolia, Senecio nudicaulis, Plumbago zeylanica, Ichnocarpus frutescens, Vallaris solanacea, Buddleja asiatica, Cuscuta reflexa, Ipomoea eriocarpa, Limnophila rugosa, Chirita bifolia, Adhatoda zeylanica, Lepidagathis cuspidata, Alternanthera sessilis, Antidesma acidum, Trema orientalis, Elatostema surculosum, Dendrobium crepidatum, Costus speciosus, Dioscorea pentaphylla, Urginea indica, Cyperus distans, C. squarrosus, Fimbristylis miliacea, Bothriochloa kuntzeana, Paspalidium flavidum, Setaria intermedia, S. italica* etc.

Plants common with Eastern Himalaya

Naravelia zeylanica, Cissampelos pareira var. *hirsuta, Rorippa indica, Shorea robusta, Sida acuta, Sterculia urens, Reinwardtia indica, Melia azedarach, Toona ciliata, Ventilago denticulata, Cayratia trifolia, Leea crispa, Semecarpus anacardium, Crotalaria albida, Dalbergia sissoo, Flemingia macrophylla, Pongamia pinnata, Sesbania bispinosa, Bauhinia vahlii, Acacia catechu, Albizia procera, Terminalia alata, T. chebula, Woodfordia fruticosa, Begonia picta, Centella asiatica, Sanicula elata, Hymenodictyon orixense, Spermadictyon suaveolens, Ipomoea purpurea, Lindernia ciliata, Aerides multiflora, Geodorum densiflorum, Goodyera procera, Malaxis acuminata, Peristylus constrictus, Rhynchostylis retusa, Amomum dealbatum, Hedychium coronarium, Commelina benghalensis, Amorphophallus bulbifer, Arisaema tortuosum, Apluda mutica, Capillipedium assimile, Digitaria ciliaris, Ischaemum indicum, Panicum notatum, Paspalum scrobiculatum, Pennisetum pedicellatum, Setaria verticillata, Vetiveria zizanioides*, etc.

Plants common with Rajasthan and Gujarat

Flacourtia indica, Polygala elongata, Vaccaria pyramidata, Hibiscus panduraeformis, Sida rhombifolia, Firmiana colorata, Waltheria indica, Boswellia serrata, Cassine glauca, Ziziphus rugosa, Alysicarpus hamosus, Crotalaria retusa, Dalbergia sissoo, Flemingia bracteata, Vigna vexillata, Cassia fistula, C. mimosoides, Acacia *catechu, Albizia odoratissima, Mimosa himalayana, Trichosanthes bracteata, Pimpinella heyneana, Knoxia sumatrensis, Blumea lacera, Gnaphalium polycaulon, Pulicaria angustifolia, Tridax procumbens, Campanula benthamii, Canscora diffusa, Swertia minor, Heliotropium marifolium, Solanum incanum, Centranthera nepalensis, Kickxia incana, Limnophila indica, Verbascum chinense, Utricularia striatula, Dolichandrone falcata, Dicliptera roxburghiana, Hygrophila auriculata, Petalidium barlerioides, Duranta repens, Anisomeles indica, Pogostemon pubescens, Baliospermum montanum, Euphorbia dracunculoides, Curcuma pseudomontana, Hypoxis aurea, Dioscorea hispida, Chlorophytum tuberosum, Phoenix acaulis, Carex cruciata, Cyperus alulatus, Fimbristylis tetragona, Lipocarpha chinensis, Brachiaria reptans, Coix aquatica, Dichanthium annulatum, Dimeria connivens, Eulaliopsis binata, Hemarthria compressa, Isachne globosa, Phragmites karka, Themeda triandra,* etc.

Plants common with Maharashtra and Southern India

Dillenia pentagyna, Tinospora cordifolia, Hybanthus enneaspermus, Polycarpon prostratum, Abutilon persicum, Hibiscus lobatus, Kydia calycina, Urena lobata, Helicteres isora, Sterculia urens, Corchorus aestuans, Grewia tiliifolia, Triumfetta rhomboidea, Impatiens inconspicua, Soymida febrifuga, Ziziphus oenoplia, Ampelocissus latifolia, Cissus repanda, Lannea coromandelica, Alysicarpus vaginalis, Crotalaria nana, Dalbergia lanceolaria, Desmodium motorium, Flemingia semialata, Mucuna pruriens, Pterocarpus marsupium, Tephrosia purpurea, Bauhinia racemosa, Cassia mimosoides, Drosera burmannii, Glinus lotoides, Pimpinella heyneana, Centratherum anthelminticum, Eclipta prostrata, Emilia sonchifolia, Lagascea mollis, Siegesbeckia orientalis, Diospyros melanoxylon, Wrightia tinctoria, Ipomoea hederifolia, Solanum nigrum, Lindernia crustacea, Justicia betonica, Nilgirianthus heyneanus, Rungia pectinata, Gmelina arborea, Lantana camara, Tectona grandis, Vitex negundo, Hyptis suaveolens, Leucas mollissima, Euphorbia prostrata, Homonoia riparia, Trema orientalis, Dendrobium herbaceum, Liparis atropurpurea, Vanda testacea, Curcuma decipiens, Dioscorea belophylla, Eriocaulon quinquangulare, Cyperus cuspidatus, Rhynchospora rugosa, Aristida setacea, Arundinella setosa, Chloris dolichostachya, Panicum brevifolium, Saccharum spontaneum, Setaria homonyma, etc.

ECONOMIC PLANTS

A number of plants of the reserve have economic importance and are variously utilised for different purposes as given below :

1. **Timber** (for construction work, poles, agricultural implements, furniture etc.) : *Albizia lebbeck, Anogeissus latifolia, Azadirachta indica, Dalbergia sissoo, Gmelina arborea, Kydia calycina, Lannea coromandelica, Mangifera indica, Ougeinia oojeinensis, Schleichera oleosa, Shorea robusta, Syzygium cumini, Tectona grandis, Terminalia alata.*

2. **Thatching** : *Phoenix acaulis, P. sylvestris, Saccharum spontaneum.*

3. **Broom** : *Phoenix acaulis, Sida acuta, Thysanolaena maxima, Vetiveria zizanioides.*

4. **Basket, mat and hat** : *Dendrocalamus strictus, Indigofera cassioides, Phoenix acaulis, P. sylvestris, Phragmites karka.*

5. **Fibre** : *Abutilon persicum, Bauhinia vahlii, Corchorus aestuans, Cryptolepis buchanani, Eulaliopsis binata, Hibiscus sabdariffa, Triumfetta rhomboidea.*

6. **Gum** : *Acacia nilotica* subsp. *indica, Anogeissus latifolia, Boswellia serrata, Lannea coromandelica, Sterculia urens.*

7 **Dye**: *Acacia catechu, Butea monosperma, Mallotus philippensis, Nyctanthes arbor-tristis, Woodfordia fruticosa, Wrightia tinctoria.*

8. **Beverage** : *Madhuca longifolia* var. *latifolia, Phoenix sylvestris.*

9. **Oil** (for illumination and lubrication etc.) : *Argemone mexicana, Jatropha curcas, Ricinus communis.*

10. **Fish poison** : *Gardenia turgida, Catunaregam spinosa, Verbascum chinense.*

11. **Floss** (for stuffing pillows) : *Bombax ceiba, Calotropis gigantea.*

12. **Wild edible** :

    (a) Tubers or rhizomes : *Curcuma angustifolia, Dioscorea bulbifera, D. pentaphylla, Sauromatum venosum.*

(b) Leaves and young shoots : *Alternanthera sessilis, Amaranthus viridis, Celosia argentea, Dendrocalamus strictus, Ipomoea eriocarpa, Nymphoides indica, Oxalis corniculata, Phoenix acaulis, Solanum nigrum.*

(c) Flowers : *Bauhinia racemosa, B. variegata, Madhuca longifolia* var. *latifolia, Moringa oleifera, Oxystelma esculentum, Semecarpus anacardium.*

(d) Fruits : *Aegle marmelos, Buchanania lanzan, Carissa congesta, Cordia dichotoma, Dillenia pentagyna, Emblica officinalis, Limonia acidissima, Ficus hispida, F. racemosa, F. virens, Flacourtia indica, Manilkara hexandra, Momordica charantia, M. dioica, Moringa oleifera, Phoenix acaulis, P. sylvestris, Solanum nigrum, S. torvum, Syzygium cumini, Tamarindus indica, Ziziphus rogosa.*

(e) Seeds : *Cassia occidentalis, Coix aquatica, Panicum sumatrense, Paspalum scrobiculatum, Semecarpus anacardium, Sterculia urens, Vigna trilobata, V. umbellata.*

Besides, a number of species have medicinal value and used for the treatment of a variety of ailments. Such some species along with their uses are given in table VI.

Table VI
Medicinal plants

Botanical name	Part used	Uses
Abrus precatorius	Root	Cough
Achyranthes aspera	Whole plant	Skin diseases, cough and as antidote to snake bite
Ageratum conyzoides	Leaf	Cuts
Andrographis paniculata	Leaf	Fever and liver disorders
Anogeissus latifolia	Whole plant	As antidote to snake bite
Asparagus racemosus	Root	Lactagogue
Barleria prionitis	Leaf	Boils
Berberis asiatica	Root	Stomachache

Botanical name	Part used	Uses
Bidens biternata	Leaf	As antidote to snake bite and scorpion sting
Blumea lacera	Whole plant	Inflammation and piles
Bombax ceiba	Bark	To regulate menstruation.
Boswellia serrata	Whole plant	Stomach diseases
Brassica napus	Root	Cough
Buchanania lanzan	Leaf	Wound
Calotropis gigantea	Flower	Cough, cold and asthma
	Root	Night blindness
Careya arborea	Bark	Diarrhoea
Carissa congesta	Root	Leucorrhoea
Casearia elliptica	Bark	Tonic
Centella asiatica	Whole plant	Nervous diseases
Cissampelos pareira var. *hirsuta*	Root	As antidote to snake bite
Clematis triloba	Root	Stomachache
Cleome monophylla	Root	Restoration of consciousness
C. viscosa	Leaf	Ear diseases
Clerodendrum serratum	Root	Malaria
Cyperus rotundus	Root	Eye diseases
Datura innoxia	Seed	Skin diseases
Diospyros melanoxylon	Seed	Spermatorrhoea and Urinary diseases
Dodonaea angustifolia	Leaf	Rheumatism and to rugulate menstruation
Elephantopus scaber	Root	Fever
Emblica officinalis	Leaf and fruit	Stomach diseases and piles

Botanical name	Part used	Uses
Eulophia herbacea	Pseudobulb	Tonic
Euphorbia neriifolia	Latex	Skin diseases
Evolvulus alsinoides	Leaf	Asthma
Ficus benghalensis	Bark	Diabetes
F. hispida	Fruit	Purgative
F. microcarpa	Bark	Liver diseases
F. racemosa	Latex	Piles
F. religiosa	Fruit	Laxative
Gardenia latifolia	Leaf	Wound of cattle
G. turgida	Flower	Fever
Gloriosa superba	Root	Leprosy
Gomphrena celosioides	Root	Cough
Grewia subinaequalis	Root	Rheumatism
Gymnema sylvestre	Leaf	Diabetes
Helicteres isora	Fruit	Stomach diseases
Hemidesmus indicus	Root	Fever and as antidote to snake bite
Indigofera glandulosa	Seed	Tonic
Ixora pavetta	Flower	Toothache
	Fruit	Diuretic
Kydia calycina	Leaf	Skin diseases
Lannea coromandelica	Gum	Earache
Lantana camara	Whole plant	Malaria
var. *aculeata*	Leaf	Skin diseases
Leucas cephalotes	Flower	Cold and cough
Mallotus philippensis	Seed	Rheumatism
Melastoma malabathricum	Leaf	Diarrhoea and dysentery
Michelia champaca	Bark	Abortifacient
Mitragyna parvifolia	Bark	Contraceptive

Botanical name	Part used	Uses
Momordica charantia	Fruit	Diabetes
M. dioica	Fruit	Diabetes
Plumbago zeylanica	Root	Abscess
Rhus parviflora	Fruit	Stomach diseases
Rorippa indica	Seed	Asthma
Semecarpus anacardium	Gum	Veneral diseases
Sida acuta	Root	Urinary diseases
S. alba	Root	Fever and debility
S. cordifolia	Leaf	Dysentery
S. rhombifolia	Stem	Skin diseases
	Whole plant	Rheumatism and Tuberculosis
Solanum incanum	Root	Stomachache
S. nigrum	Leaf	Skin diseases
Spermacoce hispida	Whole plant	Headache
Sphaeranthus indicus	Leaf	Fever
	Seed	Anthelmintic
Spilanthes paniculata	Whole plant	Bleeding piles
Sterculia urens	Gum	Throat infection
S. villosa	Root	Tonic
Syzygium cumini	Seed	Diabetes
Tectona grandis	Leaf	Cough and bodyache
Tephrosia purpurea	Whole plant	Impotency
Terminalia arjuna	Bark	Cardiac tonic
T. bellirica	Fruit	Stomach diseases, piles
T. chebula	Bark	Cardiac tonic
	Fruit	Stomach diseases
Thalictrum foliolosum	Root	Jaundice
Trichodesma indicum	Root	Stomach diseases

Botanical name	Part used	Uses
Tridax procumbens	Leaf	Carbuncle
Ventilago denticulata	Root	Ear diseases
Vernonia cinerea	Leaf	Fever
Viscum articulatum	Whole plant	Fever
Vitex negundo	Leaf	Rheumatism and headache
Waltheria indica	Bark	Boil
Woodfordia fruticosa	Flower	Cough
	Leaf	Ulcer
Xanthium indicum	Whole plant	As diaphoretic

ENDEMIC PLANTS

The biosphere shows very poor representation of endemic species probably because of the migration of species to neighbouring and far places. There are only two species namely, ***Berberis hainesii*** with two varieties ***hainesii*** and ***brevifilipes*** and ***Ficus cupulata*** endemic to the biosphere reserve.

RARE PLANTS

The biosphere also exhibits numerous rare species having less population (Table VII). Out of 92 species, 36 species are not only rare in the biosphere but also in the state as they have not been reported from other parts of the Madhya Pradesh (Table VII, column 1). Species like *Glochidion johnstonei*, *Leucas zeylanica*, *Plectranthus rugosus* and *Senecio bombayensis* are confined only to high altitude. Further, 20 species are rare in the reserve but have been reported from one or two other districts of Madhya Pradesh (Table VII, column 2). On the other hand, 36 species are rare in the reserve but they have been reported from more than two other districts of Madhya Pradesh i.e. they are common elsewhere (Table VII, column 3).

Table VII

Rare plants of Pachmarhi Biosphere Reserve and their status in Madhya Pradesh

* Plants are confined to high altitude.

Rare in Pachmarhi Biosphere Reserve and not reported from any district of Madhya Pradesh	Rare in Pachmarhi Biosphere Reserve but reported only from one or two other districts of Madhya Pradesh	Rare in Pachmarhi Biosphere Reserve but reported from more than two other districts of Madhya Pradesh
1	2	3
Abrus pulchellus	*Cardamine trichocarpa*	*Aerides multiflora*
Begonia malabarica		
Berberis hainesii* var. *hainesii	*Citharexylum spinosum*	*Anagallis pumila*
	Crotalaria nana	*Asphodelus tenuifolius*
		Biophytum petersianum
B. hainesii* var. *brevifilipes	*Eulophia explanata*	*Campanula benthamii*
Brachiaria deflexa	*E. herbacea*	*Centranthera nepalensis*
	Galinsoga parviflora	
Buddleja madagascariensis	*Geranium ocellatum*	*Cochlearia cochlearioides*
Bupleurum plantaginifolium	*Justicia latispica*	*Cochlospermum religiosum*
Cajanus heynei	*Ischaemum duthiei*	
		Conyza leucantha
Corallocarpus epigaeus	*Limnophila connata*	*Cyperus diaphanus* var. *latespicatus*

1	2	3
Desmodium ferrugineum	*Lindernia hookeri*	
Desmodium multiflorum	*Malaxis mackinnonii*	*Dioscorea wightii*
Dimeria connivens	*Manisuris clarkei*	*Gnaphalium luteo-album*
Dysolobium grande		*Hibiscus panduraeformis*
Ficus cupulata		
Galactia villosa	*Nervilia aragoana*	*Hygrophila polysperma*
**Glochidion johnstonei*	*Oropetium roxburghianum*	
Holmskioldia sanguinea		*Hymenodictyon orixense*
Indigofera hochstetteri	*Pycnocycla glauca*	*Kickxia incana*
Isachne gracilis	*Stylidium tenellum*	*K. ramosissima*
Ischaemum semisagittatum	*Synedrella nodiflora*	*Knoxia sumatrensis*
Lamium amplexicaule	*Thunbergia alata*	*Limnophila aromatica*
Leea compactiflora	*Vaccaria pyramidata*	*Lindernia hyssopioides*
Leptadenia pyrotechnica		*L. procumbens*
* *Leucas zeylanica*		*Lysimachia candida*
Manisuris forficulata		*Morus alba*
* *Plectranthus rugosus*		*Murraya koenigii*

1	2	3
Rhynchelytrum villosum		
Rhynchosia rothii		*P. vaginatum*
Rubus ellipticus		*Passiflora edulis*
Sanicula elata		*Pennisetum polystachion*
* *Senecio bombayensis*		*Potentilla supina*
Smithia pycnantha		*Rhynchostylis retusa*
Solanum seaforthianum		*Rotala mexicana*
Trachyspermum stictocarpum var. *lebecarpum*		*Schizachyrium exile* *Solanum incanum*
Tripogon lisboae		*Sonchus brachyotus*
Tylophora fasciculata		*Sonerila tenera*
Viola betonicifolia		*Thalictrum foliolosum* *Utricularia exoleta*

CONSERVATION

It is apparent from the foregoing account that the area of biosphere reserve shows great floristic diversity. It harbours few endemic taxa and a number of useful and rare plants. Although the area has been conserved by declaring it as a biosphere reserve, concerted steps should also be taken for its proper management and the *ex situ* conservation of endemic and rare plants.

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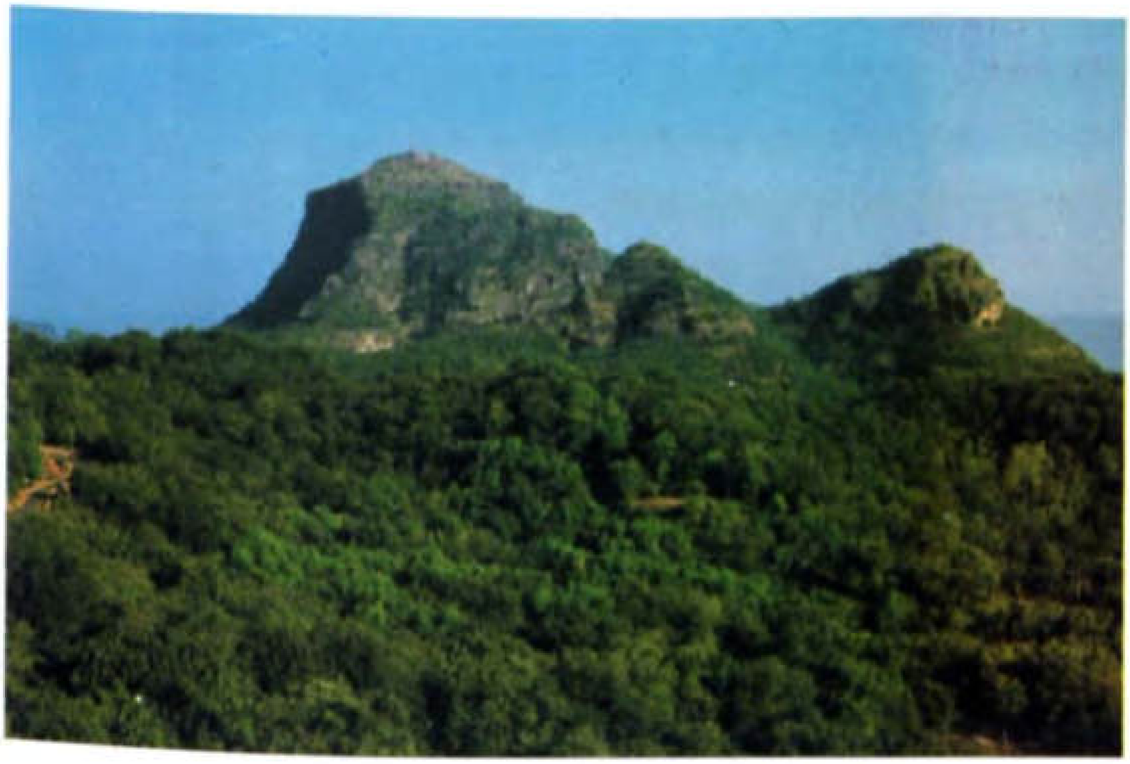
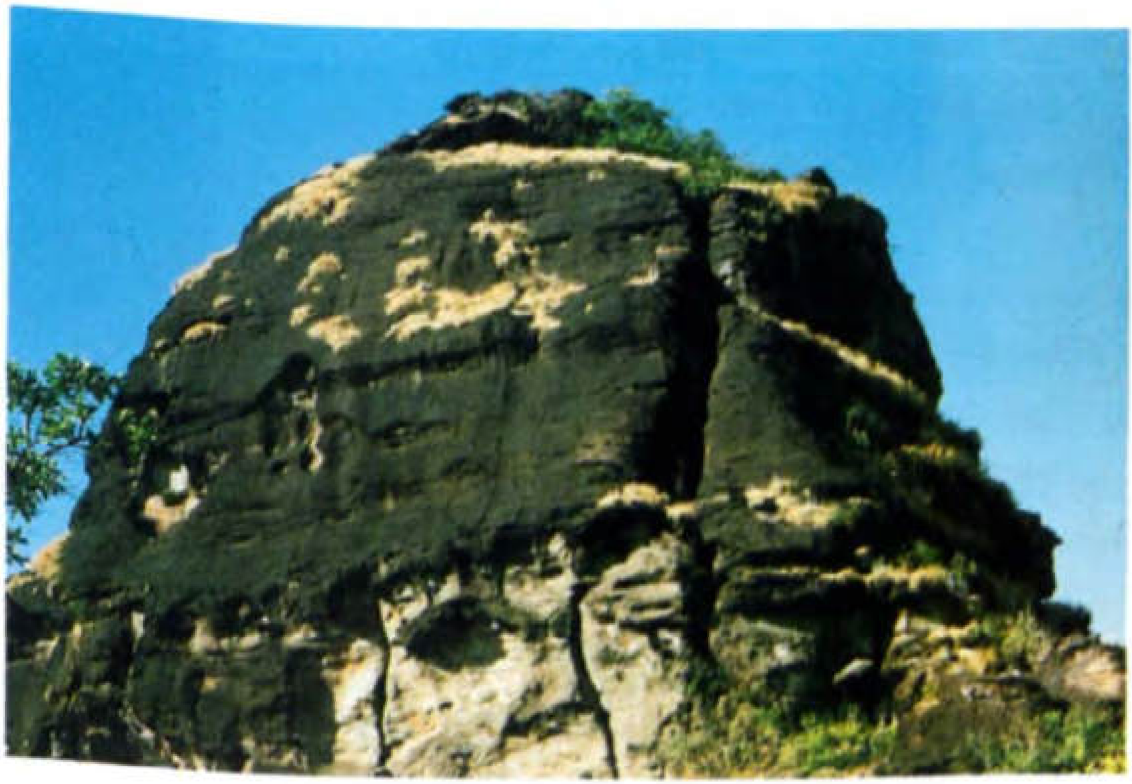
ADDENDA

Pachmarhi Biosphere Reserve was under study for quite some time by Dr. B.K. Sinha, Botanical Survey of India, Allahabad. Recent information based on field surveys, identification of materials preserved at Botanical Survey of India, Allahabad, State Forest Research Institute, Jabalpur and Project document (Anonymous, 1996)*, the floristic diversity of the biosphere reserve at present comprises approximately 1185 species belonging to 647 genera and 164 families, including 70 species under 38 genera and 79 families of pteriodophytes and 10 species under 7 genera and 4 families of gymnosperms. The angiosperms alone comprises 1105 species, distributed within 602 genera and 131 families. It is again hoped that further studies may add more species to this known knowledge of the biosphere reserve.

*Anonymous 1996. *Panchmarhi Biosphere Reserve.* Project Document. Environmental Planning & Co-Ordination Organisation, Bhopal.



A view of sal forests.



Dhupgarh - highest peak in Madhya Pradesh.

Tinospora cordifolia

Melastoma malabathricum

Drosera burmanni

Costus speciosus

Euphorbia antiquorum

Ficus cupulata - endemic.

SIMILIPAL BIOSPHERE RESERVE

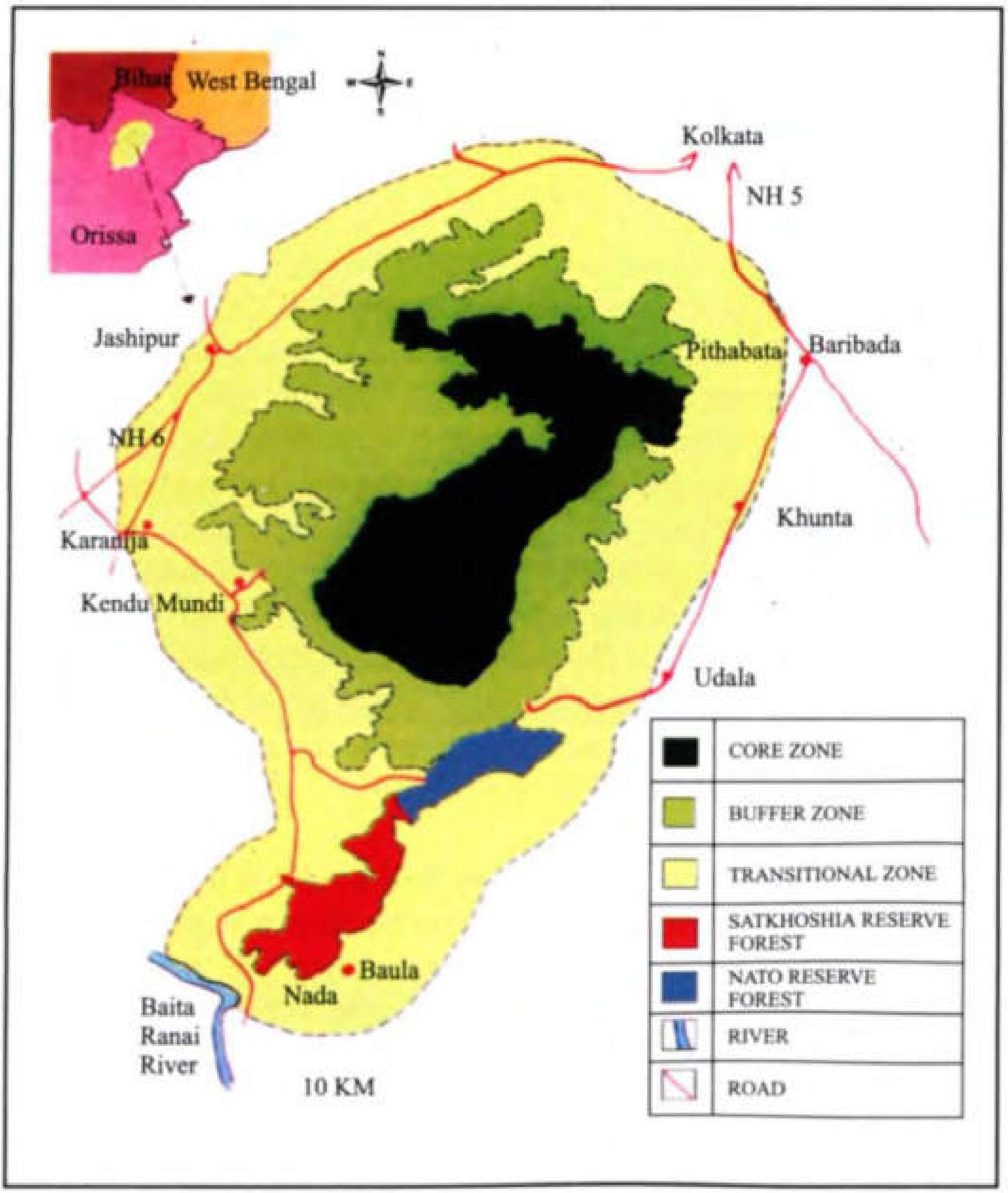
L.K. Banerjee
S.K. Srivastava

The Similipal Biosphere Reserve established on 21st June, 1994, lies between 86°04′-86°37′E longitude and 21°16′-21°32′ N latitude in the Mayurbhanj district of Orissa state. It covers a total area of 4374 sq. km. The biosphere represents three distinct biogeographic zones viz., Deccan Peninsula, Chhotanagpur and Mahanadi. It is characterized by presence of some common features found in Eastern Plateau, Chhotanagpur, Lower Gangetic Plain and some coastline areas. The reserve is remarkably interconnected with the network of several perennial streams and rivers like Burhabalanga, Palpala, Bandan, Khairi, Salandi, Sanjo and Deo which flow through different hills. The presence of dominant 'Sal forests' is the most interesting feature of this reserve. Majority of the population in and around the forests depends mostly on the forest and animal resources for their livelihood.

The biosphere reserve is bounded by Baitarani river to the south-west and partly by No. 5 National highway to north-east region and No. 6 National highway towards the north-west periphery. Of the total area of the biosphere reserve, the core zone comprises of 845 sq. km, buffer zone 2129 sq. km and transitional zone 1400 sq. km. Out of the total buffer zone, an area of 147 sq. km and 77 sq. km is occupied by Satkosia and Nato reserve forests respectively.

Climate

The climate of Similipal Biosphere Reserve may be described as monsoonic which represents a dry and comparatively cool season. June to September are the wettest months and about 79% rainfall occur during this period. Average rainfall varies from 2500-3000 mm. In summer, the relative humidity ranges from 70-96% in morning and 30% during midday. Winter has a cold wind, commonly known as *Kalyani Hawa*, blows towards the west. The temperature ranges from 20°C to 42°C during summer and 12°C to 30°C during winter. Periodic earth thunder and dust-storms usually occur during late May to early June.



Map : Similipal Biosphere Reserve (source : S.S. Srivastava, 2002)

Geology

In Palaeozoic era (350 million years ago) Similipal plateau was a part of Gondwana-land. The tract of Similipal hill is an inclined tableland, which has risen abruptly from the low coastal plains. The steep side of the plateau faces the Bay of Bengal. Rocks of Similipal are composed of metamorphic, sedimentary and igneous rocks. It has an average height of 1000 m and dips towards the north and finally merges into Chhotanagpur plateau. Meghasini (1163 m) is the second highest peak approachable by road through the Khairiburu (1166 m) which is the highest peak. Bowl shaped quartzite layer of Similipal is made of volcanic rocks and Ajmari silt. Dharwar rock formation consists of typically Shales and Phyllites with

Quartz veins. Siliceous clay, Slates, Mica, Quartzite and Hematite Schist are common in this area. Several clefts and fissures are present on the rocks.

Soil

The soil of the biosphere reserve is generally developed by the erosion of rocks and it is slightly acidic in nature. The soil pH varies from 4.8 to 6.8. It can be classified into four different types viz., Red loam soil; Reddish deep soil; Clay loam soil and Reddish loam soil. Of these, the former is derived from erosion of hematite rocks and promotes high biotic activity. Reddish deep soil develops from Laterites and promotes good growth for tall trees. Weathering of Shale produces Clay and Clay loam soils which also promote very high biotic activity. Reddish Sandy soil derived from Sandstone and Quartzite encourage good growth for both plants and animals. Massive soil erosion is a perennial problem particularly around the Balanga valley.

SOCIO-ECONOMIC STATUS

Socio-economic structure of Similipal biosphere reserve is not well looked after. There are about 1265 villages, of which 4 are situated in the core zone, 61 in buffer zone and 1200 in transitional zone. The total population of these villages is about 4.5 lakhs, of which more than 73% belong to various tribal communities, 5% to scheduled castes and 21% to other castes. The tribes residing in the biosphere reserve area are Bhumija, Bathudi, Kolha, Gonda, Santhal, Khadia, Mankadia and Mahali.

Inhabitants around the area belong to the poor classes and adapt themselves with the nature by a simple life style. The literacy rate as well as skill among the inhabitants are very low. Most of the inhabitants are landless labourers. Employment opportunities are not available to the villagers. Due to absence of irrigation facilities agriculture is not well developed. As a result the pressure on the forests is gradually increasing.

VEGETATION

The flora of Similipal biosphere reserve shows a great diversification due to varied topographic, climatic and edaphic conditions. It represents a virgin semi-evergreen forests which express the climatic climax type of vegetation. The central core of the forest, covers the ridges and valleys of the hills and is undisturbed by any biotic factor. The forest growth is thick and impenetrable and is dominated by gigantic growth of a large number of tree species. *Shorea robusta* (Sal) mainly occupies the ridges while the steeper and drier hill slopes represent mixed vegetation with scattered 'Sal'. Bamboos are seen along the quartz and mica schist zones, where, the 'Sal' is poorly represented in association with *Gardenia, Phoenix acaulis* and several grass species with an approach to thorn scrub vegetation type with *Flacourtia* sp., *Capparis zeylanica* and *Ziziphus* species. Along the river banks *Syzygium cumini, Homonoia riparia, Hypericum* sp., *Cyathea* sp. and *Angiopteris evecta* are observed. Members of Acanthaceae, Fabaceae and Lamiaceae represent the ground vegetation. The vegetation of the biosphere reserve can be classified as follows.

1) Northern tropical semi-evergreen forests

This type of vegetation occurs in high hilly regions where the climate is humid and moist. Flora of these forests shows a mixture of species represented in both Chittagong and Eastern Himalayan region. The common species occur in this region are *Shorea robusta, Machilus villosa, Alphonsea ventricosa, Sapium insigne, Turpinia pomifera, Elaeocarpus wallichii, Styrax serrulatum, Artocarpus lakoocha, Toona ciliata, Mangifera indica, Michelia champaca, Ailanthus excelsa, Mesua ferrea, Stereospermum chelonoides, Xylia xylocarpa, Bridelia retusa, Leea acuminata* and *Clematis smilacifolia*, etc. Along the river banks *Salix tetrasperma, Macaranga denticulata, Pongamia pinnata, Saraca asoca, Trewia nodiflora, Anthocephalus chinensis, Diospyros peregrina, Syzygium cumini, Bombax ceiba, Alstonia scholaris, Dillenia pentagyna, Polyalthia cerasoides* and several species of *Litsea* and *Ficus*.

2) Northern tropical moist deciduous forests

These forests are mainly dominated by the pure stands of 'Sal' *(Shorea robusta)*. The other associates are *Terminalia tomentosa, Pterocarpus marsupium, Mangifera indica, Anogeissus latifolia, Schleichera oleosa, Haldinia cordifolia, Bridelia retusa, Careya arborea, Strychnos potatorum, Mallotus philippensis, Ziziphus glaberrima, Polyalthia cerasoides, Bambusa arundinacea, Bauhinia purpurea, B. vahlii, Diospyros buxifolia, Glycosmis pentaphylla,* *Dillenia pentagyna, Gmelina arborea, Kydia calycina, Combretum album, Wendlandia tinctoria, Woodfordia fruticosa, Randia dumetorium, Phoenix acaulis, Gardenia gummifera, Imperata cylindrica*, etc.

3) Dry deciduous hilly forests

These forests occur on the steep slopes below the ridges. 'Sal' trees are totally absent here. The vegetation of this area comprises species like *Bursera serrata, Dalbergia latifolia, Cleistanthus collinus, Callicarpa arborea, Grewia tiliifolia, Hymenodictyon excelsa, Sterculia villosa, S. colorata, Anogeissus latifolia, Walsura piscidia, Ougenia dalbergioides, Bridelia retusa, Drymaria quercifolia, Diospyros sylvatica, Capparis* sp., *Erythrina suberosa, Cochlospermum religiosum, Helicteres isora, Nyctanthes arbor-tristis* etc.

4) High level Sal forests

These forests are found in drier areas on metamorphic rocks and boulders where the vegetation shows a peculiar stunted tree species in association with some Sub-Himalayan shrubs and herbs. In these forests *Shorea robusta* dominates along with *Garcinia cowa, Citrus aurantium, Amoora spectabilis, Alphonsea lutea, Canthium glabrum, Unona discolor, Aporusa roxburghii, Berberis asiatica, Pygeum acuminatum, Smithia ciliata, Anotis calicina, Vitex glabrata* and several species of *Chlorophytum, Asparagus, Habenaria, Pogonia*, etc.

5) Grasslands

Like semi-evergreen mixed forests, the grasslands also cover *ca* 4% of the total vegetation. These are common on hill tops at higher elevations. Several interesting species viz., *Butea monosperma, Aegle marmelos, Ehretia laevis, Vitis latifolia, Grewia hirsuta, Syzygium nervosum, Acacia catechu, Cassia fistula, Gardenia turgida, Wendlandia tinctoria, Symplocos racemosa, Phyllanthus emblica* are intermittent along with several species of grasses like *Dicanthium annulatum, Apluda mutica, Imperata cylindrica, Chloris variegata, Themeda quadrivalvis, Heteropogon contortus, Arundinella hookeri, Bothriochloa pseudoischaemum, Cymbopogon nardus, Saccharum spontaneum, Eulaliopsis binata, Thysanolaena maxima, Eulalia trispicata, Cynodon dactylon* and many others, are common in this formation.

Wetland vegetation

Aquatic plants are frequently observed in large numbers in ponds, streams and lakes within the reserve area. Majority of the species grow in marshy land. Submerged and free floating plant species are common throughout these wetlands. These mainly comprise *Hydrila verticillata, Blyxa aubertii, Ottelia alismoides, Pistia stratioites, Trapa bispinosa, Nymphaea stellata, Nymphoides cristatum, Ceratophyllum demersum, Nechamandra alternifolia, Utricularia stellaris, Neptunia oleracea, Eichhornia crassipes, Monochoria* sp. etc. The species occur in marshy places are *Canscora diffusa, Lindernia anagalis, Hygrophila polysperma, Juncus prismatocarpus, Jussiaea suffruticosa, Tamarix ericoides, Rumex dentatus, Alternanthera sessilis, Limnanthemum indicum, Phragmites karka, Fimbristylis dichotoma, Cyperus elusinoides, C. pygmaeus, Trapa natans, Ipomoea aquatica, Polygonum barbatum, Scirpus supinus, Elytrophorus spicatus* etc.

FLORISTIC DIVERSITY

Haines (1921) described the botany of Bihar and Orissa. Mooney (1950) supplemented Haines work and enumerated *ca* 2700 species from both the states. Bal (1942) described useful plants of Mayurbhanj district which covers most of the part of biosphere reserve. Panigrahi *et al.* (1964) reported more than 750 species of angiosperms, of which many taxa were recorded as additions to the flora of Orissa. Mudgal and Pal (1980), Tribedi *et al.* (1982) reported some medicinal plants from Mayurbhanj, used by the tribal communities. Saxena and Brahmam (1989) published the flora of Similipahar (Similipal), Orissa and enumerated *ca* 1076 species of vascular plants including 64 species of cultivated plants. Saxena and Brahmam (1994-96) also published flora of Orissa, where they included plants of Similipal (Similipahar) and recorded *ca* 600 species. Banerjee (1983), Banerjee and Sastry (1998) also presented an account of vegetation of Similipal Tiger Reserve.

Based on the above publications and other available literature, it is estimated that the flora of Similipal Biosphere Reserve comprises *ca* 992 species excluding cultivated ones, belonging to 597 genera and 168 families of angiosperms, gymnosperms and pteridophytes (Table I).

Table I
Statistics of the Flora

Plant group	Family	Genera	Species
Gymnosperms	3	4	4
Pteridophytes	28	40	60
Angiosperms			
Monocots	24	142	273
Diocots	113	411	655
Total	168	597	992

An analysis of the flora reveals that dicots represent 655 species, monocots 273, pteridophytes 60 species and gymnosperms with only 4 species in the reserve.

Based on the number of species, the family Poaceae is the largest. It is followed by Fabaceae, Orchidaceae, Asteraceae, Cyperaceae, Rubiaceae (Table II), etc.

The family Poaceae shows maximum diversity and is represented by 61 genera and 108 species. *Themeda* (8 spp.) is the dominant genus, followed by *Digitaria* (5 spp.), *Cymbopogon* (4 spp.), *Eragrostis* (4 spp.), *Arthraxon* (4 spp.) and *Setaria, Pennisetum* and *Bambusa* with 3 species each. Similarly family Fabaceae is represented by 32 genera and 75 species. *Desmodium* is the dominant genus with 12 species, followed by *Bauhinia* (6 spp.), *Flemingia* (6 spp.), *Crotalaria* (5 spp.), *Acacia* (4 spp.) and *Butea* (3 spp.). Among the woody lianas *Entada* and *Mezoneurum* are known by single species each.

Orchidaceae the third largest family is represented by 36 genera and 70 species. *Dendrobium* is the dominant genus with 11 species, followed by *Habenaria* (7 spp.), *Bulbophyllum* (6 spp.), *Oberonia* (5 spp.), *Liparis* and *Peristylus* with 4 species each and *Acampe, Goodyera* and *Malaxis* with 3 species each.

Asteraceae again a largest family is represented by 28 genera and 54 species. *Blumea* is the dominant genus with 5 species. *Gnaphalium* and *Conyza* are known by 3 species each. *Dichrocephala, Blumeopsis, Anaphalis, Artemisia, Laggera, Launea, Sonchus, Sphaeranthus* are known by single species each.

Table II
Dominant families in the biosphere reserve

Family	No. of species
Poaceae	108
Fabaceae	75
Orchidaceae	70
Asteraceae	54
Cyperaceae	43
Rubiaceae	43
Euphorbiaceae	41
Acanthaceae	37
Lamiaceae	24
Scrophulariaceae	20

The generic diversity is also interesting. The genus *Cyperus* exhibits maximum diversity and has 19 species, followed by *Desmodium* (12 spp.), *Dendrobium* (10 spp.), *Ipomoea* (10 spp.), *Solanum* (9 spp.), *Blumea* (9 spp.), etc. (Table III).

Table III
Dominant genera in the biosphere reserve

Genera	No. of species	Family
Cyperus	19	Cyperaceae
Desmodium	12	Fabaceae
Dendrobium	10	Orchidaceae
Ipomoea	10	Convolvulaceae
Solanum	9	Solanaceae
Blumea	9	Asteraceae
Polygonum	8	Polygonaceae
Oldenlandia	8	Rubiaceae
Crotalaria	8	Fabaceae
Dioscorea	7	Dioscoreaceae

Affinities

The biosphere reserve harbours many orchids, ferns, bamboos and number of other species having their phytogeographical importance. *Aschynomene indica, Spermacose pusilla, Desmodium motorium, Rubus ellipticus* and *Sphaeranthus indicus* have a greater range of distribution, extending from Kashmir to Assam in the north and Sri Lanka in the South, whereas *Canthium diccocum, Diospyros montana, Meliosma simplicifolia, Micromelum integerrimum, Flemingia strobilifera* are common to Similipal, Assam, Himalaya and Sri Lanka. Likewise *Garcinia cowa* and *Microstylis congesta* represented in the biosphere reserve are also known from Andaman islands and Khasi hills in Meghalaya.

ENDEMISM

Though the endemism is not fully explored but it is observed that the flora of reserve shows high degree of endemism. Some endemic species are listed below in table III.

Table III
Endemic species in Similipal Biosphere Reserve

Botanical name	Family
Aglaia haslethiana	Meliaceae
Bulbophyllum panigrahianum	Orchidaceae
Cyathia spinulata	Cyathiaceae
Eria meghasinensis	Orchidaceae
Gardenia gummifera var. *gummiferoides*	Rubiaceae
Habenaria panigrahiana var. *parviloba*	Orchidaceae
Mucuna minima	Fabaceae
Rhynchosia hainensiana	Fabaceae
Themeda mooneyi	Fabaceae
Themeda saxicola	Poaceae
Toona ciliata var. *brevipetiolulata*	Meliaceae
Toona ciliata var. *hainesii*	Meliaceae

Besides, the biosphere reserve has several rare and threatened species which are important from conservation point of view. Some of them are listed below (Table IV).

Table IV
Rare and threatened species

Botanical name	Family	Status
Acacia donaldii	Mimosaceae	Threatened
Bulbophyllum guttulatum	Orchidaceae	Threatened
B. polyrrhizum	Orchidaceae	Threatened
Dendrobium cathartii	Orchidaceae	Threatened
Dicrocephala integrifolia	Asteraceae	Restricted
Dimeria mooneyi	Poaceae	Threatened
Eria bambusifolia	Orchidaceae	Threatened
Eulophia dubia	Orchidaceae	Rare
Flemingia neilgheriensis	Fabaceae	Rare
Gnetum montanum	Gnetaceae	Rare
Gomphostema parviflorum	Lamiaceae	Restricted
Hypericum gaitii	Hypericaceae	Rare
Neocinnamomum caudatum	Lauraceae	Restricted
Nervilia punctata	Orchidaceae	Rare
Pavetta brevifolia var. *ciliolate*	Rubiaceae	Rare
Smilax lanceaefolia	Smilacaceae	Rare
Wendlandia gamblei	Rubiaceae	Rare

Medicinal plants

The biosphere reserve harbours a large number of medicinal and economical plants. The tribal communities *viz.*, Sabars, Santals Bhumij, etc. utilize these plants in curing their various ailments. Many important contributions have been made on the documentation of the medicinal plant resources. Bal (1942) while carrying out general survey, collected more than 500 plants and categorized them under food, fodder, medicinal, gum, fibre, resin, dye, tannin, perfume, paper pulp and timber yielding plants. Mudgal and Pal (1980) and Tribedi *et al.* (1982), surveyed the Mayurbhanj district and reported 114 interesting medicinal plants from Similipal Biosphere Reserve. Some of these along with their uses are listed (Table V).

THREATS AND CONSERVATION

Forests and their produce have been the source of food, shelter, medicines and livelihood for the people since time immemorial. The biotic and natural factors have affected the biosphere reserve area from time to time. 'Akhand Sikhar' and the expansion of villages in the core and buffer zones have resulted in loss of plant diversity. Forest fire, timber operation and poaching of wild fauna are some of the other causes responsible for degradation of forests.

For an effective conservation of plant diversity an Eco-development programme should be launched involving local communities. It is necessary to create awareness among local people for protection and conservation of plant resources of the region. Rare and endemic species which are threatened owing to various human activities should be propagated through *ex situ* means.

Above all, the forest managers and the authorities should ensure that the needs of local communities are met through the provision of alternative sources of income and forests and their produce are used sustainably.

Table V
Medicinal and ethnomedicinal plants

Botanical name	Local name	Family	Uses
Argyreia nervosa	*Mundanoi*	Convolvulaceae	Roots for diabetes, ring worm and blood diseases.
Aristolochia indica	*Iswarmula*	Aristolochiaceae	Root decoction for fever.
Azanza lampas	*Banakapas*	Malvaceae	Leaves paste for curing gonorrhoea.
Barleria strigosa	*Banmalli*	Acanthaceae	Leaf juice for curing skin diseases and gum pain.
Baringtonia Acutangula	*Hijala'*	Lecythidaceae	Powdered seeds in liver trouble.
Bridelia crenulata	*Kosigacha*	Euphorbiaceae	Stem bark decoction for preventing pregnancy.
Bridelia retusa	*Kashi*	Euphorbiaceae	Leaf paste with goat milk in stomach pain.
Buchanania lanzan	*Charkuri*	Anacardiaceae	Kernel is consumed as sweat-meats.
Butea monosperma	*Guchpalas*	Fabaceae	Seeds in stomach disease.
Butea superba	*Lat-Palas*	Fabaceae	Bark juice for healing new wounds.
Canthium dicoccum	*Karuna*	Rubiaceae	Root paste is prescribed for diarrhoea.
Celastrus paniculatus	*Koorsana*	Celastraceae	Oil from fruits applied for skin diseases.
Clausena excavata	*Agnijal*	Rutaceae	Infusion of roots, flowers and leaves for colic pain.
Croton oblongifolium	*Putla*	Euphorbiaceae	Decoction of root bark given for diarrhoea and dysentery.

Botanical name	Local name	Family	Uses
Cryptolepis buchanani	*Kongha*	Asclepiadaceae	Root bark paste for rheumatism.
Desmodium triquetrum		Fabaceae	Leaf extract for cough and cold.
Dioscorea oppositifolia	*Pani-alu*	Dioscoreaceae	Tubers in constipation to clear bowel.
Dendrophthoe falcata	*Banda*	Loranthaceae	Stem bark decoction for preventing pregnancy.
Ehretia acuminata	*Pangacha*	Ehretiaceae	Stem bark chewed to cure tongue sores.
Elaegnus latifolia	*Dibaguda*	Elaegnaceae	Flowers and fruits in curing ulcers.
Elaeodendron glaucum	*Raj jehula*	Celastraceae	Decoction of stem bark for genito-urinal diseases.
Entada pursaetha	*Gilaphal*	Fabaceae	Water vapour of boiled cotyledons relieve watering eyes.
Erycibe paniculata	*Kani*	Convolvulaceae	Infusion of herb in gum pain.
Flemingia macrophylla		Fabaceae	Juice of whole plants for stomach troubles.
Gardenia gummifera	*Khurdu*	Rubiaceae	Gum in constipation.
Helicteres isora	*Atmura*	Sterculiaceae	Fruit decoction in fever, cough and cold.
Hemidesmus indicus	*Chimura*	Asclepiadaceae	Root paste in stomach pain.
Holoptelia integrifolia	*Chorla*	Ulmaceae	Stem bark with water to treat ringworm and scabies.
Hymenodictyon excelsum	*Bhurkunda*	Rubiaceae	Paste of stem bark in menstrual disorders.

Botanical name	Local name	Family	Uses
Ichnocarpus frutescens	*Phir-Phira*	Apocynaceae	Infusion of herbs to check vomiting.
Morinda tinctoria	*Achchu*	Rubiaceae	Powdered root is used to heal discharge ulcers.
Phyllanthus emblica	*Amla*	Euphorbiaceae	Fruits in promoting salivary secretion.
Plumbago rosea	*Lalchandua*	Plumbaginaceae	Stem latex for curing headache. Root paste for rheumatism.
Rauvolfia serpentina	*Patal garura*	Apocynaceae	Root paste for snake bite and also for curing nervous disorder.
Pterocarpus marsupium	*Pit-sal, Bijasal*	Fabaceae	Gum resin mixed with sugar and water for cooling purpose.
Schleichera oleosa	*Kusum*	Sapindaceae	Seed oil in curing medicine.
Schrebera swietenioides	*Aksia*	Oleaceae	Fruit in treatment of aksir (Hydrocoel).
Smilax perfoliata	*Ramdatun'*	Smilacaceae	Root powder with rice powder cures blood discharge in urine and also in gum pain.
Soymida febrifuga	*Sawam*	Meliaceae	Stem bark decoction in fever.
Strychnos potatorum	*Korhaka*	Loganiaceae	Powder of seeds as raw for sedative effect.
Terminalia bellerica	*Bahera*	Combretaceae	Fruit juice in stomach pain.
Terminalia chebula	*Harr*	Combretaceae	Fruit powder for gastric disorder.
Ventilago calyculata	*Piskogacha*	Rhamnaceae	Flowers juice in ear pain.
Wendlandia tinctoria	*Banabasanga*	Rubiaceae	Paste from bark used externally on the body to relieve the cramps of ulcers.

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A view of dry deciduous forests.

Cochlospermum religiosum

Sesbania sesban

Crotalaria spectabilis - medicinal.

SUNDARBANS BIOSPHERE RESERVE

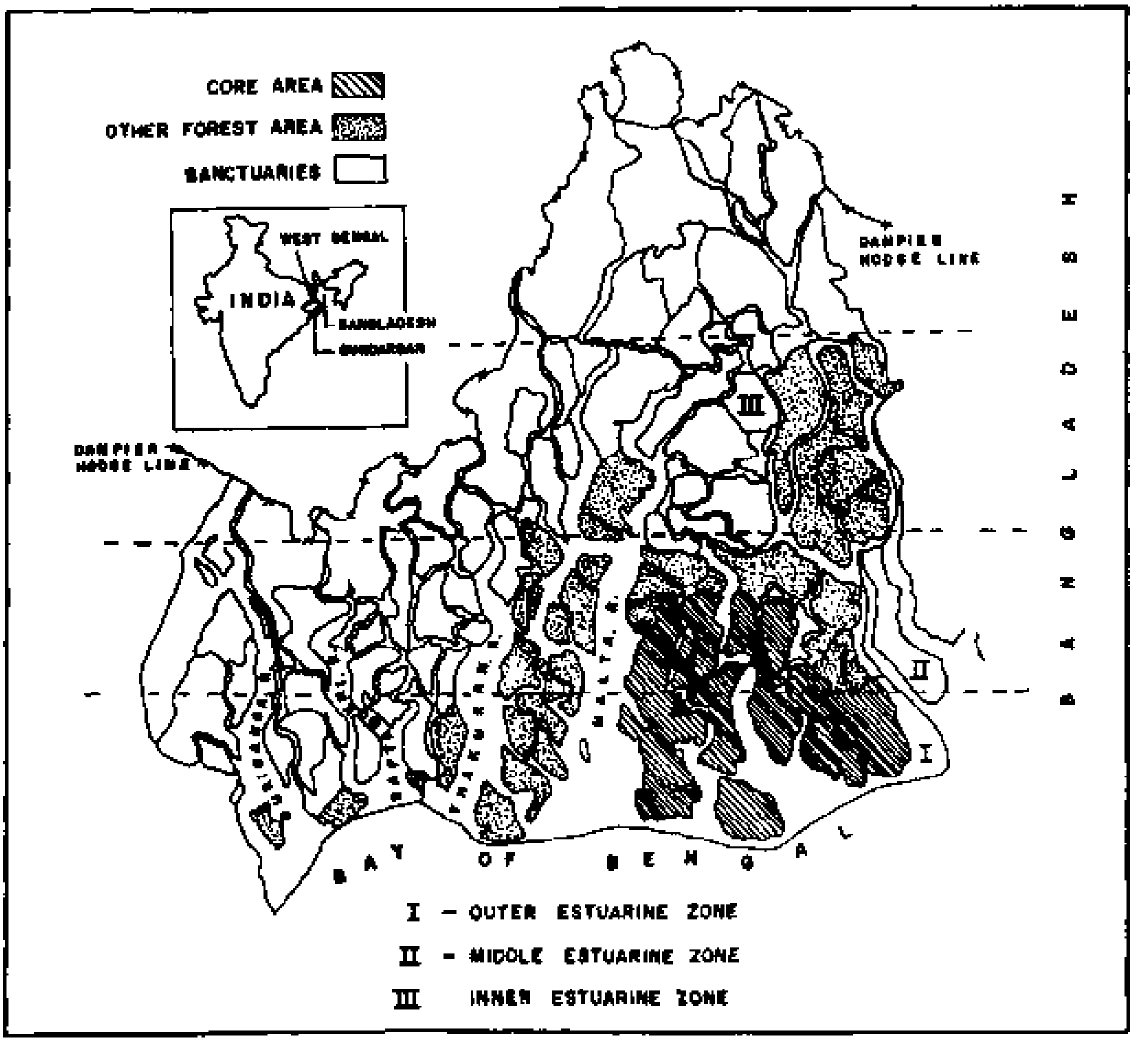
L.K. Banerjee

The Sundarbans Biosphere Reserve covering an area of 9630 sq. km in the delta of great rivers, the Ganges and Brahmaputra, lies between 21°32′ to 22°40′ N latitude and 88°05′ to 89°00′ E longitude in district 24-Parganas of West Bengal state. It was established on 29th March, 1989 as a part of the National Man and Biosphere Reserve Programme, to conserve the unique biodiversity of the area. Out of total geographical area, an area of 4264 sq. km forms the Reserved forest area and the rest is the reclaimed area for human habitation. The Reserved forests consist of many protected zones namely National Park in Tiger Reserve, Wildlife Sanctuaries at Sajnekhali, Holiday island and Lothian island.

It is a remarkable sheltered part of India's wet coastal ecosystem of the tropics. Biosphere comprises of core zone (1700 sq. km), manipulation zone (2400 sq. km), restoration zone (230 sq. km) and development zone (5300 sq. km). The major portion of the Sundarbans Tiger Reserve is situated within the core zone and mangrove forests occupy about 4330 sq. km area of these core, manipulation and restoration zones. This area is surrounded by 8 major rivers connected each other with the help of various tributaries, innumerable criss-cross canals, streams and creeks to form a composite network of large salt water low lying tidal swamp (Chaudhuri & Chaudhuri, 1994).

Indian and Bangladesh Sundarbans together comprise a continuous saline intertidal land with largest mangrove block in the world covering an area of 26,000 sq. km. The biosphere reserve is bounded by the Hooghly river to the west, the Bay of Bengal to the south, the Harinbhanga-Raimangal river along the boundary of Bangladesh to the east and the Dampier-Hodge line to the north. [Map]

This deltaic ecosystem is the single largest continuous area in the world for threatened Royal Bengal Tiger and third largest mangrove formation after Indonesia and Australia. It is well known for its greater degree of specialization in structure, function and organisation and is one of the most backward region of the state of West Bengal. Here more than 50% of the inhabitants live much below the poverty line and their lives depend on the biodiversity resources of the biosphere reserve. This region is covered with dense growth of mangrove forests, unstable substrate and saline tidewater flow. The surface water salinity, greater depth of ground water and premature soil make the condition unstable for any major agriculture. On the other hand this region commands highest importance by virtue of its biological productivities and specialized adaptive biodiversities. Major fringed inhabitants of this biosphere reserve are fully dependent on its biological resources directly or indirectly for fuel, charcoal, timber, thatching, boat building and house materials, fish, tiger prawn seeds, honey, crabs, and various others natural resources for balancing their economic conditions (Banerjee, 1964).



Map: Sundarbans Biosphere Reserve

Topography

It is one of the world's largest deltaic complexes formed by the sediments deposited by the great rivers, Ganges and Brahmaputra. The areas are of recent origin and the alluvial plain of lower Bengal raised 6-9 m above the mean sea level. The biosphere reserve is associated with various habitats such as estuaries, swamps, tidalflats, interidal creeks, coastal dunes, back dunes, islands, agricultural lands and forest areas. About 35% of the area is covered by water flow and 65% with islands. Due to abundance of river sediments mainly carried from the Himalayan regions, the area is surrounded by 104 islands and some of these islands are under the active geomorphological process of regular accretions and depositions. Biosphere reserve can be divided into 6 main locality types depending upon the characteristics of different deltaic heads and influence of sweet water flow (Naskar & Guhabakshi, 1987).

1. **Sagar-Mahisani-Ghoramara sand head group of islands:** These islands covering a total area of *ca* 90 sq. km are formed at the estuarine mouth of the river Hooghly. They are recent one, contain sandy upper strata and influenced by the sweet water flow of the river Hooghly. Salinity of the soil in these islands is reduced by leaching. Recently due to release of Farakka barrage water, some changes in salinity of Hooghly river water and impact on the surrounding islands need proper investigation. Natural regeneration of fresh water loving species and rabi production of water-melon and chili are famous (Curtis, 1933).

2. **Area between Mahisani island and the river Thakuran:** This 900 sq. km area is the second deltaic lobe and due to lack of sweet water flow it forms a typical sheltered part of the delta. Due to presence of more zooplankton and phytoplankton these regions are used for breeding and haching of tiger prawns, crocodile farm and Wildlife Sanctuary at Lothion island.

3. **Area between the river Thakuran and the Matla:** This 1600 sq. km area is the 3rd deltaic lobe of the Gangetic delta and is totally detached from any upstream flow. The area is mostly influenced by the back water flow. This part is covered with mangroves and palm swamps.

4. **Area lying between the river Matla on the west and the river Harinbhanga on the east:** This is the core zone of Sundarbans Tiger Reserve. The biosphere reserve is bounded by the river Netidhopani and Gosaba on the north and Bay of Bengal on the south. This 1692 sq. km area is influenced by both salt and fresh water flow and is

recognized as an ideal site for the growth of mangroves and Tiger habitats. The area is more or less free from interference.

5. **Northern part of the core area of Sundarbans Biosphere Reserve surrounded by the river Ichhamati (Buffer zone of Tiger Reserve):** This 893 sq. km area is the buffer zone of Sundarbans Biosphere Reserve and manipulated for conservation and sustainable development of forest area. Southern part of these areas receives sweet water flow from the river Ichhamati (Banerjee, 1998).

6. **Extreme northern area lying to the east of the river Matla:** The easterly flowing effect of the river Ganges through tributaries of Padma influence the area in an ideal agricultural manipulated region. Due to the influence of sweet waterflow from the river Ichhamati this 4455 sq. km area is more advance in agriculture, aquaculture and agroforestry.

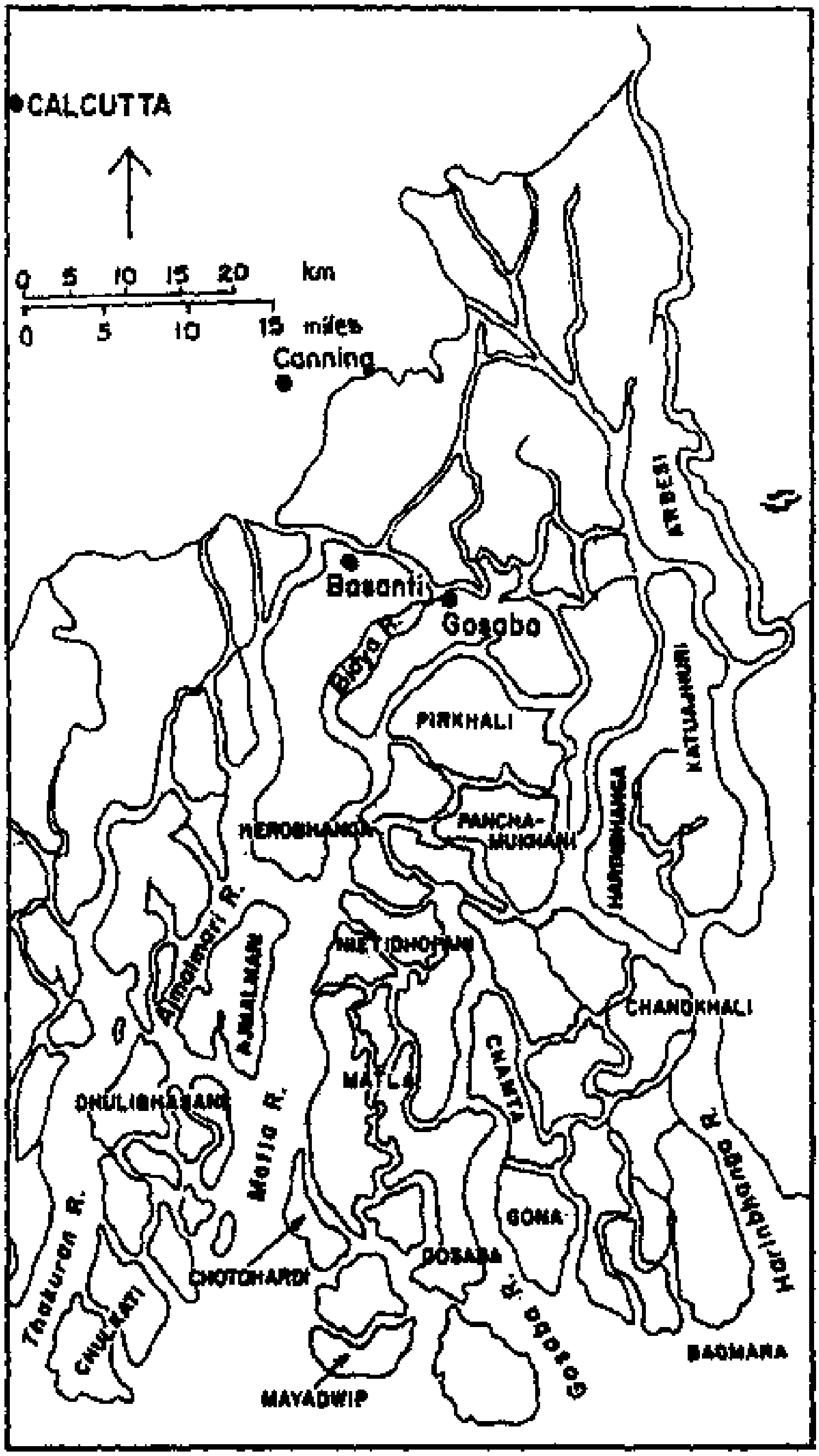
Geology

The Bengal basin is tilted eastward during the 12th century because of neotectonic movement. The raising of the western part of the river Ganges forms the area which today comprises the Indian Sundarbans. This may be the cause of reduction of fresh water flow into the western part of the delta and more accretion at the river mouth and increased saline water into the western part (Sanyal, *et al.,* 1984). Geologically, the frequent subsidence of some part of the Sundarbans, causes the complete disappearance of forest land. As a result settlement areas known as 'swatch of no ground', are very common in the biosphere reserve. Due to interaction of eastward and westward currents in the Sundarbans, the silt carried by the river may not be able to settle in one place and it may be diverted further south or east causing formation of new islands (Banerjee, 1964).

Geomorphology

The important geomorphic units in the Sundarban delta may be mentioned as -

1. Distributary channels with sub aqueous levees and tidal flow.
2. Marginal marshy areas above the mean tidal level.
3. Tidal sandbars and islands with tidal channels.



FOREST BLOCKS OF THE INDIAN SUNDARBANS

4. Distal bars and pro-deltaic clays and silts.
5. Coastal processes where a coastal tract varies during pre and post monsoon periods.

Geomorphic features of Hooghly-Matla estuarine complex are tide dominated, funnel-shaped deltaic head, where sand bars of the islands lie more or less perpendicular to the shoreline and parallel to the direction of tidal flow. From the month of February the sea levels start rising at the mouth of the rivers and reach maximum during September and again fall during the winter months (Mukherjee & Mukherjee, 1978). This phenomenon is mostly due to the change in wind velocity from the Bay of Bengal. There are some tidal islands on which the tidal channels are often sinuous in shape. Due to this shape these tidal islands are active sites of erosion (Chapman, 1976).

The movement of the foreshore sands to the backshore regions creates characteristics sand dunes. The stability of the dunes depends upon wind velocity and association of plants species for protecting the upliftment of the sand grains.

Climate

The area experiences a humid tropical climate with pronounced hot and wet seasons. Rainy season extends from June to September with annual rainfall ranging from 2500-3000 mm. The area is subjected to cyclones during the months of October and November. Maximum temperature ranges from 25°C - 35°C and minimum from 12°C 24°C. Tidal level varies from 4-6.5 m depending upon seasons. pH ranges from 7.2-7.9.

Due to low pressure in Bay of Bengal from the month of May to October, these areas are frequently effected by large cyclones and storms. The history reveals that during 1582, about 2 laks people died with destruction of their valuable property. In the year 1688, about 60,000 people were effected due to cyclone in the Sagar island. During 1737 both the earthquake and cyclone effected the entire Sundarbans area. At that time water level in the river Ganges raised up to 13 m high. During 1833, again the Sagar island was effected and about 10,000 people died. During 1876, the eastern part of the Sundarbans was severely damaged and vegetation was completely destroyed. Such types of environmental hazards are of frequent occurrence even in recent times in this region.

River system

Most of the rivers, which generally flow from the north to south, are influenced by tides from the Bay of Bengal. The channels connecting these rivers generally flow east or west. Innumerable silt laden rivers, rivulets and creeks cover the entire area and have various grades of currents flowing through water.

The main estuaries from west to east are Hooghly (Hugli), Saptamukhi, Thakuran, Matla, Bidya, Ajmalmari, Bidyadhari, Gosaba, Kalindi and Raimangal. These rivers, apart from the Hooghly, have no connections with the head water channel of the upland river system.

Hooghly: The Hooghly river flows from the western border of Sundarbans in south 24-Parganas district. The Hooghly is the main river of West Bengal and along with rivers, the Ganges and Bhagirathi it forms a national waterway.

Muriganga: It is a branch of the Hooghly river and flows along the east of Sagar island.

Saptamukhi: This river originates near Sultanpur and joins Muriganga (Bartala), a branch of the Hooghly river.

Thakuran: This river begins near Jaynagar in South 24-Parganas and has a number of connections with the Saptamukhi. It was perhaps earlier connected with the Calcutta canal through the Kultali and the Piali rivers, which exist today in a dying condition.

Matla: This river begins at the confluence of three rivers, these being the Bidyadhari, the Khuraty and the Rampura Khal, close to the town of Canning in South 24-Parganas. It was once considered the largest and deepest river of the area and was navigable through out the year by ocean going vessels. Canning was an important part connected with the Calcutta canal through the rivers Piali, Bidyadhari and Rampuara Khal. The Matla is today connected with the Bidya and flows to the sea. There is no fresh water flow in the river and it is now famous for high tidal webs and water salinity.

Bidyadhari: This was a flourishing branch of the Bhagirathi, but now serves only as a sewage and excess rain water outlet from the city of Calcutta. The riverbed is completely silted and its connection with the Bhagirathi has been inactive. The river remained active till the end of the 15^{th} century or early 16^{th} century.

Gosaba: It is formed by waters of Matla and Harinbhangha (Raimangal) through a large number of canals and flows through the reserve forests.

Harinbhanga: This river begins from Sahebkhali in North 24-parganas and is connected with Rampura Khal by Bara kalanchi river and with Gosaba river through the river Terobanki. The Harinbhanga (also known as Ichhamati and Raimangal) forms a natural demarcation between the border of India and Bangladesh.

The rivers flowing within the Sundarbans Project Tiger area may be divided into outer, middle and inner estuaries. The estuaries in Mayadwip and Gona blocks were classified as outer estuaries and those of Pirkhali and Jilla blocks as inner estuaries. It was found that salinity of the river water varies seasonally as well as with the distance from the sea. As a result, salinity was highest in the outer estuaries than in the inner ones. Insignificant variations in salinity with in the outer and middle estuaries were also recorded although a significant variation was found to exist in the inner estuaries.

Soil

The deltaic soil of Sundarbans Biosphere Reserve comprises mainly with saline alluvial soil consisting of clay, silt, fine sand, and coarse sand particles. It falls under the category of saline coastal soil types.

Along the outer estuarine regions of the biosphere reserve the soil consists of more sand particles than the clay and silt. In the middle and inner estuarine parts the particles of the silt and clay are more dominated than the sand. Some of the islands like Prenties and Lothian are mostly dominated by 40-65% silt particles and on the other hand the islands like Harinbari and Sagar are covered with 20-40% sand particles. Besides the sand, silt and clay particles, the soil also contains small percentage of nitrogen, phosphate, calcium-oxide and carbon. In general, the inner estuarine parts towards the region of more fresh water flow, the oxygen content of the soil is found very low. The soil of the mangrove forests within the biosphere reserve shows different characteristics in structure, organic matter and soil particle contents. In the Netidhopani block within the depth of 15-30 cm, it shows 28% sand, 35% silt, 37% clay and 0.71% organic matter. In the area of Nawabanki-Gosaba with in the same depth the soil contents show 32% sand, 31% silt, 37% clay and 0.78% organic matter. Along the Matla region within the same depth the soil contents show 16% sand, 35% silt, 49% clay and 0.90% organic matter. It shows that towards the outer estuarine region percentage of sand is higher and towards the middle and inner regions the percentage of silt and clay is more (Banerjee, 1987).

The salinity of soil and water is a very important monitoring factor for distribution pattern of different plant species as well as the soil types. The salinity of the soil and water depends on the tidal flow, rainfall, elevation of land, proximity of the area from the sea and the fresh water inflow etc. However, it changes seasonally and becomes lower during the monsoon and higher during winter. The soil analysis data are presented below (Table I).

Table I
Soil analysis data

Areas	Particle size distribution (depth 30 cm)						
Sundarban delta	Clay %	Silt %	Fine sand %	Coarse sand % (1:25)	pH	Organic matter %	EC ds m^{-1}
Outer estuaries	24.5	48.5	18	9	7.8	0.79	38.4
Inner estuaries (Creeks & Canals)	46.5	23.5	20	10	8.02	1.04	33.5
Hinter land	23.5	12.5	33.5	30.5	8.01	1.50	22.8

The data represent average value of ten (10) samples from each type.

Tidal range and water salinity

The tidal level of biosphere reserve varies from the estuarine mouth towards the inland areas subjected to wide range of seasonal variation.

Maximum tidal height observed from the tide datum is 6.2 m towards the river mouth and 3.5 m towards the inland areas during October and November. Minimum tidal level is 3.5 m and 1.8 m during May and June.

Variation of water salinity of the river Ganges depends upon the amount of fresh water flow, tidal amplitude and amount of rainfall. It decreases from the river mouth towards the inland areas. Seasonal salinity ranges at a depth of 30 cm indicates that maximum salinity is 41.1 EC (ds m^{-1}) at the river mouth during October and November which decreases gradually to 21.7 EC (ds m^{-1}) towards the inner tidal creeks. These details are shown in table II.

Table II
Analysis of river water salinity and tidal levels of the Sundarban delta

Areas	Salinity EC (ds m^{-1}) Depth 30 cm				Tidal level from tide datum meter			
Sundarban delta	Jan.- Mar.	Apr.- Jun.	Jul.- Sep.	Oct.- Dec.	Jan.- Mar.	Apr.- Jun.	Jul.- Sep.	Oct.- Dec.
Outer estuaries	32.5	34.4	38.8	41.1	3.5	4.5	5.9	6.2
Inner estuaries	17.6	18.3	21.2	29.5	3.1	3.8	4.1	5.9
Hinter- land area	12.2	13.2	14.5	21.7	1.8	2.9	3.1	3.5

SPECIAL FEATURES

The Sundarbans Biosphere Reserve falls under a dynamic deltaic ecosystem, which is not only fragile but ecologically very sensitive. It is a representative of an area and very rich in the diversity of mangrove flora and fauna within the Asian Provinces where environmental gradation limits are significantly stressed. The large mangrove forests have been conserved with their wilderness under the protective shelter of Project Tiger. Almost all the mangrove species in India except one or two are found in a single forest area. It is also a home of many endangered and threatened species of animals.

This biosphere reserve is one of the most unique and wonderful in the country where during high tide 70% of the land area is impregnated with vary high degree of salinity, continuous deposition of silt and substances. Here biotic diversity is enormous and attractive. Vegetation represents a serial type depending on the variation in salinity, tidal flow and soil morphology. Plant species are unique and adapted to withstand high salinity of river water, great velocity of tidal waves and less aeration in the sticky, muddy soils. Majority of the plant species dominated over the regions produce stilt roots, salt glands, vivipary and pneumatophores in order to maintain a remarkable balance for their survival in this specialized environmental conditions. The estuarine complexes formed by several rivers in this system are highly productive due to intermixing of fresh water with the seawater. In this zone both marine and riverine microbial decomposers convert the mangrove litters into consumable protein which serves as a primary source of energy and subsequently enters into the food chains of invertebrates, fish, and ends up with the tigers and crocodiles. The biomass productivity in this ecosystem is very high and stands comparable to any other biosphere reserve in India. Some of the plants like *Avicennia, Sonneratia, Excoecaria, Derris, Acanthus, Myriostachya* and underground roots and bulbs of many other species are good fodder for deer, monkeys and wild boars. Besides, the mangrove forests play a vital role in the protection of soil from erosion, storms and cyclones as well as development of socio-econimic structure of the surrounding villages with the potentials of timbers, tannins, fodder, thatching materials, honey, fish, crabs, prawns and others. Therefore, the success of Sundarbans Biosphere Reserve depends on the existence of ecologically balanced ecosystem and careful protection and conservation of dependent herbivores, plants, wild animals and their entire habitat.

VEGETATION

The vegetation of Sundarbans Biosphere Reserve has already been presented in detail earlier (Banerjee, 1998). However, for ready reference it is again discussed breafly. The vegetation of Sundarbans can be divided into four major types as follows.

1. Mangrove formation

It covers about 75% of the tidal forest area. Innumerable ramifications of the river system and several islands of this saline intertidal land masses are the ideal sites for the growth of maximum number of mangrove species. Ecologically this region exhibits different habitat conditions within a short distance due to the impact of various gradation of water salinity, edaphic conditions, tidal level and elevation. Floristic diversity and richness of mangrove species tapers gradually from the Sundarbans and the Mahanadi delta to southwards along the east coast of Andhra Pradesh and Tamil Nadu and finally tapering downwardly to the west coast and Gujarat region.

This vegetation can be further divided into two major types and three-sub types depending on the influence of interacting ecological factors, tide, salinity, soil condition and elevation (Blasco, 1977; Banerjee, 1998).

a. Outer estuarine mangrove vegetation

Vegetation in this zone is dominated by *Avicennia marina* and it is associated with *Sonneratia griffithii*, *Bruguiera cylindrica*, *B. parviflora*, *Ceriops tagal*, and *Aegialitis rotundifolia*. Sometimes *Avicennia alba*, *Phoenix paludosa* and on the newly formed tidal flats, *Porteresia coarctata* grow gregariously. Presence of salt excretory glands in the leaves and petioles of *Avicennia marina* and water storage mechanism in the leaves of the species of *Sonneratia*, *Ceriops* and *Aegialitis* are the adaptive mechanism for withstanding high salinity conditions. All the above plants are found specially along the forest blocks of Chulkati, Chotohardi, Mayadwip, Baghmara and Gona.

b. Inner estuarine or riverine mangrove vegetation

Best development of mangroves occur in this formation and flora becomes rich and diversified due to sheltered situation and availability of more fresh water. It exhibits three distinct zones as follows:

i. True mangrove zone: This zone covers the lowermost part of the river system, just away from the estuarine mouth where tidal flats are associated with maximum number of creeks and channels. Here the salinity is lower than the river mouth but tidal velocity is higher as the flow enters into the creeks. Vegetation is mainly dominated by *Rhizophora apiculata*, *R. mucronata*, *Kandelia candel*, *Aegiceras corniculatum* along with common associates like *Excoecaria agallocha*, *Bruguiera gymnorrhiza*, *Xylocarpus granatum*, *X. mekongensis*, *Avicennia officinalis*, *A. alba*, *Ceriops decandra*, *Dalbergia spinosa* etc. *Phoenix paludosa*, *Finlaysonia obovata, Derris scandens, Tylophora tenuis, Sarcolobus globosus, Acanthus volubilis* and *Hoya parasitica* are found as common climbers. Most of the species in this typical mangrove formation are adapted by formation of stilt roots and vivipary for survival and easy regeneration. These plants are found in Dhuli Bhasini, Ajmalmari, Matla, Netidhopani, Chamta, Chandkhali, Durgaduani, Panchamukhani forest blocks.

ii. Semi or less pronounced mangrove zone: This zone covers the middle part of the riverine system which is slightly elevated from the former type and is associated with less number of tidal creeks. As this part is further away from the sea and more nearer to the fresh water source, the salinity is less and sticky, muddy conditions of the soils become very prominent. The dominant species in this zone are *Sonneratia apetala, Heritiera fomes, Nypa fruticans, Excoecaria agallocha* usually which occur in association with *Brownlowia tersa, Sonneratia caseolaris, Xylocarpus mekongensis, Bruguiera gymnorrhiza, Avicennia officinalis, Aglaia cucullata, Cerbera manghas, Intsia bijuga, Cynometra iripa* and *Phoenix paludosa.* The common shrubs, climbers, grasses and sedges in this formation are *Acanthus ilicifolius, Clerodendrum inerme, Caesalpinia bonduc, Sarcolobus carinatus. Derris trifoliata, Pentatropis capensis, Solanum trilobatum, Flagellaria indica, Myriostachya wightiana, Porteresia coarctata, Crinum asiaticum, Cyperus exaltatus, Fimbristylis ferruginea, Scirpus articulatus,* etc. Most of the tree species in this zone produce knee roots, pneumatophores, peg-like woody root suckers and buttresses to withstand the less aerated condition of the muddy soils and to support their massive boles. These adaptive features give a distinct stamp to the overlying topography, distinguishing this zone as less pronounced or semi mangrove formation from the previous zone. The above mentioned species are found in Harinbhanga, Pirkhali, Katuajhuri, Arbesi forest blocks.

iii. Transitional or hinterland mangrove zone: This zone is usually devoid of regular tidal flow and mostly dominated by species like *Clerodendrum inerme, Hibiscus tiliaceus, Avicennia officinalis, Derris scandens, Thespesia populnea, Pongamia pinnata, Acanthus ilicifolius* and *Acrostichum aureum*. Towards high limit these are found associated with fresh water elements like *Salvadora persica, Syzygium ruscifolium, Carissa spinarum, Ochna obtusata, Manilkara hexandra, Diospyros* *cordifolia, D. buxifolia, Trewia nudiflora, Kleinhovia hospita, Salacia chinensis, Barringtonia racemosa, Aristolochia indica*, etc. Most of the species in this zone do not show any adaptive features like stilt roots, pneumatophores and vivipary and they transit successfully towards non-saline zone. The plants are associated towards the most inner part of the islands and found in Basanti, Kaning, Gosaba, Mourjhapi, Sajnakhali forest blocks.

2. Coastal beach and sand dune vegetation

Some parts of Bakkhali, Jambu and Sagar islands have characteristic vegetation on coastal dunes and sandbars. Here species are very effective for sand binding. Commonly occurring species are *Ipomoea pes-caprae, Launaea sarmentosa, Aristolochia indica, Sesuvium portulacastrum, Saccharum spontaneum, Cyperus polystachyos, C. arenarius, Rothia trifoliata, Wedelia scandens* and *Canavalia cathartica*.

3. Salt marsh formation

Some areas within the mangrove zone become dried and slightly elevated along the margins due to deposition of sand and vegetation debris. Due to these microtopographic changes, the rate of outflow of saline tide waters from these flats decreases gradually and eventually comes to a halt along the sallower places. Accumulation of saline tide water high evaporation rate make these soils more saline than the adjacent mangrove swamps. Thus these flats suffer from regular balanced tidal inundation and remain physiologically dry with high concentration of salts. The common species in this formation are *Sesuvium portulacastrum, Heliotropium curassavicum, Suaeda nodiflora, S. maritima, S. monoica, Salicornia brachiata, Arthrocnemum indicum, Aleuropus logopoides, Trianthema portulacastrum, Scirpus littoralis, Tamarix troupii* and such other halophytes.

4. Non mangrove formation along open pasture, bunds, fresh water swamps around the buffer region

Some species of trees, shrubs and herbs are characteristically associated in these areas but occasionally they are found to withstand the salt water condition of the region. These species are also found in the fresh water regions of the lower Bengal areas outside the biosphere. The common species are *Salvadora persica, Syzygium ruscifolium, Carissa spinarum, Ochna obtusata, Diospyros buxifolia, Trewia nudiflora, Kleinhovia hospita,. Barringtonia racemosa, Aristolochia indica, Premna corymbosa, Tamarix troupii, Trianthema portulacastrum, T. triquetra, Tribulus terrestris, Tylophora fasciculata, Vigna luteola, Wedelia biflora*, etc. The common species of grasses and sedges found around the wetlands are, *Cyperus procerus, C. exaltatus, C. kyllingia, Typha angustata, Eragrostis tenella, Scirpus articulatus, Chrysopogon aciculatus, Arundo donax, Panicum repens, Paspalum scorbiculatum, Phragmites karka, Vetiveria zizanioides, Saccharum benghalense, Leersia hexandra* and *Cynodon dactylon*.

Some of the species which have been introduced to meet the requirements of fuel wood and fodder in this area are *Casuarina equisetifolia, Acacia nilotica, A. leucophloea, Parkinsonia aculeata, Polyalthia longifolia, Anacardium occidentale, Eucalyptus* spp., etc. (Naskar & Guhabakshi, 1982).

SPECIES DIVERSITY AND DISTRIBUTION OF MANGROVES IN SUNDARBANS AND INDIA

Through out the world mangroves are distributed in two groups such as new world group and old world group. The new world group includes North, Central and South America and West Africa. This group is dominated by only ten mangrove species which are not even found in the old world group. The old world group consists of 3-subgroups viz., Persian-Gulf-Madagascar, Indo-Malaysian and Australian groups. Indo-Malaysian group represents mangroves of Pakistan, Bangladesh, India, Myanmar, Indonesia, North Australia, Celebes and Papua New Guinea. This group is dominated by 65 mangrove species which are also not found in the new world group. As far as distribution of mangrove forest areas in India is concerned, it is interesting to note that out of total 6,740 sq. km area of mangrove forests in India, Sundarbans alone covers 4200 sq. km area of mangrove forests. The remaining area is distributed among Andaman and Nicobar group of islands, Mahanadi deltaic area of Orissa coast, Coringa-Godavari and Krishna delta of Andhra Pradesh, etc. as presented below (Table III).

Table III
Mangrove forest areas in India

Name of States/UT	Mangrove areas	Area in sq. km
Andaman & Nicobar Islands		1,190
West Bengal	Sundarbans (South 24 Parganas)	4,200
Orissa	Mahanadi delta, Bhitarkanika and Manipura estuary	215
Andhra Pradesh	Coringa, Godavari and Krishna estuarine delta	251
Tamil Nadu	Pichavaram, Tanjore	150
Gujarat	Narmada, Tapi estuaries, Gulf of Cambay, Sourashtra and Kutch	260
Maharashtra	Bombay, Ratnagiri, Malvan, Devgad and Vijayadurg	330
Goa	Mandovi-Zuari estuary	38
Karnataka	Kalindi, Coondapur, Harnover, Malpac	90
Kerala	Cochin, Vembanad, Quilon, Trivandrum, Cannanore, Kozikode, Kottayam	16
Total mangrove areas in India		**6,740**

Though species diversity in the mangrove ecosystem is usually low due to dominance of large physical forces of saline tide water and lack of stable substrate but this ecosystem commands the highest importance by virtue of its biological productivity, complexity in ecological processes and finally the importance of biodiversity resources. Major mangrove forest areas as shown in table III are represented by 65 number of species belonging to 31 families, 59 genera and 2 varieties. Out of 65 species, Sundarbans Biosphere represents 62 number of species belonging to 40 genera and 25 families. The Godavari-Krishna delta represents 32 species belonging to 28 genera and 16 families. Other west coastal mangroves represent 33 species, 24 genera and 19 families. The islands of Andaman & Nicobar represent 43 species, 30 genera and 23 families.

Along with mangroves, about 13 species of salt marshes belonging to 8 genera and 5 families are also found distributed all over the Indian mainland mangrove forests, but not a single species is recorded from

Andaman & Nicobar islands. On the other hand about 7 species of orchids and 2 species of Asclepiadaceous climbers are restricted only in the Andaman & Nicobar mangrove forest areas. These details are presented in the table IV.

Table IV
Species diversity and distribution of mangroves, salt marshes and orchids

Botanical name	East coast				West	Andaman
	Sundarban delta	Mahanadi delta	Krishna delta	Godavari delta	coast	& Nicobar Is.
Acanthus ebracteatus						+
Acanthus ilicifolius	+	+	+	+	+	+
Acanthus volubilis	+					+
Acrostichum aureum	+	+			+	+
Acrostichum speciosum						+
Aegialitis rotundifolia	+	+	+			
Aegiceras corniculatum	+	+	+		+	+
Aglaia cucullata	+	+				
Avicennia alba	+	+	+	+	+	+
Avicennia marina						
Avicennia marina var. *acutissima*	+	+			+	
Avicennia officinalis	+	+	+	+	+	+
Amoora cucullata	+	+	+	+	+	+
Brownlowia tersa	+	+				
Bruguiera cylindrica	+	+	+	+	+	+
Bruguiera gymnorrhiza	+	+	+	+	+	+
Bruguiera parviflora	+	+				+
Bruguiera sexangula	+	+				
Caesalpinia bonduc	+	+	+	+	+	+
Caesalpinia crista	+	+	+	+	+	
Cerbera manghas	+	+			+	+
Ceriops decandra	+	+	+	+	+	
Ceriops tagal	+	+			+	+
Clerodendrum inerme	+	+	+	+	+	+
Cynometra iripa	+	+				+
Dalbergia spinosa	+	+	+	+		
Derris scandens	+	+	+	+	+	+
D. heterophylla	+	+	+		+	+
Dolichandrone spathacea	+	+	+	+	+	+

Botanical name	East coast				West	Andaman
	Sundarban delta	Mahanadi delta	Krishna delta	Godavari delta	coast	& Nicobar Is.
Excoecaria agallocha	+	+	+	+	+	+
Fimbristylis ferruginea	+	+	+	+	+	+
Finlaysonia obovata	+	+				+
Heritiera fomes	+	+				
H. littoralis		+			+	+
H. kanikensis		+				
Hibiscus tiliaceus	+	+	+	+	+	+
Hoya parasitica	+	+	+	+		+
Intsia bijuga	+	+				+
Ipomoea tuba	+	+	+	+	+	
Kandelia candel	+	+			+	
Lumnitzera littorea						
Lumnitzera racemosa	+	+	+	+	+	+
Merope angulata	+	+				
Mucuna gigantea	+	+			+	+
Myriostachya wightiana	+	+	+	+		+
Nypa fruticans	+					+
Phoenix paludosa	+	+				+
Porteresia coarctata	+	+	+	+	+	
Rhizophora apiculata	+	+	+	+	+	+
Rhizophora mucronata	+	+	+	+	+	+
Rhizophora stylosa		+				
Sarcolobus carinatus	+	+	+	+		
Sarcolobus globosus	+	+	+	+		+
Scirpus littoralis	+	+	+	+		
Scyphiphora hydrophyllacea						+
Salvadora persica	+	+	+	+	+	
Sonneratia alba		+			+	
Sonneratia apetala	+	+	+	+		
Sonneratia caseolaris	+	+			+	+
Sonneratia griffithii	+	+				+
Thespesia populnea	+	+	+	+	+	+
Thespesia populneoides	+	+				
Tylophora tenuis	+	+				
Xylocarpus granatum	+	+				+
Xylocarpus mekongensis	+	+				+
Xylocarpus moluccensis						+

Members of Asclepiadaceae and Orchidaceae in Andaman & Nicobar mangroves

Botanical name	East coast				West	Andaman
	Sundarban delta	Mahanadi delta	Krishna delta	Godavari delta	coast	& Nicobar Is.
Dischidia benghalensis				-		+
Dischidia nummularia						+
Cymbidium madidum var. *lerovi*						+
Dendrobium cruentum						+
Dendrobium teretifolium var. *fasciculatum*						+
Dendrobium discolor						+
Dendrobium granatum						+
Eria pudica						+
Pholidota imbricata						+

Salt marshes/halophytes along the degraded part or blanks/salt pans in mangrove forests

Botanical name	East coast				West	Andaman
	Sundarban delta	Mahanadi delta	Krishna delta	Godavari delta	coast	& Nicobar Is.
Aeluropus lagopoides	+	+	+	+	+	
Arthrocnemum indicum	+	+	-		+	
Cressa cretica	+	+			+	
Heliotropium curassavicum	+	+	+	+	+	
Salicornia brachiata	+	+	+	+	+	
Sesuvium portulacastrum	+	+	+	+	+	-
Suaeda fruticosa	-	-	+	+	+	
S. maritima	+	+	+	+	+	-
S. monoica	+	+	+	+	+	-
S. nudiflora	+	+	+	+	+	-
Tamarix troupii	+	+	-	+	+	-

Non Mangroves

Besides the mangrove and salt marshes, there are some non mangrove species which are found along the development zone of the Sundarbans Biosphere Reserve, mostly in the paddy fields, thickets, hedges, road side bushes, river banks, river slopes, and open coast line areas of the deltas. The association of these species is commonly found even besides the demarcation line of the biosphere reserve. These comprise total 84 species, distributed in 46 and 30 species of herbs and shrubs respectively in 38 families. Some common non mangrove species are *Abutilon graveolens*, *Acacia intsia*, *Alpinia allughas*, *Ammannia salicifolia*, *Asplenium falcatum*, *Barringtonia acutangula*, *B. racemosa*, *Calotropis gigantea*, *Capparis sepiaria*, *Cassytha filiformis*, *Conyza semipinnatifida*, *Crateva roxburghii*, *Cyperus imbricatus*, *C. malaccensis*, *Dalbergia candenatensis*, *Dendrobium umbellatum*, *Dischidia nummularia*, *Eleocharis spiralis*, *Eragrostis diarrhena*, *E. unioloides*, *Fimbristylis complanata*, *F. polytrichoides*, *Flacourtia indica*, *Gnaphalium indicum*, *Hemidesmus indicus*, *Hibiscus tetraphyllus*, *Hydrophila phlomoides*, *Launaea aspleniifolia*, *L. sarmentosa*, *Luisia brachystachys*, *Merremia gangetica*, *Merremia hederacea*, *Morinda bracteata*, *Murdannia nudiflora*, *Opuntia dillenii*, *Oberonia gammiei*, *Pandanus tectorius*, *Parkinsonia aculeata*, *Paspalum distichum*, *Pentatropis capensis*, *Polycarpaea corymbosa*, *Pseudoraphis brunoniana*, *Premna corymbosa*, *P. mucronata*, *Prosopis chilensis*, *Pulicaria crispa*, *Saccolabium ochraceum*, *Salacia chinensis*, *Sarcanthus inscetifer*, *Scirpus littoralis*, *Seseli diffusum*, *S. trilobatum*, *Spinifex littoreus*, *Sporobolus tremulus*, *Stictocardia tiliifolia*, *Teramnus flexilis*, *Trewia nudiflora*, *Trianthema portulacastrum*, *Tribulus terrestis*, *Tylophora fasciculata*, *Vicoa vestita*, *Viscum monoicum*, *Wedelia biflora*, *Xeromphis spinosa*, *Zoysia matrella*, etc.

THREATENED PLANTS

The gradual disappearance of species collected previously from an area indicates the state of change in the ecosystem. The extinction of species within a specified area is usually due to biotic factors. The main causative factor is the anthropogenic action of urbanisation of habitats. Mangroves like *Acanthus*, *Aegiceras*, *Bruguiera*, *Carallia*, *Ceriops*, *Excoecaria*, *Heritiera*, *Kandelia*, *Lumnitzera*, *Nypa*, *Sonneratia*, *Rhizophora*, *Xylocarpus*, etc. are gregarious in growth with low speciation rate, the measure of loss of such species can not be ruled out.

However, several species are established as a part of the ecosystem in the tidal forests and their presence or absence give an indication of the magnitude of ecological disturbances.

The most visible casualty is the poor occurrence of orchids in the mangrove forests. A list of orchids which are considered rare from the collections housed at Central National Herbarium (CAL) is given below

i. *Acampe rigida* : Eastern Himalaya and Tenasserim. Reported from Sundarbans (Prain, 1903) and no new collections are available.

ii. *Dendrobium anceps* : A botanically interesting plant occurs in gangetic delta, Sikkim and Assam Himalaya. After Heining's collection (Heining -13) from Sundarbans, no new collections are available.

iii. *Luisia brachystachys* : It is an interesting ornamental species of lower Himalayan range. Once reported from Sundarbans (Prain 1903), no recent collections are available.

iv. *Oberonia gammiei* : A small epiphytic orchid was reported earlier from Sundarbans (Prain 1903), but no new collections are available.

v. *Saccolabium ochraceum* : A tropical eastern Himalayan epiphytic orchid was reported from Peninsular India and Sundarbans (Prain 1903). No new collections are available.

vi. *Sarcanthus insectifer* : An interesting scandent epiphytic orchid of Bihar, Assam and Cachar, was reported from Sundarbans (Prain, 1903), but no recent collections are available.

vii. *Trias oblonga* : An epiphytic Myanmar orchid was reported from Sundarbans, but no specimens are available at CAL.

ENDANGERED SPECIES

Sundarbans Biosphere reserve falls under the category of ecologically sensitive zone and a fragile ecosystem where the habitat itself is very vulnerable. Therefore, it would be advisable if all the plants growing in this ecosystem are considered as rare and threatened. The information available in the literature and the studies carried out by various workers in the field indicate that the following plant species may be considered as endangered in this belt.

Amoora cucullata Due to environmental change and alteration of habitats.

Cynometra iripa - Due to change of environmental conditions.

Heritiera fomes - due to change of environmental conditions and biotic pressure.

Intsia bijuga - Due to over exploitation for its highly valuable furniture wood.

Kandelia candel Due to change of environmental factors.

Merope angulata Due to environmental change and alteration of habitats.

Rhizophora apiculata - Due to change of habitat and biotic pressure.

Sarcolobus carinatus - Due to its effective medicinal properties.

Sonneratia griffithii - Due to over exploitation and change of habitat.

ENDEMIC TAXA

The geographical distribution of the global mangroves shows that the mangroves are distributed in to new world group and old world group. The new world group belongs to the North, Central and South America as well as West Africa and have some characteristic species such as *Rhizophora mangle, R. racemosa, R. harrisonii, Conocarpus erecta, Langauncularia racemosa, Avicennia germinans, A. schaueriana, A. africana, Pelliciera* and *Osbornia* spp. These 10 species are seen completely restricted in distribution with in the new world region and none of these species are found in the old world group. Within the old world group, distribution of mangroves originates from Persian Gulf Madagascar region, Indo-Malaysian region and Australian region. This Indo-Malaysian group includes mangroves of Pakistan, Bangladesh, India, Myanmar, Malaysia, Indonesia, N. Australia, Celebes and Papua New Guinea.

The endemism in this tidal forest region of Indian subgroup is very low. It is observed that the species like *Sonneratia apetala, Heritiera fomes* and *Phoenix paludosa* are the main endemic species in the

Sundarbans Biosphere Reserve. Their distribution towards the other mangrove region of India is very much restricted.

SOCIO-ECONOMIC STRUCTURE

Though the deltaic intertidal regions are very rich in biodiversity resources but inhabitants of the area are very poor. Even though the physical environment, water salinity and substrate are the main problems for development but the area is so productive that it can generate high production of sustainable biological resources if properly managed. About 25 lakh people are dependent on the biosphere reserve but the reclaimed lands for agriculture are single croplands as irrigation is not possible due to salt water and very low depth of sweet water sources. Thus, majority of the people have to depend on aquaculture, fishing, honey collection, wood cutting and daily labours. They live much below the poverty line. Recent collection of post-larval Tiger prawn seeds has provided them some better economic conditions. Nearly 95% of total population depends on agriculture while remaining 5% of the engaged in fisheries, forestry and handicrafts.

POTENTIALITY

The values of mangrove resources have been well established both from the direct product and the amenities provided by the resources. Mangroves are used as potential resources for fuel, wood, charcoal, timber, particle board, house and boat building materials, synthetic fibres, viscous rayon, dyes, tannin, sugar, alcohol, condiments, adhesive, medicines, incense, paper and pulp, packing boxes, thatching materials, match sticks, etc. Amenities provided by the mangrove resources which cannot be measured in terms of monetary values are of various types for protection and conservation of natural ecosystem. They serve as natural protective barrier with self-repairable capacity against high winds and cyclones and protect vegetation and properties. The mangrove stilt roots and trunks substantially lower the tidal currents and cause deposition of suspended sedimentary materials, while ramifying roots also help in stabilizing the substrate. Wide uses of mangrove seeds have been recorded from various parts of the world. They are used for recovering from various diseases such as blood impurities, boils, rheumatism, ulcers, tumours, diarrhoea, leprosy and many others. They also contain high protein contents and yield illuminating, medicinal and hair oils. Some toxic substances are usually associated with the carbohydrate, proteins and oils of many mangrove seeds. These toxic constituents may be used as drugs, insecticides and nematicides.

Potentiality of the biosphere reserve depends on the sustainable use of biological resources by the people for their livelihood.

Source of thatching materials

The main source of thatching materials was the leaves of *Nypa fruticans* (Golpata) which may lost for more than 10 years due to waxy coating but in the present Sundarbans its growth has been restricted in one or two pockets. Besides *Nypa*, straw form paddy, *Porteresia coarctata* (wild paddy) and *Myriostachya wightiana* (wild grass) are also used for thatching purposes.

Source of fuel

Generally mangrove trees and shrubs have much weight with high calorific values. A ton of mangrove firewood is approximately equivalent to 2-5 tons of Indian coal. It burns with a oven heat and is alsò clean; does not create much smoke and ignites easily when partially dry. Mangrove wood also yields 21.8% fully charred charcoal and 10.2% half-charred charcoal. The common plants used for this purpose are *Avicennia, Aegialites, Excoecaria, Lumnitzera, Dalbergia, Acanthus, Rhizophora, Ceriops, Bruguiera, Sonneratia,* etc.

Source of timber

The mangrove forests provide a large quantity of timber yielding species which are used for boat building, house hold materials, furniture, electric poles, pillars of bridges, tetties, packing boxes, walling board, plywood agricultural equipment and others. Some of these important species are *Heritiera fomes, Xylocarpus granatum, Ceriops decandra, Excoecaria agallocha,* etc.

Source of fodder

Villagers near the mangrove forests left their cattles like buffaloes, goats and cows, in the forest during the months of summer as they graze the mangrove grasses viz., *Porteresia coarctata, Myriostachya wightiana, Aeluropus lagopoides* along with some common herbs and shrubs. The green leaves of *Avicennia* sp. are collected by the local people as it has high fodder value and is also found to increase the production of milk in buffaloes.

Source of tannins

Barks of the mangroves are much valuable due to presence of high percentage of tannin. Chemically tannins may be classified into hydrolizable and condensed groups. Most important condensed tannins are extracted from the leaves, wood, barks of different mangrove species, which are used in fishing net, leather industries, dying fabrics, making inks and various medical applications.

Average contents of tannin in different mangrove species are as follows

Botanical name	Percentage (%)
Bruguiera cylindrica	17.8
B. parviflora	25.4
B. gymnorrhiza	36.0
Ceriops decandra	29.0
Rizophora apiculata	33.0
Excoecaria agallocha	12.0
Sonneratia apetala	9.0
Xylocarpus granatum	25.0
Aegiceras corniculatum	7.0
Aegialitis rotundifolia	12.2
Lumnitzera racemosa	19.2

Source of medicine

In course of field observations the following species are found very useful.

Botanical name	Uses
Acanthus ilicifolius	Fruit pulp as blood purifier.
Avicennia officinalis	Bark for skin and wounds.
A. alba	Bark for skin and wounds.
A. marina	Bark for skin and wounds.
Bruguiera gymnorrhiza	Medicine from fruit, pneumatophores for preparation of cent.

Botanical name	Uses
Bruguiera cylindrica	Medicine form fruit, pneumatophores for preparation cent.
Ceriops decandra	Bark stops haemorrhage.
Rizophora mucronata	Decoction of bark for haematuria, diarrohoea, dysentery, leprosy, stops bleeding and neck formation.
Sarcolobus carinatus	Leaves and roots as medicine.
Sonneratia apetala	Fermented juice to check haemorrhage. Fruits for increasing eye power.
Xylocarpus granatum	Seed paste to relief breast tumor and barks for cholera.

Source of honey and wax

Sundanbans Biosphere Reserve yields about 700-100 quintal of honey and 500-600 quintal of wax per year between the months of April and June. Some mangrove species like *Acanthus ilicifolius, Aegiceras corniculatum, Ceriops decandra, Phoenix paludosa, Xylocarpus mekongensis* and *Avicennia, Excoecaria agallocha* contribute various quantity of honey at different times depending on the phenological periods of the species. *Apis dorsata* is the honey bee which produces different size and shape of honey combs during the month of April-June. This large quantity of honey production in Sundarbans Biosphere Reserve is not found in other mangrove regions of India.

CONSERVATION STRATEGIES

Due to high population density in the lower Bengal areas as well as one of the worlds most populated city like Kolkata surrounding the Sundarbans Biosphere Reserve, it faces many difficulties and human pressures on the resource management and conservation of the area. Large number of floral and faunal species are being over exploited to meet the requirements of the poor people. Structurally the Biosphere Reserve has been demarcated into core, manipulation, restoration and development zones. Starting from core zone to restoration zone, mangroves as well as others faunal diversities are well conserved. This zone includes a Tiger Reserve under Project Tiger Programme and also the area has been converted into a National Park within the manipulation and restoration zones. There is a well-protected bird sanctuary as Sajnikhali and also there are two other Wildlife Sanctuaries at Lothain island and Holiday island for the study of successional pattern of both plants and animals.

There are various policies and acts for management of this Biosphere Reserve, such as Wildlife Protection Act (1972), Environmental Protection Act (1986), National Conservation Strategies and Policies Statement on Environment and Development (1992), National Forest Policy (1988) and Forest Conservation Act (1980), etc.

Govt. of India in the year 1990 established a special committee named as National Mangrove Committee comprising of representatives from the Govt. of India's departments and other experts from the country for acting as an advisory committee and monitoring the conservation and other research etc. required specially for the conservation of mangrove ecosystem. The conservation strategies have also been discussed separately under the chapter on mangroves.

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A view of river creek.

Avicennia alba - a pure community.

Rhizophora apiculata - stilt roots.

Xylocarpus granatum - woody pneumatophores.

Bruguiera gymnorrhiza - hypocotyle.

Nypa fruticans

COASTAL REGIONS

L.K. Banerjee

India has a long coastline of over 7500 km, starting from the Bay of Bengal on the east, the Arabian Sea on the west and the Indian Ocean touching the southern end. The coast line or the littoral region, lying between the main land and the inner most edges of the seashore is the meeting line of the sub-aerial and marine processes of erosion and deposition. These continental and marine systems are very different in their rate, intensity, coastal processes and vary widely in their structure and function in different parts of the country due to various geomorphological features. It is narrow along the Konkan and Malabar coasts of the west due to formation of cliffs, barriers, spits and lagoons immediately behind the shore and water and, in the Coromandel-Circar regions due to formation of deltas, sand beaches and offshore bars. The West coast is much narrow except around the Gulf of Cambay and the Gulf of Kutch. The widening in these two places is due to sedimentation and isostatic adjustment. The depositional action of the rivers on the West coast is very meagre along its length from the south of Gujarat to the Cape Comorin due to tilting of the West coast. Extreme southern part of the south Sahyadri is also wider in this coast. Formation of rocky shore line, cliffs lagoons and back waters are characteristic features of the West coast. The East coast in contrast is much broader in outline and associated with depositional activities of the rivers. This is partly due to change of their base levels and formation of extensive deltaic complexes like, the Ganga-Bramhaputra, the Mahanadi, the Krishna-Godavari and the Kauveri. All the major deltas along the East coast are in progressive stage into the sea and are still continuing. Formation of sandy beaches, dunes and vast estuarine tidal flats are the characteristic features of this coast.

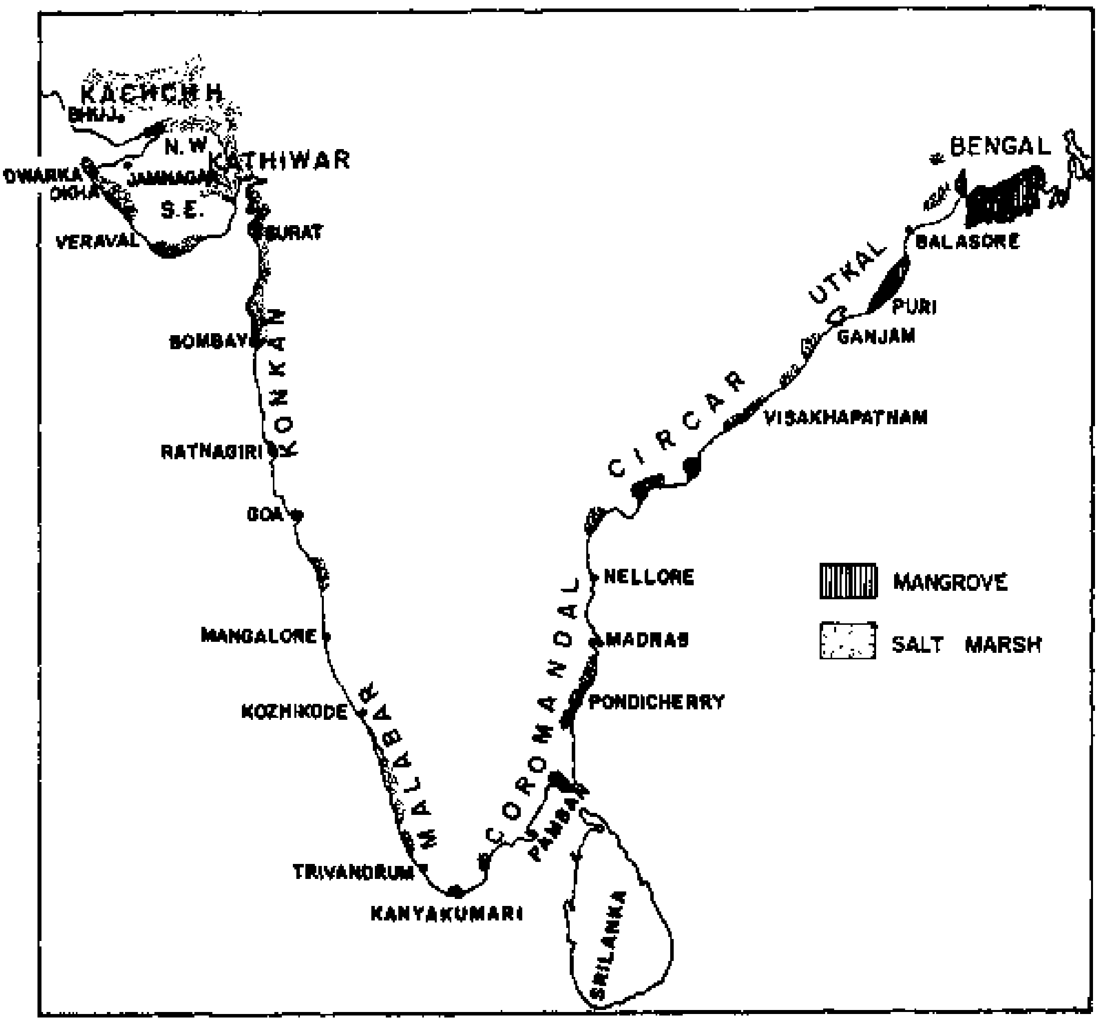
PHYSIOGRAPHY

East coast

The east coastal plains of India fall between Bengal and Orissa in the north and Andhra Pradesh and Tamil Nadu in the south, covering about 3,289 km long and 40-100 km broad coast line with an area of 1,02,882 sq. km. The Coromandal and Circar coasts are considered to be very fertile and include the states of Bengal, Orissa, Andhra Pradesh and Tamil Nadu.

In Bengal, the coastal plain is nothing but the deltaic plains of the Sundarbans and sand beach, and dune forming part of Midnapur areas.

The Orissa coast, also known as Utkal coast is slightly curved. It has a length of about 400 km and lies approximately between the rivers Subarnarekha and Rushikulya including the delta of Mahanadi and coastal lagoon of Chilka. Here the hills arise almost from the coast. The Mahanadi delta along the sea ward margin is more straight and fringed with sand dunes because of stronger wave action. The marshy terrain along the coast is covered by forests which are comparatively less conspicuous than the Sundarbans. The most important physiographic unit of the area is the Chilka lake, situated south of Mahanadi delta. Its origin is due to formation of bay-mouth bar, and at places it is more than 200 m wide. The lake is 7 km long and pear shaped, widening in the north-east and tapering in the south-west. Two rivers, Bhargavi and Daya drain into the lake, making the water sweet in rainy season. Hills bound the shore on the south-west.



Formations along the Indian coast

There are a number of rocky islands. The coastal plain of Chilka lake is dotted with low hills and drained by the Rushikulya river. In Andhra Pradesh and Tamil Nadu, the East coast is called Payan Ghat. The Andhra Pradesh part of coromondal coast extends from the southern limit of Utkal plains to the Pulicat lake and confirms more or less to the state boundary. The coast line exhibits both rocky and sandy types. The Andhra Pradesh coast line fringed with many back water, estuaries and lagoons.

Kakinada and Nizampatnam bays are deep and usually exhibit high waves. Two of the biggest rivers of Deccan, the Godavari and Krishna, flow through Andhra plains and form deltas in their lower reaches. The Kolleru lake near Eluru town is situated between these deltas. It receives the drainage from adjoining hills and is connected with the sea by a single channel. The present position of this lake is taken as evidence of the advance of the coastal plains towards the sea. Some of the important back water and estuaries of Andhra Pradesh are near Bhiminipatnam, Coringa, Nitmazpatnam, Bapatta, Chinnaganjam, Tummalapenta, Gyunnamola, Utukuru, Krishnapatnam etc. Pulicat lake and Buckingham canal are situated partly in Andhra coast.

The Tamil Nadu coast extends from south of Pulicat lake up to Kanya Kumari. The Tamil Nadu part of Coromandel coast is about 675 km long with an average width of about 100 km. Cauvery delta is its most important physiographic unit. The river divides into 2 channels at the island of Srirangam. There is a marshy area along the southern Hinge of the delta to the east of Point Calimer. A number of small islands lie in the Gulf of Mannar. Some of the leading islands of the region are Rameswarm, Kurusadai, Shingle, Hare and Church. The major lagoons of Tamil Nadu coast are Muthupetai in Tanjore district and Pichavaram in South Arcot district. Some of the important back water and estuaries in this region are in Muttukadu, Palar, Marakkanam, Velar, Pazhaiyar, Chunnambar and Purrakayal. Palk Bay in Tamil Nadu coast is shallow and almost waveless. The entire seashore of Tamil Nadu coast is mainly sandy with an outcrop of rocky headlands of Mahabalipuram. Mandapam and Cape Comorin also exhibit tidal creecks and flats at the riverine mouths, of which the Vellor and the, Cauvery (Coleroon) are note-worthy. At the mouth of these rivers numerous creeks, extensive mud and saline flats with the formation of proestuarine vegetation is noticeable particularly at Pichavaram, Tuticorin and adjoining regions. Apart from above habitats, there are coral reefs in the Gulf of Mannar from Mandapam to Tuticorin, giving rise to hard substratum with huge percentage of calcium carbonate, making it a specialised habitat.

Gulf of Mannar situated in Tamil Nadu may be termed as Marine Province containing about 26 islands. Kurusadai is one of the biggest island here. The flow of water during tidal action from the Gulf of Manner to Palk Bay is through Pamban channel. The islands here are characterised by the presence of coral reefs.

West coast

It is a distinct strip of lowlands interspersed by hills. The elevation varies from 150 to 360 m. Its landscape is composed of one or more of the following types : sandy beach, coastal sand dunes, alluvial tracts of muddy flats along the rivers, lagoons or river laterite platforms and erosional surface in the hard basement rock or the residual hills.

Low lands are very narrow, confined and limited along the lower courses of streams in northern Karnataka. However, along the south of Karwar, a conical hill ridge of 610 m high composed of gnisises is very prominent along the coast line. Further south, these low lands are wide near Mangalore in the Netravati valley. Three parental belts of land forms are characteristic of Karnataka coastal plains. 1) Immediately behind the coast is a narrow belt of sand dunes, muddy-flats and marshes formed usually by lagoons or estuaries. 2) Further inland of these belts are succeeded by high erosional platforms associated with laterite deposits of Pliocene age and dissected by steep valleys. 3) Further inlands are associated with isolated residual hills of Archacan gneiss and are very prominent along the south-east of Hanover and near Karwar.

The Malabar coast is about 550 km long and 20 to 100 km wide, narrow in the north and south but wide in the middle, specially in the valley of Ponnani, the Periyar and Pamba. Sand dunes of various forms are found all along the Kerala coast except to the south of Kovalum where rocky projection ends right up to the sea. These sand dunes of Pleistocene are of recent origin and have helped to form numerous shallow lagoons and back-water flows. Besides, there are some erosion platforms and laterite cliffs near Kozhikode district. The gneisses hill lies further inland areas.

Geology

The geological features of Indian coast were studied by Wadia (1961), Ahmed (1972) and scientists of Geological Survey of India from time to time.

The regions of Ganga delta and the adjoining Mahanadi delta up to Chilka lake are Pleistocene and recent alluvial deposits are under sedimentation, subsidence and isostatic subsidence. The coastal zone of these deltas are unstable due to recent faults and deltaic subsidence. The land surface is gradually rising and prograded into the sea. Though Ganga delta is completely alluvial but in the Mahanadi delta some patches of sedimentaries like limestones, laterite and sandstones are common near Baripada, Puri and Midnapur.

Coastal regions of Circars are formed by gneisses and granite with patches of charnokites and khondalite. Recent coastal alluvium also occurs in the rocky and hilly regions of inner coastal tract between Puri and Kakinada except in Vishakapatnam where cliffed rocky interior border the shoreline. The inner coastal belt is frequently capped with laterite. The pre-Cambrian crystallines are known to represent the primodial crust in this zone. Absence of marine sediments mark the continued terrestrial aspect of the peninsular shield.

Geological formation of the Godavari and Krishna deltas is similar to that of the Mahanadi delta. Thickness of recent aluvium gradually decreases from the shore to the crystalline interior. A narrow belt composed of Gondwana sandstone, cretaceous sandstone, Deccan lava and fossiliferous marine sediments are common in between this alluvial and crystalline zone. Apart from deltaic subsidence the coastal region of this tract is underlying towards northeastern and southwestern margin by permo-carboniferous fractures that bordered with the ancient Gondwana rift valleys.

From the Krishna delta towards the south up to Cape Comorin there is a continuous belt of coastal alluvium of varying width. This belt is associated with sedimentaries of various ages from the upper Gondwana, to pleistocene. Near Ongole, Madras, Trichinopoly, Madurai and Ramnathapuram upper Gondwana sediment is prominent. Cretaceous fossiliferous bed occurs near Uttatur, Trichinopoly, and Ariyalur. Eocene limestone and extensive Cuddalore sandstones are found in Pondicherry. All these beds are slightly tilted eastward and some section across the coastal zones show successive stages. These continuous sequences of marine beds are the real geological structure, which has been preserved along the Coromandal coast.

Near Cape Comorin, crystalline gneisses of Cardamom hills mix in the same line with the shore. North west part of this coast line is up to a distance of 100 km. A very narrow alluvial bar towards the shore intermixes with the edges of gneisses and granitic interior on the east. This is known as Warkalli and Quilon series and consist of fossiliferous coral line lime stone, sand, clay and a band of lignite. This is also known as coastal tertiary formations.

From north of Quilon to Karwar, coastal alluvium of various width directly adjoins the gneisses and granites of Deccan, but between Mahe and Quilon for about 350 km, the lateritic cover of Warkalli and Quilon bed intervenes between this coastal alluvium and interior gneisses.

North of Karwar in Goa, the geology of coastal regions is of granites and gneisses. Further north up to 17° N, there is interruptions of gneisses and laterite cover beds in Ratnagiri district. Gneisses rock extends upto 16° 15'N but further north, it is covered with Deccan lava. Coastal tertiaries of the Ratnagiri consist of white and blue clay with carboniferous seam resting upon Deccan trap and capped by a layer of ironstone having lignite, pyrite and mineral resin.

From North of the Ratnagiri, Deccan lava extends right upto the water line from Ratnagiri to Bulsar region. Deccan trap is the dominant geological formation between Karwar to Buisar. Crystalline rocks of the Deccan lava in Maharastra with adjoining parts of Goa and Karnataka directly join the shore line. The presence of very hard lava formation in Goa to Bulsar along the shore line indicates the absence of coastal plain in these areas. From the north of Bulsar, Coastal alluvium extends over most of the Cambay regions. In Broach and Surat, the coastal tertiaries capped with laterite are composed of clays, sandstone, lime stones and gravel of basalt.

Deposits of sea along these areas cause the joining of Cambay with the Rann of Kutch. In Kathiawar, Deccan lava forms the inner part of coastal zone. Here coast and shore lines are of low plain and marshy. Some where it is cliffed. Some where it is covered with coastal alluvium and tertiaries. There are some white lime stones which are of calciferous deposits of Pleistocene consisting of wind blown grains of foraminifers fire stone.

Dwarka and south Kathiawar are covered with Dwarka bed which is formed by clays and foraminiferal limestones. The coastal zone of Kutch is formed by alluvium and consists of loam sand and clay. Along the Lakshadweep group the coastal zone is absent as they are in most cases 5 m above the sea level and composed of coral lime stones.

In the Andaman & Nicobars, the geological formation is interesting and varies in different islands. In north Andaman, coastal zone is composed of Eocene conglomerates and sandstones except a 10 km patch of Cretaceous serpentinites. In south Andaman this clay and sandstones predominate over the conglomerates. Middle Andaman represents a geological transition between the north and south Andaman. The sandstones are more common towards eastern side and clays towards the south. Basalts and serpentinites occur in scattered localities. There are few pockets of limestones of pre-middle and tertiary time. Little Andaman is dominated with serpentinites but Kar-Nicobar is dominated by raised coral reefs. Katchal and Great Nicobar are also dominated by coral reefs. Ritchie's archipelago and intermediate islands are mostly dominated by soft clays.

CLIMATE

The climate along the coast line is relatively uniform. Based on the moisture index it has been classified into the following five climatic groups: perhumid, humid, subhumid, semiarid and arid. It is arid in the Gujarat coast. Along Veraval and Bhavnagar it is semi-arid. South western shores stretching into the Surat of South Gujarat is dry. Coastal belts of Maharastra, Karnataka and Kerala fall under humid and sub-humid zones but Kozhikode and Thiruvanantpuram represent perhumid climate. In the east, the Bengal basin chiefly the Sunderbans region falls under humid type of climate. The Coromandal and Circar coasts experience moist sub-humid type of climate, but the Utkal coast experiences humid climate.

Despite these regional climatic variations it is generally seen that the influence of the maritime climate on the upland parts of the coastal biosphere is very much affected by the combined action of precipitation and local topography, and the all pervading influence of the sea is seen only in the low lying areas of the coast.

Effect of the land climate is not appreciable in the low lying areas of the coast. Here, they are chiefly influenced by tides, wave action, sea winds, saline water and nature of substratum.

East coast

The East coast represents a hot tropical climate characterised by oppressive summer, low daily range of temperature, high humidity and moderate rainfall. This coastal strip experiences local climatic variation in regard to the variation of physiographic conditions such as from the coastal tract of Bengal-Orissa to the Godavari-Krishna delta, it enjoys tropical savanna climate and from the Krishna delta to the Vaippar represents tropical wet and dry climate with distinct dry summer. The parts of the southern coastal districts experience a tropical monsoon climate with a short dry winter season and the interior parts of these districts have a tropical arid climate, with winter drought. Temperature increases from the month of February to the end of May. During the hottest montl. 'Bengal and Utkal Coastal regions represent 31°C-34°C temperature while the interior parts experience 33°C-36°C. Similarly, Andhra-Tamil N.· u coast represents 35°C-38°C temperature and their interior parts experience over 40°C. January is the coldest month and temperature recorded along Bengal-Utkal coastal areas ranges front 13°C-20°C and 18°C-23°C along the Andhra- Tamil Nadu coastal regions. The interior parts of these coastal track represent 12°C-20°C during the coldest months.

Rainfall along the East coast belt usually ranges from 1130 to 1840 mm and decreases towards the interior parts. From Bengal to Utkal coastal areas up to Balasore rainfall ranges from 1,686 to 1840 mm whereas in Puri coastal regions, it experiences 1482 mm. Along the Andhra coast in Kakinada, it shows 1179 mm. In Tamil Nadu coast, rainfall varies in different regions such as 1216 mm in Madras, 1367 mm in Nagapattiamam and 602 mm in Tuticorin. Thus, it indicates wide range of variation of rainfall from north to south in East coast. It is found that due to south-west monsoon, Bengal-Utkal and northern Andhra Pradesh get maximum rainfall. Kakinanda up to Krishna delta shows decrease in rainfall as these areas fall out of the main monsoonal track and associated with depressions. Further south, rainfall is caused by retreating monsoon which is mainly associated with the storms and depressions originating in the Bay and thus providing various amount of rain fall on the coast. Humidity prevails very high throughout the year along the coastal areas. In Bengal-Utkal coast it is 70% in the driest month, and above 82% during wettest months. In Tamil Nadu it varies form 60% during June and above 80% during November-December. Some of these depressions intensify into severe storms with wind velocity of 180 to 200 km per hour, resulting heavy rains and cause cylones to these coastal belts. The entire Orissa, Bengal, Andhra Pradesh and some parts of Tamil Nadu are especially vulnerable to cyclones. More than 200 cylones are reported to have hit these coastal regions during the last 100 years and in most of the cases the regions like Sunderbans, Cuttack, Balasore, Kakinada, Krishna and Godavari mouths, Cauveryi mouth, Machilipattanam, Nizampattanam and others were seriously affected.

West coast

The west coast represents more or less moderate climate with high temperatures almost throughout the year associated with evening cool breezes on the shore. The Konkan Coastal region shows distinct climatic diversities ranging from dry climate in Surat to sub-humid type in Bombay and humid type in Ratnagiri and Goa. The Malabar Coastal region also shows two distinct climatic variations such as humid climate in Mangalore to perhumid climate in Kozikode and Thiruvanantpuram. In general, the mean monthly temperature ranges between 24°C and 31°C. The maximum temperature rarely exceeds 32°C and the minimum temperature rarely falls below 21°C. The Annual temperature decreases southwards as follows: 5.7°C at Bombay, 5°C at Karwar, 40°C at Mangalore and 3.3°C at Kutch (Cochin). April and May are the hottest months of the year. The high humidity and evening sea breezes are characteristic features of this region.

The rainfall is usually high in this coast and shows considerable variation in Karnataka and Kerala regions. In Konkan, rainfall is 2800 mm, in Karnataka 3100 mm and in Kerala 2400 mm. Heavy rainfall occurs during June to September months in Konkan and north Karnataka. The length of rainy season increases also from north to south in the West coast. It ranges from 4 to 5 months in the Konkan coast, 7 months near Mangalore and 8 to 9 months in Kerala. In Kerala, rainfall decreases from north to south that is 2400 mm to 1600 mm in Thiruvanantpuram and 1000 mm in Kanyakumari. This coast receives a double influence of rainfall from both the summer and winter monsoons during June-July and October-November and enjoys little seasonal variation and the cool season extends from December to February and hot season starts from March to May.

SOIL

East coast

The soil of the east costal plains predominates with alluvium. In some areas behind the sandy zone or in association with the sandy alluvium, traces of black soil and lateritic soil are prominent as transported soil. A special class of soil, usually known as saline and alkaline soils also occurs along the saline flats and salt marshes bordering the estuarine areas of the coast. This soil is nothing, but transformed soil due to the change of ecological and topographical conditions of the areas.

The coastal alluvium soils are of two major types. 1) All along the sandy coast from Midnapur to Kanyakumari occupying the littoral parts varying in width of 10 to 20 km, are covered with sandy alluvium which is in most cases of marine origin. In general, these are known as coastal sands composed of coarse sands, fine sands and silts, rich in lime and poor in nitrogen and phosphoric acid. 2) All along the deltas and estuarine regions where the rivers meet the sea and the areas are constantly influenced by saline tide water are mainly composed of alluvial bed. These alluvial soil occupy Ganga, Baitarini, Brahmani, Mahanadi, Godavari, Krishna and Cauvery deltas and are of riverine origin and mostly composed of clay, silts and sand particles. These soils are very fertile, rich in nitrogen and phosphoric acid.

Since these alluvial soils along the coast have a special configuration depending upon the saline tide water influence associated with the changing nature of salt water level fluctuations and seasonal, salinity conditions, these have been usefully named as "Coastal Saline Alluvium Soils" Mangrove swamps are found better developed in these areas. Along the upper terraces, these soils are naturally reclaimed due to leaching of salts by rain water. Soil mineral study shows that in Cauvery delta, smectite is predominant with few kaolinite. Godavari delta has smectite with little kaolinite and illite in traces. The Ganga delta is dominated with microchlorite in which mica is made up essentially of muscovite and the Mahanadi delta contains montmorillonite associated with halloysite and illite. The presence of quartz, clay and felspars is also common in this soil type.

Along the Utkal coast of Balasore, in Andhra Coast near the Godavari and Nellore, in Tamil Nadu at Chinglaput and Tanjavur laterite soils are found in small patches where the coastal line exhibits rocky formation.

The dominant components in these soils are iron, alumina and silicic acid as primary materials for rock.

Along the parts of Chilka lake in Utkal coast, some parts of W. Godavari, Krishna and Guntur of Andhra coast, some parts of Madurai, Sattur and Ramnathapuram and major parts of Tirunelveli of Tamil Nadu coast exhibit the presence of black soil. This tropical black clay is rich in lime, magnesium and aluminium but poor in phosphorus, nitrogen and organic matters. They originate either from decomposition of basic basalt or certain sedimentary clays or decomposition of calcium and magnesium. These black soils are not as rich as Deccan Trap. The fertility of the black soil depends on self-ploughing character.

West coast

Soils of the West Coastal regions show diversity from north to southwards. The formation of soil texture can be divided into 6 types such as sandy soil, coarse sands, lateritic yellow or red soil, black soil and peaty soil. The sea beaches, shore land, coastal dunes, plains and islands of back waters are usually covered with sandy, lateritic and black soil. The sands are mostly marine in origin. Contents of organic matters like nitrogen, phosphorous, potasium are very low in percentage and sodium chloride and calcium are higher. In Karnataka, these sands are associated with alluvium and other materials of parent laterite. These sands are also mostly marine in origin, saline and associated with low organic matter, nitrogen, phosphorous and potassium.

The river mouths, lagoons and back water estuarine areas are dominated with the alluvial soil. It is originated from river-alluvium, mud and estuarine silts. The wide belt of alluvial soil is common towards the north Konkan region, then it becomes narrower to the South Konkan and almost disappears in north Karnataka regions. Along the Netravati river valley, in Mangalore, this alluvial soil belt is prominent between the sandy and lateritic belt. In Kerala, it is restricted in some pockets of river valley. These soils have various percentage of sands, silts and clay particles with high organic matter, nitrogen, phosphorous and potassium and lower salinity than the sandy soil.

The low hills and plateaus of the north Konkan regions are dominated with coarse sands which are saline and have low fertility character. In some pockets of Kerala, a small patch of black soil, very rich in organic matter and potassium are found. These are known as peaty soil which are highly acidic. Places like Kuttanad, Vaikom and Shertallai this peaty soil formation is found at the junction of sandy and laterite soil.

In north Konkan region, black soil is associated along the trap of the rocks. They are very fertile for having rich iron, magnesium and calcium and high moisture retaining capacity.

VEGETATION

Zonation of plant communities on the littoral regions is an universal phenomenon, but while some species have a very wide vertical range over the coastline, the others show very restricted distribution. Some are remarkably constant in position as compared to other species or tide levels and salinity conditions while others occupy different levels according to the variation of the local conditions.

The wet coastal habitat with low undulating topography consisting of silty or muddy relief is mostly found in the sheltered areas where the coast line is interrupted by the rivers to form deltas, estuarine lagoons and back water, flowering plants concentrate mainly on supra littoral and mid littoral regions. But along the dry coastal habitat where high steep and slopped topography consisting of sandy or rocky relief on open uninterrupted shore conditions of the coast line, flowering plants concentrate along the supra littoral regions. The infra littoral regions are mostly dominated by algae and sometimes seagrasses.

DRY COASTAL PLANT COMMUNITY

Based on various maritime environmental factors such as, topography, edaphic and arid tidal action, the dry coastal plant communities can be divided into two main types: 1) Sandy strand and 2) Rocky strand.

1) Sandy strand

It is again divided into 4 subtypes as follows :

(i) Pioneer semistabilised strand type·

This is the pioneer vegetation zone on supra littoral region of unstabilised or semistabilised sandy or rocky sea beaches where the dynamic action of sea weaves, salt spray and wind force remain so active that very few plant species grow with special adaptive features for withstanding this hostile environment. Species like *Cyperus arenarius, Sesuvium portulacastrum, Hemarthria compressa, Cyperus pedunculatus, Launaea sarmentosa* with their thick, fleshy leaves, long runners and extensive nodal root system are found to withstand such environmental conditions and function as sand accumulators in this pioneer zone for bringing the coast towards stability. Along the rocky coast, this pioneer zone is covered mainly with *Artiplex stocksii, Polycarpaea spicata, Cyperus stoloniferus, Fagonia cretica* for tolerating the wind and wave action with their thick leaves and runner system. However, this association on rock strand is located only along the West coast. In the East coast, rocky zone is covered with algal communities.

(ii) **Stabilised strand type**

This zone is located little away from the former unstabilised sandy beaches and is found more or less in stable condition where the areas remain free from the frequent impact of sea waves. Vegetation in this zone mainly consists of closed herbaceous creepers forming mat on the sandy strand. In case of rocky strand this zone is associated with different plant species which are found only on the thin mantle of deposited sands or debris in the crevices.

Dominant plant species along the sandy strand of East and West coasts are *Hydrophylax maritima, Ipomoea pes-caprae, Canavalia maritima, Launaea sarmentosa, Psilostachys sericea, Euphorbia rosea, Geniosporum tenuiflorum, Goniogyna hirta, Perotis indica, Trachys muricata, Sporobolus virginicus, Zoysia matrella, Cassytha filiformis, Borreria articularis, Asparagus dumosus, Peplidium maritimum, Halopyrum mucronatum, Enicostema hyssopifolium* and others. Distributional resume of the above plant species responsible for different ecological conditions of the Indian coast will be described in a separate chapter of this text. However, the functional activities of all the species show peculiar adaptation on sand binding, baby dune formation and protecting upliftment of sands during storms. They are capable to withstand high wind force due to mat forming and nodal root system in their habitat and also capable to withstand salt spray due to their thick, cuticular leaves. Dominant plant species in case of rocky strand along the East and West coasts are *Indoneesiella echioides, Kickxia ramosissima, Lindenbergia* *urticaefolia, Portulaca tuberosa, P. quadrifida, Pulicaria angustifolia, Limonium stocksii, Pavonia patens, Euphorbia thymifolia, Vernonia cinerea, Indigofera aspalathoides* and others with the main functional activities of accumulating debris and sands on the pot holes.

(iii) **Dune strand type**

Stabilised sand strand follows immediately the dune strand of various size and shapes. Various types of large dunes are commonly found along the East coast while some sand bars and small dunes are frequently found along with pocket beach formation on the West coast. Zonation of plant species of the dunes depends on the variation of impact of salt spray, wind forces and sunlight conditions.

Some beautiful sand binders with long horizontal runners and fleshy nodal roots are common along the lower slopes of the sand dunes for protecting the wind blown sands. Middle and upper layers of the dunes covered with bushy herbs and shrubs also function to check the wind blown sands. Lee side of the dune shows different picture of plant zonation and most of the associated species are similar to that of the inland formation. Common plant species associated along the lower, middle and upper parts of the dunes are *Hydrophylax maritima, Spinifex littoreus, Launaea sarmentosa, Rothia trifoliata, Portulaca tuberosa, Zornia diphylla, Tephrosia purpurea, Crotalaria striata, Oldenlandia umbellata, O. stricta, Indigofera trifoliata, Borreria articularis, Synostemon bacciforme, Trianthema triquetra, Phyllanthus maderaspatensis, Perotis indica, Bulbostylis barbata, Fimbristylis falcata, F. dichotoma, Aristolochia bracteolata, Sida cordifolia, Calotropis gigantea, Opuntia dillenii, Tylophora indica, Allmania nodiflora* var. *procumbens, Mollugo disticha, Gisekia pharnaceoides, Waltheria indica, Cleome aspera, Catharanthus roseus, Datura metel, Turnera ulmifolia, Jatropha gossypifolia* and others. Similarly dominant species found on sand bars and small dunes along the pocket beaches of western coast are *Ipomea pes-caprae, Launaea sarmentosa, Corchorus aestuans, Sporobolus glaucifolius, Psilostachys sericea, Cynodon dactylon, Crotalaria retusa, Calotropis gigantea, Physalis minima, Zoysia metrella, Pandanus fascicularis, Vitex trifoliata, Pedalium murex, Murdannia nudiflora, Cyanotis cristata, Scilla hyacinthina, Borreria stricta, Sida cordifolia, Scaevola taccada, Wedelia biflora,* *Tylophora indica, Canavalia maritima, Stachytarpheta urticaefolia, Zornia diphylla, Memecylon umbellatum* and others.

(iv) Coastal woodland type/palm type

This is the last part of the coastal plant zonation where the flora have less impact of maritime environment and merge gradually with the inland formation. Here plant species, which extend from the seashore towards the inland regions even sometimes up to an altitude of 200 m. show preference of best development and growth in the coastal habitat under the maritime ecological conditions than the inland areas. Some common species and palms in this sandy and rocky strands are *Calophyllum inophyllum, Acacia planifrons, Alangium salvifolium, Ardisia littoralis, Anacardium occidentale, Allophylus concanicus, Atalantia angulata, Borassus flabellifer, Capparis cartilaginea, Casuarina equisetifolia, Cerbera manghas, Cocos nucifera, Colubrina asiatica, Commiphora wightii, Erythrina indica, Euphorbia cordifolia, Ficus benghalensis, Guettarda speciosa, Maytenus emarginata, Hernandia ovigera, Hyphaene indica, Ixora coccinea, Maba buxifolia, Memecylon umbellatum, Tournefortia argentea, Pemphis acidula, Prosopis cineraria, Premna serratifolia, Pongamia pinnata, Quassia indica, Salvadora persica, Scaevola taccada, Scutia circumscissa, Streblus asper, Suriana maritima, Syzygium ruscifolium, Ziziphus oenoplia* and others.

2) Vegetation of rocky strand

Mostly along the West coast starting from the south eastern Kathiawar to Thiruvananthapuram including Gujarat, Konkan and Malabar coastal regions show extensive formation of rocky cliffs and ghats of various sizes and shapes. Due to eroded nature of this coastal belt in some areas, the existence of shoreline and coastal belts are represented by the inland cliffs, barriers and spits. Except some pocket beaches, long extensive sandy beach and dune formations along the coastline like that in the eastern coast are absent.

Studies on rocky dry strands along the coastal region of Kutch, Saurashtra, Konkan and Malabar areas reveal that the plant zonation on rocky strands can be divided into following 4 types based on various maritime environmental conditions.

(i) Constant wave cut rocky strand

This is the pioneer zone of rocky strand consists of some specially adapted species which are capable to tolerate salinity, high wave action and wind force. Some common species found in this zone are *Polycarpaea spicata, Atriplex stocksii, Fagonia cretica, Limonium stocksii, Anotis foetida, Thuarea involuta, Polygala erioptera* and others. Along the East coast, this rocky strand in Cape Camorin and other parts is inhabited by algal communities. Growth of *Ensita superba* in Ratnagiri coastal cliff is of great interest in this zone.

(ii) Occasional wave cut rocky strand

In this vegetation zone frequent sea waves wash the undulating rocky surfaces during the very high tide. Here vegetation cover is more dominant where the crevices are covered with thin mantle of sands, limestones and debries. Some common species found here are *Indoneesiella echioides, Enicostema hyssopifolium, Kickxia ramosissima, Lindenbergia urticaefolia, Portulaca quadrifida, Pulicaria angustifolia, Pemphis acidula, Pavonia procumbens, Sporobolus diander, Helichrysum cutchicum, Limonium stocksii* and others.

(iii) Rocky slopes above the wave action

This zone lies in between the constant wave cut region and woodland zone of the rocky strand specially situated in the middle part of the rocky slopes, cliffs and undulated rocky flats where impact of regular sea wave is not functional except the wind blown salt spray and very occasional high tide condition. Some of the dominant species in this zone are *Aerva lanata, Tephrosia purpurea, Helichrysum cutchicum, Barleria prionitis, Calotropis procera, Jatropha gossypifolia, Indoneesiella longipedunculata, Toddalia asiatica, Capparis cartilaginea, Ardisia littoralis, Calophyllum inophyllum, Caesalpinia crista, Colubrina asiatica, Pisonia aculeata, Thespesia populnea, Anacardium occidentale, Ixora arborea, Syzygium caryophyllatum, Vitex alatissima, Salvadora persica, Pandanus tectorius, Premna serratifolia, Psilostachys sericea* and many others. *Hyphaene dichotoma* and *Acacia planiformis* occur where more sand is accumulated on the rocky crevices.

(iv) Rocky woodland strand or Coastal rocky woodland

This formation is very interesting along the West coast where due to constant erosional effects most of the coastal areas do not show distinction between the shore and back shore topography. In some regions, formation of pocket beaches is the only criteria for demarcating the shore and backshore topography. Moreover, formation of many cliffs and ghats along this coastline indicates the appearance of inland flora in the coastline without the presence of shore feature. Vegetation in this type also shows that major components have come only from the interior woodland. Under this category, same plants extend from the sea towards the interior, showing varied tolerance capacity. Tropical evergreen formation is remarkably concentrated here and extends from Goa, Konkan and Malabar coastal regions under the maritime influence. Certain common interesting woodland plants are *Andrographis echioides, Calotropis gigantea, Cassytha filiformis, Euphorbia nivulia, Adhatoda zeylanica, Cordia dichotoma, Erythrina suberosa, Ixora arborea, Morinda citrifolia, Carallia arilata, Hopea parvifolia, Strychnos nux-vomica, Vateria indica, Dipterocarpus indicus, Poiciloneuron indicum, Calophyllum tomentosum, Machilus macrantha, Palaquium ellipticum, Aporusa lindleyana, Schleichera oleosa, Terminalia paniculata, Mangifera indica, Vitex alatissima, Syzygium gardneri, Artocarpus heterophyllus, Fragaria nilgerrensis*. In the lower canopy - *Holigarna nigra, Dillenia pentagyna, Olea dioica, Scolopia crenata, Alstonia scholaris, Diospyros ebenum, Hopea utilis* are common examples in the coastal secondary evergreen type. The coastal shrubs in and around plain lands are represented by *Strychnos nux-vomica, Careya arborea, Carallia brachiata, Acacia sundra, A. sinuata, Randia dumatorum, Ixora coccinea,* etc.

WET COASTAL PLANT COMMUNITY

Plant communities in coastal wetlands are dominated mainly by mangroves, sea grasses, sea weeds and salt marshes spreading from the mouth of rivers up to the limit of seeline tide water flow towards the interior hinterlands.

Mangrove wetlands in India along the East coast are found in the Gangetic Sundarbans complex, the Mahanadi complex, the Godavari and Krishna river system and the Cauvery estuarine complex. Along the West coast, mangroves are confined to the back water systems, innumerable interconnecting canals, lakes and creeks in Maharashtra. The richness and diversity of mangrove vegetation along the East coast is due to its vast deltaic situation, fresh water flow and large intertidal mudflats, which are rich in organic sediments, whereas the mangrove vegetation on the West coast is poor in quality and in extent due to major topographic differences. The East coast mangrove wetlands are considered to be the best habitats and commonly harbour about 63 mangroves species, out of total 65 mangrove species known from India.

In India, a study of mangrove zonation was consolidated by Champion and Seth (1969). However, between 1936 and 1957 isolated attempts were made by many authors. In recent years, Blasco (1975), Raju (1968), Chapman (1976), Mukherjee and Mukherjee (1970), and others have studied mangrove vegetation, classification and zonation based on regional settings, correlating the localized environmental factors.

Mangrove plant communities

Based on the impact of water salinity, tidal amplitude and substratum types, mangrove plant communities from the estuarine mouth towards the end of saline tide water flow along the inner riverine system, can be broadly divided into 4 distinct types such as, estuarine mangroves, true mangroves, semi mangroves and transitional mangroves.

(i) Estuarine mangroves

Estuarine banks along the river mouths, influenced by maximum salinity, tidal waves and silty substrate are mainly dominated by *Avicennia marina*, *Aegialitis rotundifolia*, *Avicennia alba* and *Lumnitzera racemosa*. These species are able to tolerate maximum salinity conditions with the help of salt excreting glands or by increasing water storage tissue in their leaves.

(ii) True mangroves

Middle part of the estuarine regions where land masses notably influenced by innumerable meandering creeks and channels has resulted in the formation of several fringes and islets. These are dominated mostly by *Rhizophora apiculata*, *R. mucronata*, *Ceriops decandra*, *Kandelia candel*, *Xylocarpus granatum*, *Bruguiera gymnorrhiza*, *Aegiceras* *corniculatum* and others which are adapted by means of stilt roots and vivipary for adjusting greater tidal forces of the creeks and channels.

(iii) Semi mangroves

Most inland tidal flats of the inner estuarine regions which subjected to greater fresh water influence and lower tidal action due to elevation are characterized by remarkable brackish water mangrove formations, predominating *Heritiera fomes* and *Nypa fruticans* communities. It has been observed that depending on the availability of fresh water flow *Heritiera fomes* grows in association with *Cerbera manghas, Cynometra iripa, Intsia bijuga* and *Aglaia cucullata. Bruguiera sexangula* and *Avicennia officinalis* form dominant community in the muddy substrate and are adapted by means of woody pneumatophores for exchange of gases in the root system.

(iv) Transitional or Hinterland mangroves

Most interior part of the mangrove swamps where fresh water flow is predominant except some high spring tide. Species of *Derris, Dalbergia, Excoecaria, Barringtonia, Pongamia, Thespesia* and *Acrostichum* are dominated without any morphological adaptation.

SALT-MARSH COMMUNITY

Salt-marsh formation in the tropical coastal wetlands occurs in three different situations such as recently formed mud flat in open coast or on the inner elevated regions of estuaries, on the inner saline soil deposits within the mangrove swamps and as a secondary formation on the cutover or degraded areas of the mangrove forests. The first situation is found along the Gujarat and parts of the Andhra coast. The second and third situations are very common along the dry elevated parts of mangrove forests and land edges of the tidal flats and lagoons. Areas remain physiologically dry with high percentage of salt.

Salt marshes are very common along the Gujarat coast, Runn of Kutch, Krishna river estuary, Nalimundi beach, Kothapalan and Coringa in Andhra coast, Chilka lake and Mahanadi delta in Orissa coast and Sundarbans in Bengal coast. The common saltmarsh species along the Indian coast are *Aeluropus lagopoides, Salicornia brachiata, Sesuvium portulacastrum, Suaeda maritima, S. nudiflora, S. monoica, S. fruticosa, Tamarix* *troupii, T. ericoides, Arthrocnemum indicum, Cressa cretica* and others. *Acrosticum aureum*, a mangrove fern sometimes is found densely associated with these salt-marshes along Andamans, Sunderbans and Mahanadi delta but it is completely absent in Andhra Pradesh coastal wetlands. The presence of saltmarsh community in mangrove forests creates a serious problem because of the degraded topography and lack of drainage system. Here no other vegetation even the mangroves, can establish in this condition.

SEAGRASS COMMUNITY

Seagrasses occur in the infratidal and midtidal zones of shallow and sheltered localities of sea, gulf, bays, backwaters and lagoons. They are submerged monocotyledonous plants and adapted to the marine environment for completion of their life cycle under water. They occur along the Coromandel coast, West coast and Andaman and Nicobar islands. They form a dense meadow on sandy and coral rubble bottoms and sometimes in the crevices underwater. On the basis of survey work carried out mainly in Chilka lake, Andaman and Nicobar islands and, some parts of Gujarat coast it is noticed that only 14 species are found along the Indian Coast. The dominant species are *Cymodocea rotundata, Enhalus acoroides, Halodule pinifolia, H. uninervis, H. wightii, Halophila beccarii, H. decipiens, H. ovalis, H. ovata, H. stipulacea, Syringodium isoetifolium, Thalassia hemprichii* and others. About 9 species of seagrasses are extensively growing in Andaman & Nicobar islands. The unique ecological importance of the seagrasses for the conservation of rare and endangered animals like marine turtles, Dugongs, some common echinoderms, juvenile prawns and fishes is very well known. Therefore, exhaustive studies on the seagrasses especially along the west coast should be given priority.

SEAWEED COMMUNITY

The seaweeds prefer somewhat flat and rocky coastal wetlands, gradually sloping towards the sea with marked tidal effect of complete submergence during high tide and successive exposure during low tide. The distribution of such weeds extend from open shore formations to intertidal lagoons, bays, rockpools, puddles or in creeks and inlets beyond the low tide mark along the infralittoral regions of the coast. The seaweeds exhibit the luxuriance both in growth and number along the West coast, Andaman & Nicobar islands, Lakshadweep and Minicoy. Except the places like Chilka, Pamban, and Cape Comorin, their occurence in East coast is very scanty.

The coastal wetlands are well known for greater diversity as well as greater degree of specialization in structure and function of their constituent ecosystem. Here, variation of ecological processes and composition of biological components in a graded sequence within a short topographic changes are very distinct.

About 120 species of seaweeds have so far been collected from the coastal wetlands in India. Some of the important seaweeds are *Enteromorpha compressa, Ulva lactuca, Acetabularia crenulata, Dictyosphaeria cavernosa, Chaetomorpha* sp., *Caulerpa corynephora, C. peltata, Codium iyengarii, C. tomentosum, Halimeda macroloba, Dictyota atomarica, Ectocarpus breviatticulatus, Padina tetrastromatica, Gracilaria verlicoides, Polysiphonia variegata, Grateloupia indica, Sargassum duplicatum* and others. These plant communities serve as sustainable life support in the field of food, shelter, fertilizer, production of iodine, potash, glue, agar, algin, vitamins, antibiotics and others. The detailed studies on Indian seaweeds, their survey, quantitative assessment and different problems for extracting valuable products for commercial export are required to be given more attention.

STATEWISE CHARACTERISTICS OF COASTAL PLANT DIVERSITY

WEST COAST

The West coast is divided into 6 distinct parts from north to south which are represented as follows:

Gujarat coast

This extends along the peninsulas of Kutch and Saurashtra and includes a portion of areas south of Cambay, up to the borders of Konkan coast. This coast is divisible under three subtypes: Kutch, Saurashtra and Southern Gujarat.

(i) Kutch coast

The coastal area of Kutch is surrounded on the south by the Gulf of Kutch and on the west by the Arabian sea. The coast gently rises and is fringed with mangrove swamps. A separate chapter on Kutch coast is already dealt in the text.

The strand flora of the area is similar to that of Sind (Pakistan). Further, the reported occurrence of plants like *Astragalus prolixus, Heliotropium renifolium, Spinifex littoreus, Scaveola taccada, Peganum harmala, Tamarix articulata,* is of great distributional interest as these plants do not occur in the adjacent peninsular coast of Saurashtra.

(ii) Saurashtra coast

The coast line is bounded by the Arabian sea in the south and southwest, by the Gulf of Kutch in the northwest and by the Gulf of Cambay and mainland in the east. The coastal area can be divided into three sub types: (a) the coast line from the mouth of the Gulf of Kutch to Okhamandal, (b) the coast line from Okhamandal to Diu and (c) the coastline from Diu to Gopnath, continued up to Amli. These have been studied from an ecological point of view since 1960 (Rao, 1969; Rao & Safui, 1963; Rao & Banerjee, 1964; Rao & Agarwal 1966; Rao & Shanware 1967a, b; Rao *et al.*, 1963, 1964, 1966; Shah, 1962; Satyanarayana, 1958). The coastline bordering the Gulf of Kutch and Cambay is muddy with limited strand conditions, whereas the coast lines from Okhamandal to Diu and also from Diu to Gopnath are fringed with wind blown sand humps often intercepted by rocky cliffs. Rock and sand strands are frequently seen along this coast line. The recent ecological studies have revealed that the northwestern half of Saurashtra coast, more or less coresponding to that of arid zone is botanically similar to that of Kutch strand flora and the south eastern area bordering the Gulf of Cambay corresponding to the semi arid zone to the Konkan coast. The western or Persio-Arabian elements like *Asparagus dumosus, Capparis cartilaginea, Helichrysum cutchicum, Sericostema pauciflorum, Limonium stocksii, Lotus garcinii* and *Euphorbia nivulia* are well represented in the arid coastal area. However, their frequency diminishes towards the south-eastern areas of semi arid zone where the flora is represented by Indian, Malaysian and Polynesian coastal elements like *Ipomoea pes-caprae, Sesuvium portulacastrum, Hydrophylax maritima, Borreria articularis, Psilostachys sericea, Launaea sarmentosa, Canavalia maritima* and *Hyphaena indica.*

(iii) Gujarat coast (South of the river Narmada)

The coast line south of Narmada up to Daman is marshy and intercepted infrequently by sandy shores of limited stretches. The recorded sand strand flora mostly correspond to the Indo-malayan elements. The note worthy features of strand plants are the northern limit of *Spinifex littoreus* at Daman, occurrence of *Zoysia matrella* at Daman, *Perotis indica* at Daman and the absence of *Calophyllum inophyllum* along the Gujarat coast lines. The frequent occurrence of *Hyphaene indica* in the Diu Kodinar sector of Saurashtra coast is reported along the Daman coast.

Konkan coast (Maharashtra state)

The coast extends from north of Goa to Daman, with a distance of 500 km, and is more or less cliffy, occasionally intercepted by sandy beaches of limited length over littoral concrete. The northern part under riverine and tidal influence becomes muddy otherwise the coast is of jutting headlands and often covered with a thick mantle of sand.

The ecological information on the strand flora is scanty. The development of rich strand flora in the form of strand forests is not seen anywhere along the coast due to paucity of extensive strand conditions. Along the sea shores of the areas south of Daman including Bombay and Salsette island there are innumerable marshy areas fringed with mangroves, and only in raised grounds with less salinity there are saline pastures chiefly represented by *Aeluropus lagopoides, Paspalum vaginatum, Digitaria sp., Sporobolus virginicus* and *Fimbristylis* sp. The newly recorded occurrence of *Psilostachys sericea* on Juhu sands near Bombay is of great interest. *Cyperus pedunculatus* a strand creeper has been reported from Marmagaon and its north of Goa is very much limited and distribution not so extensive as in the coastal Karnataka and Kerala.

Karnataka coast (Karnataka)

The Karnataka coast extends about 225 km and is comparatively wider in the south than in the north. The coast line is sandy and rocky.

The noteworthy strand plants of this area are *Scaevola taccada, S. plumieri, Cyperus pedunculatus, Crotalaria nana* and *Anotis carnosa, Euphorbia atoto, Indigofera aspalathoides* and *I. uniflora*. Their frequency of occurrence is more in this coast than in the Konkan coast.

Ipomoea tuba shows extensive occurrence along the coast. The other interesting plants reported are *Acrostichum aureum*, a salt tolerant fern and *Flagellaria indica* on rock strand.

Malabar coast (Kerala state)

The Malabar or Kerala coast extends from the north of Kasargod to Travancore district in the south. The coast extends about 500 km with an average width of 25 km and altitude ranges from 10 to 30 m. This area bounds in lakes and back water systems, most of them are connected to the sea.

The interesting feature of the strand flora is the occurrence of *Parsonsia helicandra*, *Wedelia biflora*, *Canavalia maritima*, and *Barringtonia racemosa* under the coastal influence. Another noteworthy plant is *Scaveola taccada*, a coral sand indicator widely represented near by coral islands. The rare plants which are common to this coast and that of Karnataka are *Cyperus pedunculatus*, *Flagellaria indica*, *Calophyllum decipiens* and *Acrostichum aureum*. A fairly wide spread plant *Euphorbia rosea* of this coast has not been recorded from Karnataka coast. Similarly the strand climber *Mucuna gigantea* is not reported from the Karnataka coastal area.

EAST COAST

The physiographic area of East coast from north to south is divisible into four distinct parts viz. Bengal coast, Utkal, Andhra and Tamil Nadu coasts corresponding to the respective states.

Bengal coast (West Bengal state)

The West Bengal coast is divisible into two parts viz. Midnapur coast and the Gangetic Sundarbans with the river Hoogly forming numerous creeks and channels between them. The Sundarban is a swampy tidal delta of 4200 sq. km in 24-Parganas where the sandy areas are limited and a few are along the sea face.

The contribution towards this coastal flora is that of Prain (1903). Along the limited sea face consistent vegetation is seen. The coastal strand flora and some other characteristic elements of Utkal coast are also present in this area. The new addition to strand flora in this region is the occurrence of *Aeluropus lagopoides* on saline strand bordering the eastern bank of the liver Hoogly, at Sagar island and Junput.

The sandy coastal strip from Hoogly towards south to the mouth of Suvarnarekha river forms a part of the Midnapur coast, in West Bengal. The sand strand is composed of plant species like *Spinifex littoreus, Launaea sarmentosa, Cyperus arenarius, Borreria articularis, Polycarpaea corymbosa, Polygala erioptera, Ipomoea pes-caprae, Sida cordifolia* and *Jatropha gossypifolia.* This floristic composition is similar to that of the adjacent Utkal coast except three widely spread Utkal strand plants viz. *Euphorbia rosea, Geniosporum tenuiflorum and Hydrophylax maritima.* In this area the other recorded plants of strand dune habitat of Utkal coast are *Cyperus arenarius, Portulaca pilosa, Syzygium ruscifolium* (Mukherjee & Banerjee, 1968), *Gisekia parnaceoides, Rothia indica, Trianthema triquetra* and *Spinifex littoreus* (Rao *et al.* 1966, 1967).

Utkal coast (Orissa state)

The coast covers an area situated from a little north of Suvarnarekha river to a little south of the Rushikulya river including the Mahanadi delta and the coastal lagoon of Chilka. The strand flora is very conspicuous and sometimes strand forests are also observed at certain places.

The interesting components of strand flora are *spinifex littoreus, Euphorbia rosea, Phyllanthus rotundifolius, Fimbristylis junciformis, Geniosporum tenuiflorum* and *Hydrophylax maritima.* The other plants recorded from this coast are *Merope angulata, Myriostachya wightiana* and *Ipomoea tuba.*

Andhra coast (Andhra Pradesh)

The Andhra coast extends from the southern limit of the Ulkal plains to the Pulicat lake and conforms more or less to Andhra Pradesh state boundary. It includes the Krishna and Godavari delta, and the coast line conforms to rocky and sandy types.

The interesting report is the occurrence of *Psilostachys sericea* at Nellore sea sands. This handsome herb is reported in Saurashtra coast and Bombay coast near Juhu. It shows restricted distribution and has not spread widely along other similar situations. The other plants of interest are *Aeluropus lagopoides*, *Indigofera aspalathoides*, *Ipomoea tuba*, *Trianthema triquetra*, *Trachys muricata*, *Dimorphocalyx* sp. *Myriostachya wightiana*, etc.

Tamil Nadu coast

The Tamil Nadu coast extends from the southern limit of Pulicat lake to point Calimere and conforms to Tamil Nadu state boundary stretching about 675 km with an average width of 100 km. and includes the Cauvery delta with marshy spots in the southern parts. The noteworthy strand plants of this area are *Scaevola plumieri*, *Breweria evolvuloides*, *Heterostemma tanjorense*, *Sesamum prostratum* and *Nesaea lanceolata*. *Pemphis acidula*, a coral stone indicator is reported from the southern rocky areas of the coast. *Halopyrum mucronatum* – a widely spread coastal grass reported from Karnataka, Saurashtra coasts and Kurusadai group of islands has been reported at the southern tip of the coast. *Sesamum prostratum* occurs on sandy shore at Adyar near Madras. Species *Myriostachya wightiana* has been reported at Vedharanyam along this coast (Sebastine *et al.*, 1967).

The coast line bordering the southern strip from point Calimere to Cape Comorin including that of a few leading islands of the Gulf of Mannar like Rameswaram, Kurusadai, Shingle, Hare and Church exhibits strand flora which is akin to that of Ceylon coast. Pure strand scrub forests of *Pemphis acidula* is characteristic of all islands except Rameswaram. The chief components of strand flora are *Pemphis acidula*, *Suriana maritima*, *Thespesia populnea*, *Halopyrum mucronatum*, *Scaevola taccada*, *S. plumieri*, *Ipomoea pes-caprae* and *Spinifex littoreus*.

The reported occurrence of *Messerchimidia argentea* on the shores of Kurusadai island is obviously a newly invaded strand pioneer from Sri Lanka. This invader is a potential forest builder and if left undisturbed this may regenerate to a great extent to become a strand forest. The occurrence of *Polycarpaea spicata*, known in West coast along Saurashtra coast, Lakshadweep group of islands and also in small islands of the coast of Jaffna (Sri Lanka) is of great interest. Similarly occurrence of *Suriana maritima* and *Cordia subcordata* of Sri Lanka strand flora is interesting.

ASSESSMENT OF COASTAL PLANT DIVERSITY

The Coastal plant diversity in India comprises about 550 genera and 978 species under 132 families (Table I). Similarly species showing maximum diversity in East and West coasts are presented in the Table II.

Table I
A conspectus of families showing number of genera and species

Family	Genera	Species
Dilleniaceae	1	1
Annonaceae	3	5
Menispermaceae	5	6
Nymphaeaceae	1	2
Papaveraceae	1	1
Brassicaceae	1	2
Capparaceae	5	10
Violaceae	1	1
Flacourtiaceae	3	3
Polygalaceae	2	5
Caryophyllaceae	2	3
Portulacaceae	1	3
Tamaricaceae	1	4
Elatinaceae	1	3
Clusiaceae	1	3
Malvaceae	11	22
Sterculiaceae	7	14
Tiliaceae	4	14
Elaeocarpaceae	1	1
Linaceae	2	2
Erythroxylaceae	1	1

Family	Genera	Species
Zygophyllaceae	4	4
Oxalidaceae	2	2
Balsaminaceae	1	1
Rutaceae	5	5
Simaroubaceae	1	1
Surianaceae	1	1
Ochnaceae	1	1
Meliaceae	5	8
Olacaceae	1	1
Opiliaceae	1	1
Celastraceae	1	1
Rhamnaceae	3	6
Vitaceae	2	3
Leeaceae	1	1
Sapindaceae	6	6
Anacardiaceae	5	5
Hippocrateaceae	1	1
Connaraceae	1	1
Papilionaceae	39	99
Caesalpiniaceae	9	14
Mimosaceae	7	14
Vahliaceae	1	2
Crassulaceae	1	3
Droseraceae	1	3
Haloragaceae	1	1
Rhizophoraceae	5	11
Combretaceae	3	7

Family	Genera	Species
Myrtaceae	2	3
Melastomataceae	3	4
Lythraceae	4	5
Barringtoniaceae	2	4
Sonneratiaceae	1	4
Onagraceae	1	3
Passifloraceae	1	2
Cucurbitaceae	9	15
Begoniaceae	1	1
Cactaceae	1	1
Aizoaceae	6	9
Apiaceae	1	1
Rubiaceae	14	25
Asteraceae	31	41
Goodeniaceae	1	2
Sphenocleaceae	1	1
Plumbaginaceae	1	1
Myrsinaceae	2	2
Sapotaceae	2	3
Ebenaceae	1	5
Symplocaceae	1	1
Oleaceae	2	3
Salvadoraceae	2	3
Apocynaceae	7	10
Asclepiadaceae	16	19
Periplocaceae	1	1
Loganiaceae	1	1
Gentianaceae	4	5

Family	Genera	Species
Menyanthaceae	1	3
Hydrophyllaceae	1	1
Boraginaceae	8	17
Convolvulaceae	8	19
Solanaceae	6	10
Scrophulariaceae	16	21
Lentibulariaceae	1	10
Gesneriaceae	2	2
Pedaliaceae	3	4
Acanthaceae	14	23
Verbenaceae	6	11
Avicenniaceae	1	4
Lamiaceae	10	18
Nyctaginaceae	4	5
Amaranthaceae	11	19
Chenopodiaceae	5	11
Basellaceae	1	1
Polygonaceae	3	5
Aristolochiaceae	2	4
Piperaceae	2	2
Lauraceae	2	3
Hernandiaceae	2	2
Loranthaceae	2	5
Santalaceae	1	1
Euphorbiaceae	22	46
Moraceae	3	6
Urticaceae	2	2
Casuarinaceae	1	1
Salicaceae	1	1

Family	Genera	Species
Ceratophyllaceae	1	1
Cycadaceae	1	1
Hydrocharitaceae	7	8
Burmanniaceae	1	1
Orchidaceae	18	30
Zingiberaceae	1	1
Haemodoraceae	1	1
Amaryllidaceae	1	2
Dioscoreaceae	1	3
Smilacaceae	1	1
Liliaceae	3	5
Pontederiaceae	2	2
Xyridaceae	1	2
Commelinaceae	3	13
Flagellariaceae	1	1
Arecaceae	2	2
Pandanaceae	1	1
Typhaceae	1	1
Araceae	1	1
Lemnaceae	1	1
Alismataceae	3	4
Aponogetonaceae	1	2
Potamogetonaceae	2	2
Ruppiaceae	1	1
Najadaceae	1	2
Eriocaulaceae	1	1
Cyperaceae	10	33
Poaceae	59	120

Table II

Families showing maximum diversity in the East and West coasts

Name of the Family	No. of Species	
	West coast	East coast
Leguminosae (*s.l.*)	126	98
Poaceae	121	30
Asteraceae	40	37
Euphorbiaceae	39	38
Cyperaceae	33	33
Orchidaceae	28	21
Acanthaceae	27	21
Rubiaceae	22	23
Malvaceae	21	19
Scrophulariaceae	18	19

PHYTOGEOGRAPHY

Coastal vegetation in India is a mixture of Afro-Perso-Arabian/ Western and Indo-Malayan/Eastern elements or Polynesian and Australian affinity. Besides, a few rare, endemic or elements of localised distribution also occur. The terrestrial estuarine flora distributed in the tidal mangrove zones is derived chiefly from Malaysian and Polynesian elements.

The eastern elements, the distributional range of which covers Myanmar, Malay Peninsula, Australia and Polynesia, are represented by the species like *Allmania nodiflora, Bauhinia anguina, Calophyllum inophyllum, Calotropis gigantea, Cordia subcordata, Clerodendrum inerme, Cyperus penduncutatus, Ipomoea macrantha, I. pes-caprae, Heritiera littoralis, Morinda citrifolia, Oldenlandia diffusa, Pemphis acidula, Scaevola plumieri, S. taccada, Scyphiphora hydrophyllacea, Spinifex littoreus* and *Xyris indica*. Many of these species extend up to South-Western Indian Peninsula from Malaysian Islands through Malacca, Tenasserim, Sundarbans and Coromandel coast. *Eulophia epidendraea, Heterostemma tanjorense* and *Sesamum prostratum* are plants strictly from the Coromandel coast. The disjunct occurrence of *Psilostachys sericea* from Saurashtra and Bombay and at Nellore in Coromandel coast is of considerable interest. The strand flora of Sri Lanka is well represented along the southern shores of Tamil Nadu including the islands in the Gulf of Mannar.

Along with many new records, the recent discovery of the following new taxa from the coromandel coast proves the rich botanical wealth of this region. Some of these are *Dichrostachys santapaui, Geniosporum prostratum* var. *longiracemosum, Halophila ovalis* subsp. *ramamurthiana, Jatropha maheshwarii, J. tanjorensis, J. villosa* var. *ramnadensis, Melhania balakrishnanii, Polygala raoi* and *Theriophonum sivaganganum.*

RARE TAXA

Rare and endangered species along the Indian coast are many. However, a preliminary list of some endangered species in the Indian coastal region is given in the table III.

Table III
Some rare and endangered species

Botanical name	Distribution
Acalypha brachystachya	Only in Krusadi islands
Acalypha malabarica	Only in Saurastra coast
Acroceras munroanum	Only in West Bengal and Kerala coast
Adelocaryum coelstinum	Only in Karnataka and Kerala coast.
Aegialitis rotundifolia	Only in Orissa and West Bengal
Aeluropus lagopoides	Rare in West Bengal, Andhra Pradesh & Gujarat
Anisochilus carnosus	Only in Kerala coast
Aristolochia tagala	Rare in Tamil Nadu and Karnataka
Arundinella ciliata	Endemic to S. India
Asparagus gonocladus	Only in Gujarat coast

Botanical name	Distribution
Barringtonia asiatica	Only in Andaman & Nicobar
Borreria ocymoides	Only in Rameswaram island.
Capsicum frutescens	Only in Lakshadweep
Centranthera indica	Only in Lakshadweep
Cordia subcordata	Only in W. coast.
Crotalaria burhia	Only in Gujarat coast
Cryptocoryne ciliata	Only in Orissa and West Bengal coast
Cycus rumphii	Only Andaman
Digitaria bicornis	Only in Kerala coast
D. griffithii	Only in Kerala coast
Dimeria lowsonii	Endemic to S. India
Dipteracanthus prostratus	Only in Lakshadweep
Ehretia canarensis	Only in Karnataka coast.
Eragrostis subcordata	Only in Kerala
Euphorbia atoto	Only Lakshadweep and Kunda pur coast.
E. caducifolia	Only in Gujarat coast
E. heterophylla	Saurastra coast
Eusteralis stellata	Only in Kerala coast
Finlaysonia obovata	Only in Bengal and Orissa coast.
Halophila ovalis	Only in Coramandel coast
Halophila stipulacea	Only in Coromandel coast
Helichyrsum cutchicum	Only in Gujarat
Heliotropium crispum	Only in Saurastra coast.
Heritiera kanikensis	New species recorded from Bitarkanika forest, Orissa.
Hernandia peltata	Only in Andaman coast
Hewittia scandens	Only in Lakshadweep and Gulf of Mannar

Botanical name	Distribution
Indigofera argentea	Only in Gujarat coast
Ischaemum santapaui	Only in Maharastra coast
I. travancorense	Fisher endemic to Kerala coast
I. vembanadense	Only in Kerala coast
Jatropha glandulifera	Only in Rameswaram island
Kedrostis rostrata	Only in Gujarat coast
Launaea residifolia	Only in Gujarat
Leucas wightiana	Rare in Gujarat coast only
Lindenbergia muraria	Only in Saurastra coast
Litsea nitida	Only in Orissa coast
Lotus garcini	Only in Gujarat coast
Manilkara littoralis	Only in Andaman
Merope angulata	Only in Orissa
Nothosaerua brachiata	Only in Karnataka and Kerala
Ochrosia oppositifolia	Only in Andaman
Oldenlandia stricta	Only in Orissa and Nellore
Parsonsia albofloreseens	Only in Kerala
Pisonia aculeata	Rare only in Karnataka coast
Pluchea arguta	Only in Gujarat
Pluchea indica	Only in Gujarat
Pulicaria angustifolia	Rare in Gujarat & Karnataka
Rourea minor	First recorded from Mahanadi Delta Paradweep, Orissa
Sacciolepis myosuroides	Only in Karnataka
Salacia chinensis	Rare in Andaman
Salvadora oleoides	Only in Gujarat
Scaevola plumieri	Only in Andaman & Lakshadweep
Scyphiphora hydrophyllacea	Only Godavari and Andaman

Botanical name	Distribution
Sebastiania chamaelea	Only rare in Kerala coast
Senna incana	Endemic in Gujarat, Kutch
Sericostoma pauciflorum	Only in Lakshadweep island.
Sesuvium sesuvioides	Only in Gujarat coast
Sphenoclea zeylanica	Rare only in Orissa and Tamil Nadu
Suaeda fruticosa	Gujarat coast, New record for Godavari and Krishna.
Suriana maritima	Only reported in Lakshadweep
Thuarea involuta	Only in Gujarat coastal mainland
Urochondra setulosa	Only in Gujarat coast
Xylocarpus moluccensis	Only in Andaman

THREATS AND CONSERVATION

Dry and wet coastal plant communities provide basic sustenance for millions of people both directly and indirectly from the amenities provided by the resources. Besides, the function of stabilizing the shore and reducing coastal erosion, it serves an ideal base for pisciculture, crabs, crocodile farming, nesting ground of many migratory birds, turtles and many endangered animals including the Royal Bengal Tiger. Depending upon these resources many big cities, towns and villages have come up along the Indian coast and more than 221 million people have settled in those areas.

Certain developmental work and industries in the coastal areas, require special attention. A number of thermal plants have been set up in the coastal areas from time to time. More are coming up. The thermal plants cause serious threats to the coastal environment such as, discharge of hot water which can harm the aquatic flora and fauna. Ash may be dumped in the sea, causing damage to water quality and sea bed contours or may cause under stable landfills. Fly ash and emission may cause air pollution and harm the flora and fauna. All these require strict control. One very important aspect is the disposal of nuclear waste in the sea water. Such wastes dumped in the sea may cause disaster and vigil has to be kept against such occurrence. Quarrying operation in the coastal areas is on the increase. Rocks are being blasted, excavated and extracted affecting the natural ranges, the water flow and flora and fauna. Corals are being removed and used as building and construction materials for roads and housing.

Though there are various institutes in India conducting survey and identification of coastal and marine plant resources but recently Department of Ocean Development with the consultation of various scientists in India has estimated about 44 locations in India to be declared as Ecologically Sensitive Coastal and Marine Zones. These areas need detailed survey, collection and monitoring for coastal and marine resources. A list of the areas is as follows:

1. Sundarban 2. Lothian Island 3. Bhitarkanika 4. Gaharimata 5. Mahanadi Delta 6. Hookitola & Bharkhanashi 7. Jambu Island 8. Kansardian & Bharkhanashi 9. Chilka Lake 10. Godavari Delta 11. Sarcomanto Island 12. Coringa 13. Krishna Delta 14. Muthupalam 15. Ellichitadibba 16. Nizampatanam 17. Pulicat Lake 18. Kolleru Lake 19. Cauveri Delta in Pichavaram 20. Palk strait 21. Palk Bay 22. Gulf of Mannar 23. Vedaranyam 24. Tuticorin 25. Asthamundi Lake 26. Vambanad Lake 27. Cochi 28. Ernakulum 29. Calicut 30. Karwar 31. Cundapur 32. Honovar 33. Ratnagiri 34. Mangalore 35. Malpac 36. Gokaran 37. Bombay 38. Goa 39. Malvan 40. Diu Islands 41. Gulf of Cambay 42. Saurashtra 43. Gulf of Kutch 44. Rann of Kutch.

Preparation of database for coastal and marine plants with the help of sophisticated computer network is urgently necessary for monitoring the sustainable uses, protection and conservation of the valuable resources but before that, some gaps in the survey and identification of coastal and marine plants should be taken due care. The following are some major gaps which require immediate attention.

1. To study the mangroves and salt marshes in the backwaters and lagoons.
2. Detailed survey of coastal and marine fungi specially the actinomycetes.
3. Survey and estimation for seasonal population growth of phytoplankton and periphyton in coastal and marine ecosystems.

4. Micro and macro algae and sea grass population along the coral reefs.

5. Sea grass study along the West coast and lagoons.

6. Bacterial population on the seasonal pattern and especially in polluted water surface of marine coastal lagoon waters.

7. Status survey of rare, threatened and endangered marine and coastal plant diversity.

For environmental protection of the coastal areas, the Government of India has issued directions under the Environment (Protection) Act, 1986. Coastal Regulation Zone (CRZ) is defined to be the area between the low tide and the high tide line and 500 metres of land above the high tide line.

Restrictions have been imposed on the setting up and expansion of industries operations etc. in the CRZ. Certain activities are prohibited in the CRZ. These include new industries other than those requiring waterfront or off shore facilities like ports and harbours, ship repairs and ship building. Discharge of untreated wastes and effluents form industries and human settlements are strictly prohibited. Land reclamation, building, disturbance to the natural flow of sea water, harvesting or drawal of ground water and dressing or altering sand dunes, hills, natural features, etc. are totally prohibited.

For regulating developmental activities the coastal stretches within 500 metres are classified into four categories. The first category consists of areas, which ecologically sensitive and important, such as, national parks, reserve forests, wild life habitats, mangroves, coral reefs, breeding and spawning grounds of fish and other marine life, and areas likely to be inundated due to rise in the sea level consequent upon global warming. Obviously, these areas require total protection from activities, which are likely to disturb the ecological balance. Another important category is the area form the high tide line to 200 metres landward. This is the "no development zone" where no construction is permitted. The permitted activities are agriculture, horticulture, gardens, pastures parks, play fields, forestry and salt manufacture from sea water. Other categories consist of areas on which activities are permitted in varying but controlled degrees. Areas requiring special protection include the coasts of Andaman and Nicobar islands and Lakswadweep.

The state governments are required to prepare the coastal zone management plans for the coastal areas in their respective states. There are, however, a number of non-governmental organisations (NGO) that are very actively working for protection of the coasts. Mangroves constitute the main forest ecosystem in the coastal areas. Mangrove management plans are being formulated and implemented as parts of the coastal developmental plans. Management of mangroves has already been discussed separately under the chapter of mangroves.

A unique experiment is being tried during the last few years to see the efficiency of mangrove for controlling erosion in the coastal areas. It was felt that instead of engineering measures at the huge cost, biological measures could give better results at much low expenditure. The vegetation is also helping in mitigating the air and water pollution emanating from the industries and habitation in the developing towns.

In coastal areas, the main occupations of the people are agriculture and fishing. High salinity, submergence of land by tidal water and disturbed climatic conditions like strong wind and cyclones effect the agriculture adversely all along the coastal belt. Unplanned agriculture also leads to soil erosion where soil is being washed away to sea. This causes loss of fertile top soil and causes further erosion by quick water run off. Most of the coastal areas have only one crop a year. Cash crop is grown in some coastal belt. Cashew nuts, areca nuts, coconuts, bananas etc. are cultivated in these areas. For economic benefit of the people in the coastal belts, agriculture should be planned in a manner to suit the geographical and physical conditions of the coastal areas.

The conservation of biodiversity is increasingly receiving 'Stepdaughter' treatment by many government authorities. The major reason is that loss of biodiversity is a silent crisis, and most people do not understand the changes taking place. Persons who make decisions that affect coastal ecosystems are usually not aware of the consequences. Therefore, the paradigm underlying biodiversity conservation has to be more 'people-oriented' to gain support. Experts commonly lack in depth of knowledge and experience of the local society, situations and context, which inevitably a recipe for failure. Implementation will only be successful if management plans are 'owned' and understood by all the relevant local groups of protagonists, including district administrators and private enterprises.

Man and the environment have to find their due places in the holistic approach. Man's needs have to be met keeping in mind the requirements for sustainable development. It is necessary to conduct extensive studies into the physical conditions of the coastal areas and the socio-economic condition of the people inhabitating these areas. Environmental Impact Assessment for the different types of activities and for major units of industry, beach resorts, ports and harbours etc. should be conducted and appropriate, environmental management plans should be drawn up. The Union Government, the Governments of the coastal States, the Panchyats of the coastal areas and the voluntary organizations and above all the people of these areas are required to join hands in environmental protection conservation and planned use of resources in the coastal land and sea.

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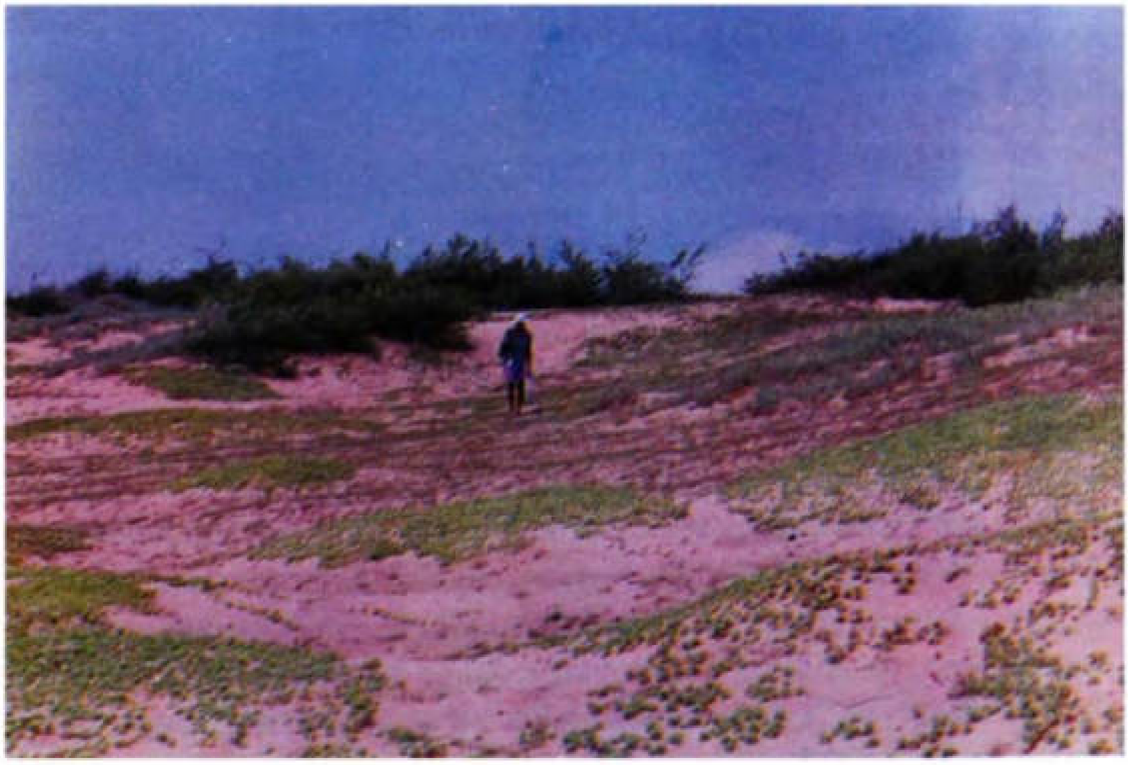


Hydrophylax maritima (fore ground) and *Spinifex littoreus* (back ground) - dunes vegetation.

Borassus flabellifer - pure stand; *Casuarina equisetifolia* (on ground).

KUTCH

M.J. Kothari
N.P. Singh

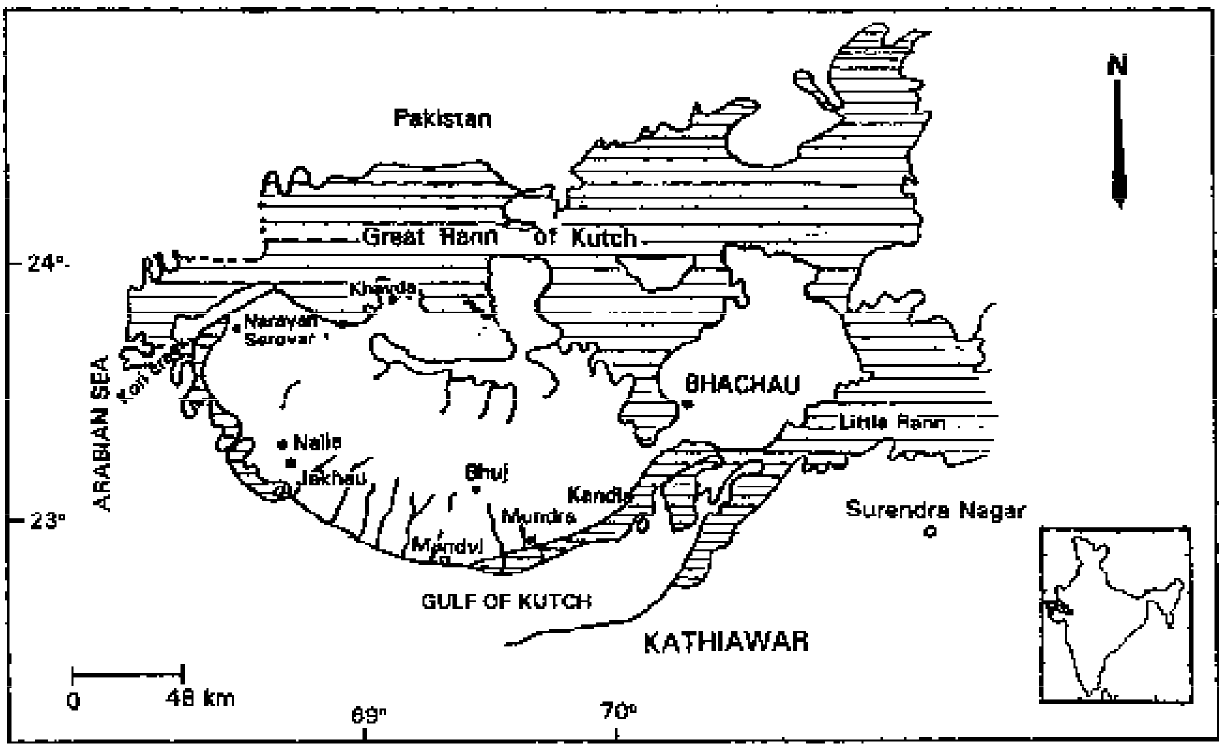
The salt deserts form a unique ecosystem in Indian flora and hence an effort is made here to present the floristic diversity of Kutch desert in the state of Gujarat.

The area lies in the western extremity of India between 22°44' 11" 24° 41' 25" N latitude and 68° 09' 46"-71° 51' 47" E longitude. It is bounded on the north by great Rann of Kutch; on the north-west by Sind (Pakistan); on the west and south-west by Arabian sea; on the south by Gulf of Kutch and on the south-east by Surendranagar district and little Rann of Kutch. The small peninsula of Kutch is isolated by great Rann of the south-east. Its central position forms the table land sloping on all sides and gives the shape like a 'tortoise'. The Rann is a dry bed of the remnant of an arm of the sea which once connected the Narmada rift with Sindh and separated Kutch from the mainland. In the middle region, there are three chains of hillocks towards east-west and north side and the plateau region 'Banni', which is a recognised wide grassland (Map).

The soil of Kutch is derived from sand and lime stone rocks. It is of three types viz. (i) Gravelly and laterite soils on hill tops, that are intermixed with large pebbles and stones on slopes, (ii) transported soil on foot hills is intermixed with alluvium of the plains and (iii) the soil in low lying coastal areas is sandy.

The rainfall is most irregular and scattered in the area. The average annual rainfall is *ca* 350 mm. Due to scanty and irregular rainfall, Rann of Kutch experiences frequent famine.

The maximum temperature recorded in the months of April and May is *ca* 45° C and minimum in cold season up to 11° C. Sometimes it goes down upto -4° C (Nalia in Abdasa Taluka). The climate varies from place to place. It is subhumid, semiarid and arid depending upon the locality conditions. The climate in general is dry throughout the area.


Pakistan
Great Rann of Kutch
24°
Khavda
Narayan Sarovar
ARABIAN SEA
Kori Creek
BHACHAU
Little Rann
Naliа
Jakhau
Bhuj
Kandla
23°
Mundra
Mandvi
Surendra Nagar
GULF OF KUTCH
KATHIAWAR
N
0
48 km
69°
70°

Map of Kutch

VEGETATION

Palin (1880) and Blatter (1908-09) published a list of Kutch plants without any precise locality. Thakar (1926) presented a comprehensive account of 611 plants along with their descriptions and uses in the regional language-Gujarati. Thereafter floristic lists of Kutch plants were published by Puri *et al.* (1960), Jain (1960), Jain and Kanodia (1960), Jain and Deshpande (1960), Bhandari (1965), etc. Subsequently Shah (1978) published Flora of Gujarat state where he made reference of Kutch plants. Raghavan *et al.* (1981) from Botanical Survey of India also presented a check list of Gujarat plants where *ca* 695 species were from Kutch. Kothari and Hajra (1983) reported *ca* 62 rare and threatened plants from Gujarat and Rajasthan region, including 12 species from Kutch (Kothari, 1988, 1991). Sabnis and Rao (1983) also made observations on some (*ca* 13) rare and endemic species of south-eastern Kutch. The vegetation and plants of Kutch desert are summarised by Kothari and Singh (1995) in the national language-Hindi.

Out of *ca* 42,909 sq. km area of the district, 50% is almost saline desert with little or no vegetation and 43% is under grazing land, crop fields and wastelands, whereas the forest vegetation occupies only 7% (2,921 sq. km) of the area. The vegetation of Kutch has been classified as 'Indian desert' by Clarke (1898), whereas Hooker (1907) and Chatterjee (1939) put it under 'Indus plains'. Champion and Seth (1968) classified plants of Kutch under Tropical thorn forests. Pandya and Sidha (1985) studied floristic composition of Kutch plants into four forest associations as under.

1. *Prosopis juliflora* - *Salvadora persica*
2. *Acacia nilotica* - *Prosopis cineraria*
3. *Euphorbia* - *Commiphora* - *Acacia senegal* and
4. *A. senegal* *Prosopis cineraria* etc.

The vegetation in Kutch as reported by Shah (1978) is mainly composed of scrub forests in plains and mangrove forests along saline coastal strips and borders of Kutch.

Scrub forests

Rann of Kutch, especially the barren plain areas like Khavda are dominated by spiny or thorny scrub forests. The main components of these forests are *Acacia nilotica* ssp. *indica*, *A. leucophloea*, *A. senegal*, *Balanites aegyptiaca, Capparis decidua, C. sepiaria, Commiphora wightii, Dichrostachys cinerea, Euphorbia caducifolia, Fagonia indica* var. *schweinfurthii, Limonia acidissima, Periploca aphylla, Prosopis cineraria, Ziziphus nummularia,* etc.

Mangrove forests

These type of forests are found especially in saline, muddy and creek areas near sea shore of Kutch e.g. Mandvi, Mundra, Jakhau, Narayan Sarovar etc. Among mangroves, *Avicennia marina* var. *acutissima, A. marina* var. *marina* and *A. officinalis* are common and dominant species. Other members of the community are *Avicennia alba, Aegiceras corniculatum, Ceriops tagal, Rhizophora mucronata,* etc.

There are number of species found along the saline areas and sandy coast in scattered or in the colonial form. These are *Aeluropus lagopoides, Aerva lanata, Cressa cretica, Cyperus arenarius, Evolvulus alsinoides, Indigofera cordifolia, Launaea sarmentosa, Limonium stocksii, Spinifex littoreus, Vitex negundo,* etc. On salt marshes and mud flats, species found are *Arthrocnemum indicum, Halopyrum mucronatum, Salicornia brachiata, Sericostoma pauciflorum, Sesuvium portulacastrum, Suaeda fruticosa, S. nudiflora,* etc.

Some common herbs occurring on road sides, wastelands and among hedges of cultivated fields are *Achyranthes aspera, Amaranthus spinosus, Boerhavia diffusa, Calotropis procera, Cassia auriculata, C. occidentalis, C. tora, Cleome viscosa, Clerodendrum inerme, Corchorus capsularis, Euphorbia tirucalli, Lawsonia inermis, Lantana camara, Martynia annua, Melilotus indica, Sida acuta, Solanum surattense, Tephrosia purpurea, Urena lobata,* etc. The wastelands form the largest parts of Kutch, next only to Rann and are not suitable for normal agricultural practices due to high salinity of the soil. Species like *Chenopodium album, Crotalaria burhia, Indigofera oblongifolia, Solanum indicum* and *Tribulus terrestris* are found in such areas (Babu *et al.*, 1992).

Some grasses also occur on sand or in moist places as scattered patches of various sizes. These are *Aristida adscensionis, Arundinella pumila, Cenchrus biflorus, Chloris barbata, Cynodon dactylon, Dactyloctenium aegyptium, Desmostachya bipinnata, Digitaria adscendens, Eleusine compressa, Heteropogon contortus, Paspalidium* *flavidum, Perotis indica, Sporobolus diander, Urochondra setulosa,* etc. Some sedges like *Cyperus exaltatus, C. halpan, C. rotundus, Eleocharis geniculata, Fimbristylis dichotoma* and *Juncus maritimus* are also found in moist places.

Along the river banks *Tamarix aphylla, T. dioica* and *T. troupii* are common and predominant. Similarly some hydrophytes like *Hydrilla verticillata, Nelumbo nucifera, Vallisneria spiralis,* etc. also occur in ponds and ditches. Besides, some parasitic species like *Cuscuta reflexa, Dendrophthoe falcata, Orobanche aegyptiaca* and *Striga asiatica* occur as stem or root parasites.

In addition to above natural forests, man-made forests locally known as 'Rakhals' maintained by forest department are also found in desert of Kutch. The monocultured or mixed cultured species grown here are *Acacia nilotica* ssp. *indica, Prosopis juliflora* and *Salvadora oleoides.*

FLORISTIC DIVERSITY

The flora of Kutch is represented by 637 species of angiosperms distributed in 367 genera and 92 families (Puri *et al.* 1960). The statistical details are presented in tables I, II and III.

Table I
Number of family, genera and species of angiosperms in Kutch flora

	Dicotyledons		Monocotyledons		
	No.	Percentage	No.	Percentage	Total
Family	77	83.69	15	16.31	92
Genera	295	80.38	72	19.62	367
Species	518	81.30	119	18.70	637

Among 637 species of angiosperms, 518 species, 295 genera and 77 families are represented in dicots, while 15 monocot families comprise 72 genera and 119 species. If we calculate the dicot, monocot ratio according to family, genera and species it comes to 5.2: 4.0: 4.4. Mean family ratio is greater than generic and specific ones. There is not much difference between specific and generic ratio.

Table II
Dominant families according to number of species, in Kutch, India and World

Families	No. of species in		
	Kutch	India	World
Leguminosae	76	1320	16,400
Poaceae	72	1259	7,950
Asteraceae	35	1069	21,000
Malvaceae	32	135	1,000
Convolvulaceae	25	186	1,650
Euphorbiaceae	22	528	7,750
Cyperaceae	22	533	3,600
Acanthaceae	21	510	4,350
Amaranthaceae	19	73	850
Cucurbitaceae	18	101	640
Boraginaceae	17	211	2,000

Source : Puri *et al.* (1960); Karthikeyan and Mudgal (1995).

Table III
Dominant families according to number of genera in Kutch, India and World

Families	No. of Genera in		
	Kutch	India	World
Poaceae	44	261	737
Leguminosae	34	194	657
Asteraceae	25	205	1,317
Acanthaceae	12	95	357
Asclepiadaceae	11	59	348
Malvaceae	11	31	75
Euphorbiaceae	10	85	326
Cucurbitaceae	10	39	110
Convolvulaceae	10	28	55
Amaranthaceae	10	20	65
Chenopodiaceae	8	25	102
Cyperaceae	6	38	115

Source : Puri *et al.* (1960); Karthikeyan and Mudgal (1995).

Among eleven dominant families, Leguminosae (*Sensu lato*) with 76 species stands first and Boraginaceae with 17 species stands last in Kutch flora. In India also the position of Leguminosae with 1,320 species ranks first while Boraginaceae with 211 species stands sixth. In India, Amaranthaceae with 73 species stands in last position. In world flora, position of Asteraceae with 21,000 species is first Leguminosae with 16,400 species ranks second while position of Boraginaceae is seventh (Table II).

According to number of genera in Kutch, India and World, family Poaceae with 44 genera and Cyperaceae with 6 genera stand first and last among 12 families in Kutch flora. In India, position of Poaceae with 261 genera is first but position of Cyperaceae with 38 genera is ninth. Family Amaranthaceae stands last (12th) in flora of India, which is tenth in Kutch. In world flora according to number of genera also, position of Asteraceae with 1317 genera is first, family poaceae with 737 genera stands second and family Convolvulaceae with 55 genera stands last (i.e. 12th), while the position of Amaranthaceae is eleventh (Table III).

PHYTOGEOGRAPHY

In Gujarat, *ca* 80% area of Jamnagar and 100% of Kutch are in desert condition, while in some areas like Banaskantha (18%), Mehsana (4%), Ahmedabad (6%), Surendranagar (29%), Rajkot (6%) and Junagadh (20%) form some upper portion of Indian desert. In monsoon, 'Rann of Kutch' is completely filled with sea-water. After the monsoon, the water evaporates due to heat and salt is accumulated in the upper layer of wastelands of Kutch. Such saline lands are also found in south-west part of Saurashtra and Rajasthan deserts. In this extremely hot climate, salty and sandy desert areas of Kutch, Gujarat and Rajasthan especially, heat and salt tolerant species grow. The Desert also provides an effective isolating barrier. Blatter and Hallberg (1920) described 17 new species from Rajasthan, their distribution possibly extending to Sind, Baluchistan and Kutch as well (Raghavan & Singh, 1983).

Therefore, phytogeographically the desert area of Kutch is akin or similar to Sind (Pakistan) and N.W. Rajasthan rather than with any other part of Gujarat. The desert flora of Kutch shows dominance of western elements over eastern or Indo-Malayan. Some elements recorded from Pakistan and Rajasthan also occur in 'Rann of Kutch' e.g. *Campylanthus ramosissimus, Convolvulus stocksii, Commiphora wightii, Dipcadi* *erythaeum* etc. (Singh & Kothari, 1994). The Phytogeographical aspects of the Kutch Flora, its statistical analysis and grasses of Kutch were also presented by Kapadia (1954) and Puri *et al.* (1960).

ENDEMISM

Percentage of endemic elements in Kutch area is very low (*ca* 2%). A few endemic elements are restricted to Kutch and Saurashtra region while others are distributed over the entire northern semi-arid zone (Kothari & Hajra, 1983; Kothari & Singh, 1995). After a scrutiny of literature survey and availability of specimens in different herbaria, according to Kothari and Singh (1995), there are *ca* 18 taxa which are noteworthy in Rann of Kutch. Out of these 2 species are endemic to Kutch and Saurashtra viz. *Helichrysum cutchicum* and *Tamarix kutchensis*. Similarly, 2 species are restricted to Gujarat and Rajasthan viz. *Indigofera coerulea* var. *monosperma* and *Tephrosia collina* var. *lanuginocarpa*, 7 species are known from India and Pakistan while remaining 7 species are found in India, Pakistan and other countries. A list of the former 11 taxa alongwith their distribution etc. is given in Table IV for reference.

Table IV
List of endemic and threatened species

Botanical name	Family	Distribution/Statistics in the area
Helichrysum cutchicum	Asteraceae	Kutch, Saurashtra. In Kutch it is known from 3 localities. Endemic and rare due to habitat destruction (Kothari, 1988).
Tamarix kutchensis	Tamaricaceae	Endemic and rare due to destruction of habitat by natural and biotic factors. So far known from type collection only.
Indigofera coerulea var. *monosperma*	Fabaceae	Gujarat (Kutch, Saurashtra) and Rajasthan. So far known from solitary locality in Kutch and becoming rare due to biotic factors.

Botanical name	Family	Distribution/Statistics in the area
Tephrosia collina var. *lanuginocarpa*	Fabaceae	Gujarat, Rajasthan. Endemic and rare due to habitat destruction.
Campylanthus ramosissimus	Scrophulariaceae	Gujarat (Kutch: Chadua Rakhal) and Pakistan (Sind). There is no specimen in CAL. Rare due to habitat destruction.
Convolvulus stocksii	Convolvulaceae	Gujarat (Kutch), Rajasthan (Barmer) and Pakistan. Rare and threatened due to overgrazing in grasslands of Kutch (Kothari and Hajra, 1983; Sabnis and Rao, 1983).
Heliotropium bacciferum var. *suberosum*	Boraginaceae	Gujarat (Narayan Sarovar and Mandvi in Kutch), Rajasthan and Pakistan. Rare.
H. calcareum	Boraginaceae	Gujarat (Kutch), Rajasthan and Pakistan. Rare. It is known from a solitary locality in Kutch.
Limonium stocksii	Plumbaginaceae	Kutch (Bhadreshwar), Saurashtra and Pakistan. Rare. Known from a solitary locality from Kutch.
Pavonia ceratocarpa	Malvaceae	Gujarat (Kutch, Saurashtra) and Pakistan. Rare. So far known from a sporadic occurence in Gujarat and Sind only.
Sida tiagii	Malvaceae	Kutch, Rajasthan and Pakistan. So far known from a solitary locality in Kutch and scattered in Rajasthan. Rare.

THREATENED AND RARE TAXA

There are *ca* 24 species in Rann of Kutch which are threatened and rare. Out of 24 species, 4 species are endemic and rare in Gujarat and Rajasthan and 7 species are known from adjoining Pakistan (Sind) region as given in table IV above. The remaining 13 species are wides but also rare and threatened in the area due to restricted occurrence and biotic factors. List of additional 13 species is provided in the table V below.

Table V
List of additional rare species

Botanical name	Family	Distribution/Statistics in the area
Aerva javanica var. *bovei*	Amaranthaceae	In Gujarat, it occurs in two localities of Kutch only.
Capparis cartilaginea	Capparaceae	In Gujarat it occurs in Kutch and Saurashtra (Narayan Sarovar) (Babu *et al.*, 1992) Rare.
Chascanum marrubifolium	Verbenaceae	In Gujarat, known from solitary locality only (Babu *et al.*, 1992). Rare.
Cassia senna	Caesalpiniaceae	Known from three localities in Kutch. This species is over exploited in Kutch because of its medicinal properties. Threatened (Sabnis and Rao, 1983).
Commiphora wightii	Burseraceae	Gujarat (Kutch, Saurashtra), Rajasthan, Pakistan and Arabia. Threatened. The species is over-exploited for 'Guggal' - gum resin, used as incence and in medicine (Jain and Sastry, 1980)
Convolvulus auricomus var. *volubilis*	Convolvulaceae	In Gujarat known from Kutch (Nakhtrana), Saurashtra (Babu *et al.*, 1992). Rare.

Botanical name	Family	Distribution/Statistics in the area
Dalechampia scandens var. *cordafana*	Euphorbiaceae	In Gujarat it is known from ravines of Narmada and Mahi, Saurashtra and Kutch (2 localities). Rare.
Dipcadi erythaeum	Liliaceae	Gujarat (Kutch), Rajasthan, Canary island, Pakistan to Egypt. Known from solitary locality in Kutch and becoming rare due to grazing and over exploitation for its edible uses. Vulnerable.
Ipomoea kotschyana	Convolvulaceae	Kutch (3 localities) Ethiopia, Sudan. Very rare. (Babu *et al.*, 1992).
Premna resinosa	Verbenaceae	In India, it occurs in Kutch and Saurashtra; Tropical Africa and Arabia. Rare.
Schweinfurthia papilionacea	Scrophulariaceae	Known from a solitary locality in Kutch. Rare.
S. pterosperma	Scrophulariaceae	Known from 3 localities in Kutch. Rare (Sabnis & Rao, 1983).
Seddera latifolia	Convolvulaceae	In Gujarat, known from Kutch and Saurashtra (Babu *et al.*, 1992) Rare.

ECONOMIC USES

Plant wealth of Kutch is utilized for several economic and medicinal purposes. It is summerised as follows:

I. Economically, a number of plants are used for fodder, fuel, timber and minor forest produce like dyes, gums, resins, tannin etc.

i) ***Fodder and Fuel plants*** : Due to scarcity of water in Rann of Kutch, fodder is very important for domesticated animals. Beside grasses, a number of plants are utilized for fodder e.g. *Acacia nilotica, Prosopis* *cineraria, P. juliflora, Ziziphus nummularia,* etc. All woody species and especially *Acacia senegal, Azadirachta indica, Butea monosperma* etc. are used for fuel (Pandya, 1992). Leaves and fruits of mangroves e.g. *Avicennia* and *Rhizophora* spp. are also utilised as fodder and wood for fuel.

ii) ***Timber plants*** : Forest species like *Acacia nilotica, A. senegal, Albizia lebbeck, Azadirachta indica, Avicennia alba, A. officinalis, Dalbergia sissoo, Lannea coromandelica, Prosopis cineraria,* etc. are utilised for furniture, railway sleepers and telegraph posts etc. Some species with soft wood are utilized for making toys, boxes, match sticks etc. eg. *Erythrina variegata, Haldina cordifolia* and *Mitragyna parvifolia,* etc.

iii) ***Minor forest produce*** : A number of plants used for various preparations are as follows.

a) *Dyes* : *Acacia catechu, Butea monosperma, Indigofera tinctoria, Woodfordia fruticosa,* etc.

b) *Gums and resins* : *Acacia nilotica, Aegiceras corniculatus, Azadirachta indica, Garuga pinnata, Sterculia urens,* etc.

c) *Bidi wrappers* : *Bauhinia racemosa* and *Diospyros melanoxylon* (Tembru).

d) *Soaps and non-edible oil* : *Acacia rugata* ('Shikekai'), *Azadirachta indica, Balanites aegyptiaca, Celastrus paniculatus, Salvadora oleoides,* etc. (Pandya, 1992).

e) *Tannic acid for leather industries* : Bark of *Acacia* spp. *Avicennia* spp., galls of *Tamarix* spp. etc.

f) *Edible fruits* from wild species like *Aegle marmelos, Carissa congesta, Ziziphus mauritiana, Z. nummularia* etc. are taken.

g) *Beverages* : *Phoenix sylvestris, Borassus flabellifer* etc.

II. **Medicinal plants** : Species like *Azadirachta indica, Boerhavia diffusa, Butea monosperma, Calotropis procera, Celastrus paniculatus, Commiphora wightii, Murraya koenigii, Tinospora cordifolia, Tribulus terrestris, Vitex negundo,* etc. are used in preparation of medicines for various diseases.

VULNERABILITY AND MAJOR THREATS

The plants of Kutch are affected by various biotic and abiotic factors. Biotically, overgrazing, over exploitation and mining operations have affected the vegetation of Kutch desert to a maximum. Over 2,500 camels of Rabari are dependent on browsing of mangroves in Kutch and Saurashtra which resulted in the stunted growth of *Avicennia* spp. Similiarly, over-exploitation of green leaves and fruits for cattle fodder and wood for fuel have also affected growth and development of mangroves (Kulkarni, 1959; Kothari & Singh, 1995). Besides, a few plants have become rare, threatened and vulnerable due to overexploitation for medicinal purposes e.g. *Cassia senna* and *Commiphora wightii* etc. (Jain & Sastry, 1980; Kothari & Hajra, 1983; Sabnis & Rao, 1983; Babu *et al.* 1992; Singh & Kothari, 1994).

The mining operations around Narayan Sarover which is denotified as *Mauled Sanctuary* in July 1993 in Lakhpat Taluka, Kutch is affected as the limestone and lignite miners are gouging out huge swathes of the sanctuary. Because of which the rare flora and fauna viz. *Commiphora wightii* (Meetha guggal) and the pangolin, caracal, desert cat and the great Indian bustard etc. have become endangered.

Abiotically, high temperature, extreme dry climate, scanty rainfall and constant drought famine conditions from 1973 to 1975 and 1984 to 1987 have affected the growth of mangroves and other vegetation (Kothari & Singh, 1995). The adverse climate coupled with extremely high temperature in Kutch resulted in scrubby mangroves (Waheed, 1959). According to H.S. Singh (1996), abiotic ecological factors, hydrological conditions, tide current and water depth during maximum tide, soil salinity and soil structure are main agents controlling the distribution of species composition of mangrove community. Therefore, mangroves growing in semi-arid region of gulf of Kutch are different from the tidal forests of other states.

Other factors affecting the vegetation are land clearing, development of man made forests (monoculture) and industrial pollution. The result of all such detrimental activities will finally lead to the depletion of plant wealth in Rann of Kutch.

CONSERVATION MEASURES

The importance of protection of forests in Kutch areas was realised much earlier by Maharaja of Kutch who demarcated certain areas like "Chadua Rakhal and Nadi baug" as reserved and protected forests where biotic activities like grazing, cutting and felling of tress were strictly prohibited. This helped in conservation and development of some spiny and non spiny trees in these forests (Sabnis & Rao, 1983; Kothari & Singh, 1995).

The man made forests of *Casuarina equisetifolia* and *Syzygium cumini* developed by private or Government bodies near sea shore and other areas for various reasons like creating shelter belts, green belts or for fire-wood purposes have helped in protection of soil from "erosion", especially along the sea shore. Of course, this monoculture has resulted to some extent in the loss of few wild plants and floristic diversity. In order to avoid illegal extraction of timber from forests by local inhabitants for fuel purposes, 'charcoal depots' at subsidised rates can be established in nearby forest areas by the Government and authorised private bodies.

Kutch desert faces problem of "fodder" for domesticated animals during drought or famine. Leaves and fruits of *Avicennia* spp. (mangrove) have proved to have much fodder value, as compared to *Medicago sativa* (Ranjko) and maize grain (reported from Animal nutrition station, Anand, Gujarat dated 2.6.1988). Hence, large scale cultivation of *Avicennia* spp. in saline areas near sea-shore may be encouraged to solve the 'fodder' problem of Kutch (Kothari & Rao, 1991). Government of India, through Ministry of Environment & Forests has also taken up certain essential conservation measures and established the Marine National Parks at Mundra and Jakhau to protect fragile ecosystem like mangroves and wetland plants. In addition, 5 Wildlife Sanctuaries viz. Kutch bustard Wildlife Sanctuary (*ca* 2.03 sq. km), Kutch desert Wildlife Sanctuary (*ca* 120.82 sq. km), Marine (Gulf of Kutch) Wildlife Sanctuary (*ca* 457.92 sq. km), Narayan Sarovar Wildlife Sanctuary (*ca* 120.82 sq. km) and Wild Ass Sanctuary (*ca* 4953.70 sq. km) have also been established for conservation of endangered fauna and flora of the Kutch region. These concrete steps will certainly help to conserve the saline desert ecosystem and floristic diversity of Kutch provided necessary co-operation from local inhabitants and Non-Government Organisations (NGO) is forthcoming.

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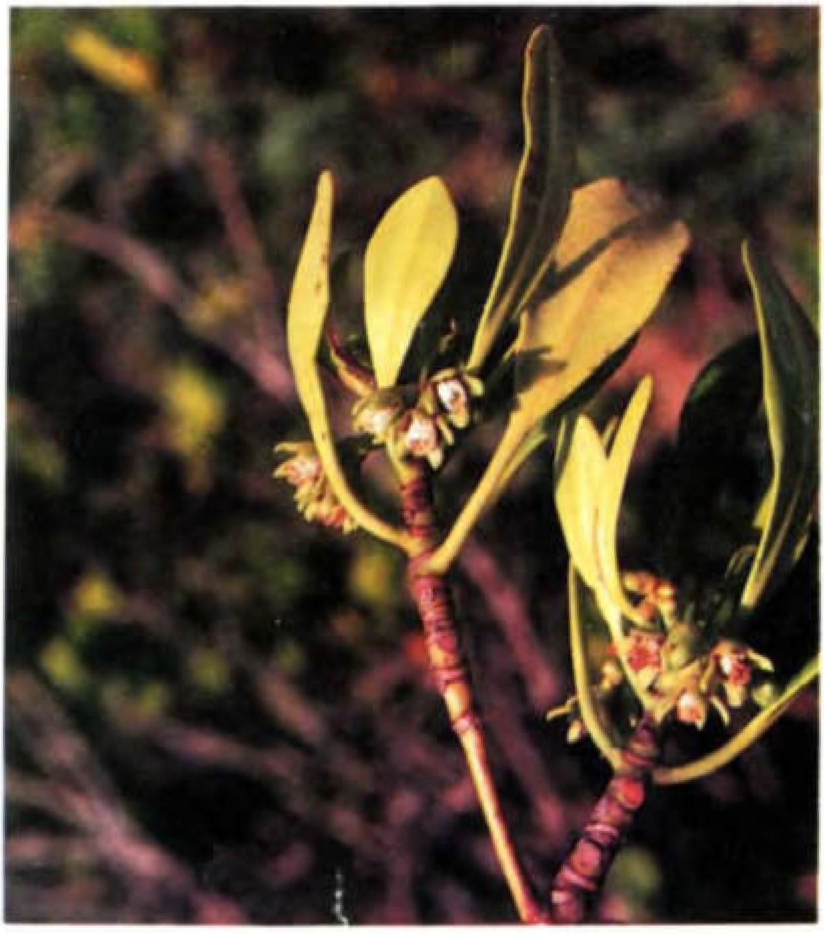
Cressa cretica - a pure community.

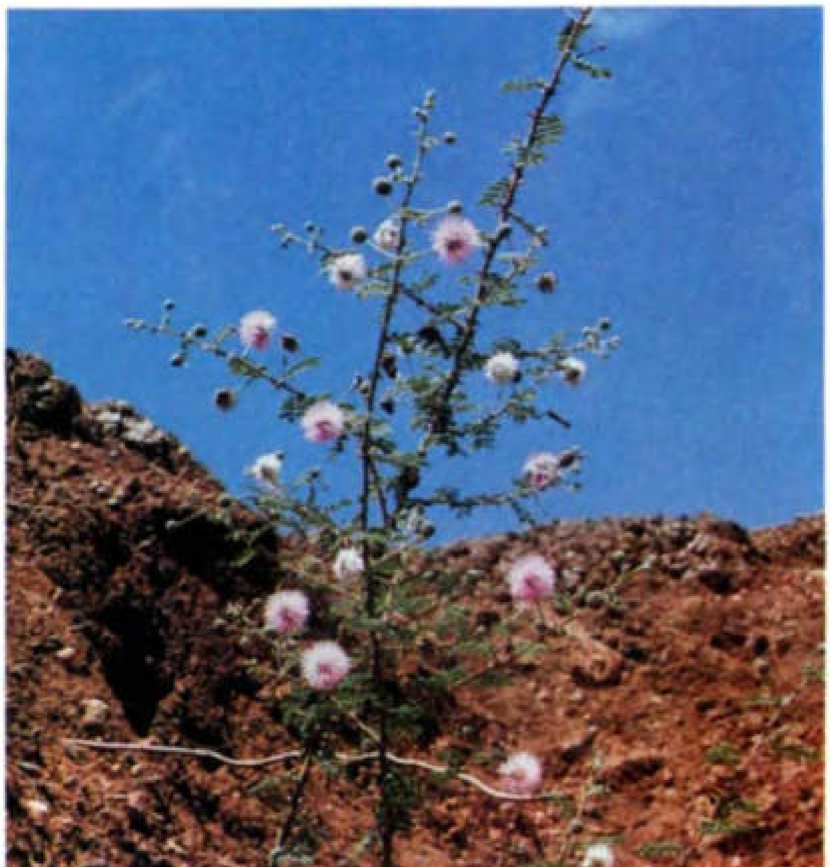
Avicennia marina var. *acutissima*

Avicennia marina var. *marina*



Ceriops tagal

Aegiceras corniculatum



Dichrostachys cinerea

Acacia leucophloea

MANGROVES

L.K. Banerjee

Portuguese were probably the first foreigners to visit mangrove forests along the Indian coast around 14th century and called them "Mangue" In 'Surinum', the common name of *Rhizophora mangle* is known as "Mangrow" In Malayan language plants growing under tidal influences and producing arched aerial roots are referred to as "Mangil" Macnae (1968) gave the term Mangrove for individual plant species and the term "Mangal" for plant community.

'Mangroves' can be defined as a group of plant species taxonomically isolated and remarkably successful in colonizing the intertidal zone at the interface between land and the sea along the banks of estuaries, creeks and canals of deltas, shallow lagoons and backwaters.

In general, mangroves are found mainly in the tropical and subtropical sheltered coastline with dark green shining foliage and negatively geotropic roots. They show maximum modification in their morphology, physiology and bio-chemical activities with superficial adaptive characters like pneumatophores, stilt roots and vivipary for withstanding partly submerged saline situation. It can only extend its spread upto the limit of saline tide water flow.

Best mangrove formations are seen where the tidal regime is normal with a constant mixing of sea water and fresh water. The temperature does not go below 20°C. Soil is mostly alluvial in nature with high salt and water contents and low oxygen and high hydrogen sulphides. Rain fall remains 2000-3000 mm per year.

Though species diversity is very low in this ecosystem due to dominance of large physiological forces of saline tide water and lack of stable substrate, but it commands the highest importance by virtue of its biological productivity, specialized adaptive diversity, complexity in the ecological processes and finally the importance of the biodiversity resources which are used directly or indirectly. Besides the economic significance, they help in maintaining atmospheric equilibrium, checking soil erosion, stabilizing the coastline, building new islands or areas, acting as a wind breaker to protect storms and cyclones and providing protection to many important wildlife habitats including those of Royal Bengal Tigers.

About 6740 sq. km littoral region including deltas, estuaries, backwaters, bay islands and lagoons in India is protected by extensive cover of mangals (mangrove community) which is the third largest formation in the world after Indonesia and Australia. In India, the distribution of mangrove diversity is found in Andaman and Nicobar group of Oceanic islands; Sundarbans in the Gangetic delta of W. Bengal; Mahanadi deltaic complex of Orissa coast; Coringa, Godavari and Krishna delta of Andhra Pradesh; Khambat, Cambay, Saurashtra and Kutch in Gujarat; Bombay, Ratnagiri, Malvan, Devgad and Vijayadurg in Maharashtra; Mandovi-zuari estuary of Goa; Coondapur, Hannover and Malpe in Karnataka and Kochi, Vembanad, Quilon, Trivandrum, Kananore, Kozhikod and Kottayam in Kerala state.

Studies on Indian mangroves were initiated as early as 17th century when van Rheede for the first time in 1686-1703 provided a scientific account on Indian ocean mangroves *in "Hortus Malabaricus"* Roxburgh (1814) described the flora of Sundarbans in "*Hortus Bengalensis*". Clarke (1896) also provided an account of the Sundarbans. Prain (1903) published the flora of Sundarbans in the Records of Botanical Survey of India.

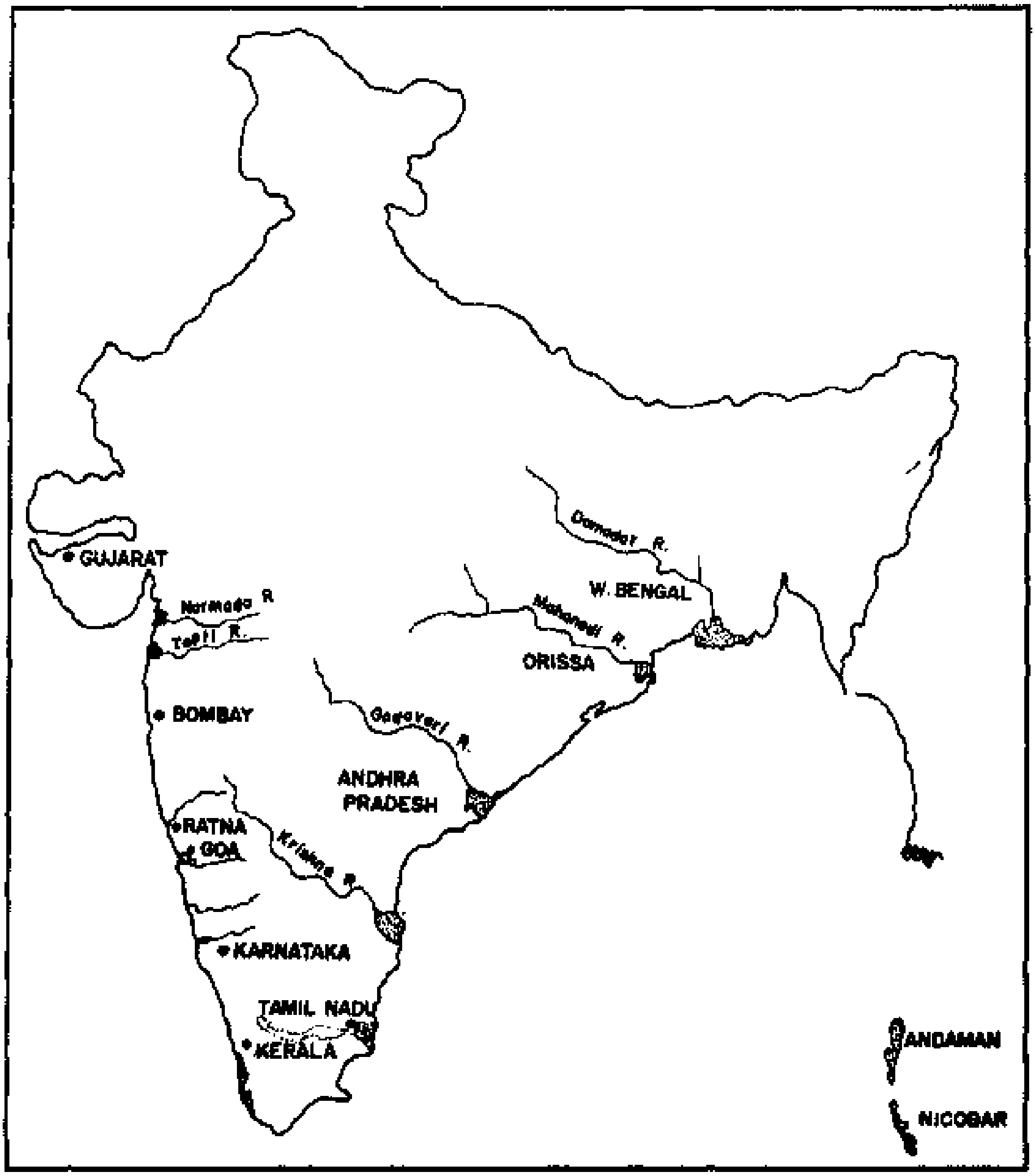
Subsequently during 20th century many workers viz., Hooker (1872-1897), Blatter (1905), Cook (1908), Cown (1928) Curtis (1933), Champion (1936), Ding (1958), Griffith (1936), Cornwell (1937), Navalkar (1951), Krishnamurty *et al.* (1987), Untawale (1982, 1984), Naskar and Guhabaksi (1982), Banerjee (1987), Banerjee and Rao (1990), and Banerjee *et al.*, (1989a, 1989b), Forsberg (1971), Jagtap (1985, 1992), Joshi (1933), Khan (1965), etc. have contributed significantly to the knowledge of mangroves.

MANGROVE VEGETATION

Structure of vegetation, richness of species, association and zonation of mangroves vary from East to West coast. There are four phases of development in mangrove vegetation such as Estuarine mangroves, Riverine true mangroves, Riverine semi mangroves and Riverine transitional mangroves which are well represented in the Sundarbans and in the Mahanadi delta of the East coast. This may be due to regular supply of fresh water flow from various rivers and innumerable ramifications of the river system. Starting from the Godavari-Krishna delta towards the Tamil Nadu, Karnataka, Kerala, Maharashtra, Goa, and Andaman and Nicobar islands, the Riverine semi mangrove formation is completely absent, thereby suggesting that the mangrove vegetation has developed in three phases along these areas due to lack of some ecological factors, specially less influence of fresh water flow. Again in Gujarat coast only Jamnagar, Pirotan island and Tapi river mouth are dominated by Estuarine mangrove formations with very little trace of Riverine true mangrove zone but throughout the Gulf of Khambat, and Western side of the Gulf of Kutch up to the border of Pakistan, the vegetation forms a climatic climax and except the Estuarine mangrove formation, no other formations are found. Therefore it is evident that the mangrove species diversity gradually tapers from the Sundarbans and is much less along the west coast in Kerala to Saurashtra and ends in a single species dominated regions along the Gulf of Khambat and extreme west of Gulf of Kutch regions.

Mangroves of the East coast

Sundarbans, the largest deltaic complex of the world are formed by the sediments deposited by the three great rivers, the Ganga, Brahmaputra and Meghna. Almost 62% of the delta falls under Bangladesh and remaining 38% lies within India. The Indian and Bangladesh parts of the Sundarbans together comprise the largest continuous mangrove block in the world. Vegetation in the Indian Sundarbans, covering 4200 sq. km in district of 24 Parganas in West Bengal is fully covered with dense growth of mangroves on the unstable substrate and saline tide water flow. Here salinity and tidal amplitude vary seasonally and according to the impact of salinity and tidal flow the associations of different mangrove species are found in different zones. Along the estuarine mouth *Avicennia marina, Aegialitis rotundifolia, Bruguiera parviflora, Ceriops tagal, Sonneratia griffithii, Porteresia coarctata* and others are dominant. Along the Riverine true mangrove zone where the areas are associated with more number of creeks and channels, *Rhizophora apiculata, Rhizophora mucronata, Kandelia candel, Aegiceras corniculatum, Bruguiera gymnorrhiza, Xylocarpus granatum, Xylocarpus mekongensis, Sonneratia apetala, Avicennia alba, Excoecaria agallocha, Ceriops decandra* are dominant. In the Riverine semi mangrove zone where soil surface is more clayey and influence of fresh water flow is more, *Heritiera fomes, Cynometra iripa, Cerbera manghas, Intsia bijuga, Excoecaria agallocha, Brownlowia tersa, Aglaia cucullata* and others are dominant. In the Riverine transitional mangrove zone where the areas are mainly influenced by the high spring tide, *Clerodendrum inerme, Dalbergia spinosa, Acanthus ilicifolius, Derris* sp. *Thespesia populnea* and others are dominant. *Phoenix paludosa*, the palm which serves as den of the Royal Bengal Tiger is



Map : Mangroves of India

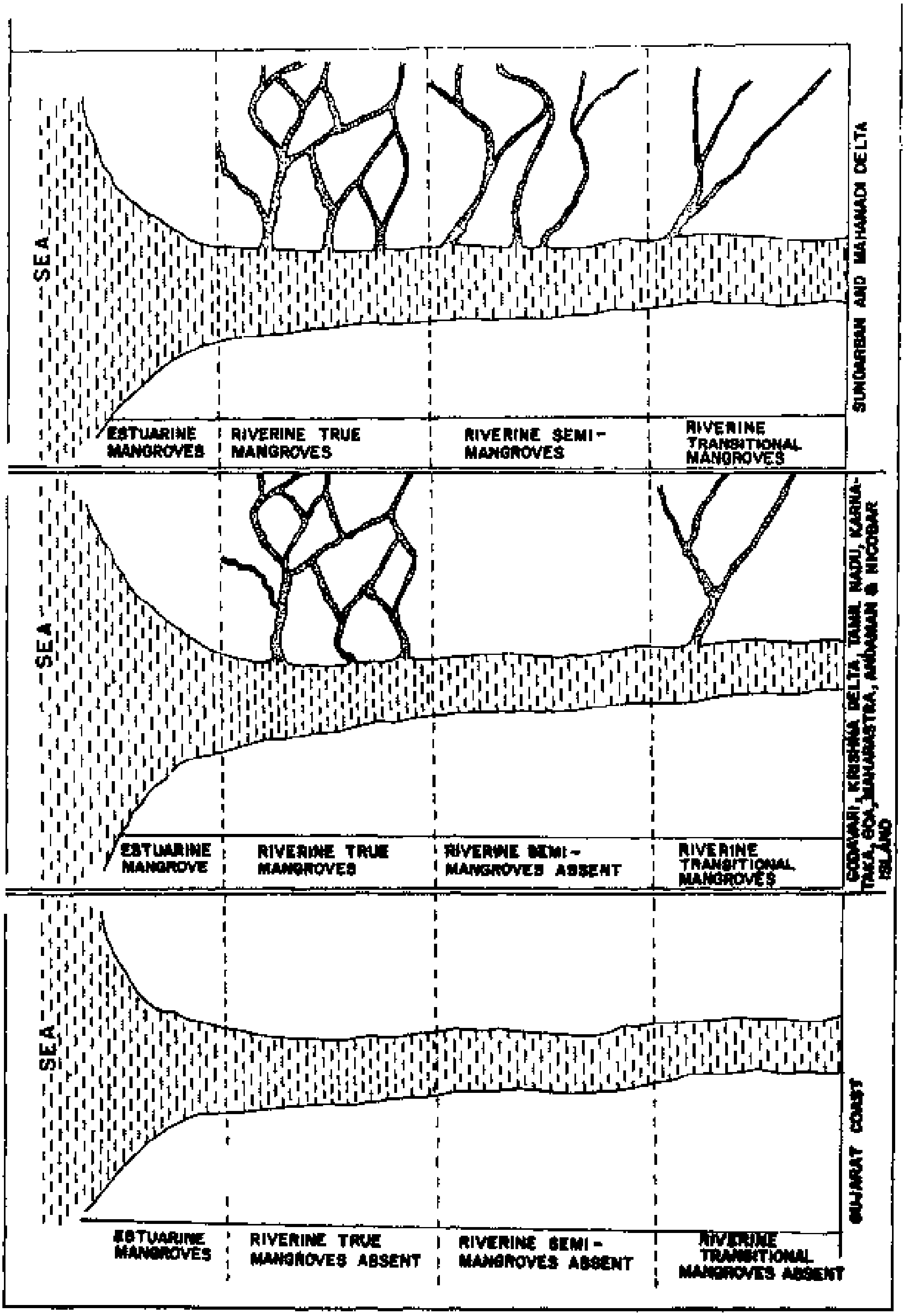
dominant as pure stand on elevated fringes. The mangrove fern, *Acrostichum aureum* generally colonizes towards the back mangrove areas where soil and pH are abruptly changed. Salt marshes dominated by *Suaeda, Salicornia* and other species are frequently found along the degraded areas. Mangrove vegetation of the Mahanadi delta in Orissa covers an area of only 215 sq. km. Due to influence of many fresh water rivers in the Batighar, Karisardiom, Jambu, Hookitola, Bhitarkanika, Ghaurimata and Thakurdian, the structure of the vegetation becomes more unique than that of Sundarbans. All the four developmental phases along with all mangrove species except *Nypa fruticans* are present within this small area. Moreover, this small area harbours some interesting species such as *Heritiera littoralis, Rizophora stylosa, Sonneratia alba* which are not found in the Sundarbans. Formation of salt marshes and pure strand of *Phoenix* and *Acrostichum* are also common in this delta.

Mangrove vegetation of the Godavari-Krishna delta in Andhra Pradesh, covering an area of 200 sq. km shows a regression due to less fresh water influence and large scale over- exploitation and reclamation. Vegetation in this delta is developed in three developmental phases. The Riverine semi mangrove stage is completely absent and therefore, the species diversity is much less in comparison with the Sundarbans and that of the Mahanadi delta. The species compositions in the 1st, 2nd and 4th developmental phases of the vegetation are the same in this delta as found in the Sundarbans and Mahanadi delta. The speciality of the vegetation structure in this delta is the occurrence of *Scyphiphora hydrophyllacea,* a member of family Rubiaceae that is restricted only in Andaman Islands. *Nypa fruticans, Phoenix paludosa, Heritiera fomes, H. littoralis, Brownlowia tersa, Aglaia cucullata* and even *Acrostichum aureum* are also not found in this delta. Due to large scale exploitation and some ecological changes, vast areas of the mangrove vegetation are transformed into salt marsh formations and here the species of *Suaeda, Salicornea, Arthocnimum* and others are dominant.

Mangrove vegetation of the Cauvery delta in Tamil Nadu covers about 150 sq. km area. Due to discontinuity of its topographic condition and lack of fresh water flow, majority of the mangroves are shifted to the Pichamvaram and Muthupet areas. Vegetation structure of these reserve forests represents the same three developmental phases as found in Godavari-Krishna delta. Except *Scyphiphora hydrophyllacea*, all mangrove species present in the Godavari-Krishna delta are dominant. The main speciality of the vegetation is the luxuriant growth of *Rhizophora apiculata*, *R. mucronata* and one new hybrid species *R. annamalaica* which seems to be *R. stylosa*. Recently it is estimated that only 14 mangroves species are from the Pichamvaram areas. Mangrove vegetation of these areas has been degraded due to several anthropogenic factors and reduced supply of fresh water.

Mangroves of the West coast

The mangrove vegetation along the west coast is mostly a fringe mangrove formation and is formed due to absence of large deltas, less


SEA
ESTUARINE MANGROVES
RIVERINE TRUE MANGROVES
RIVERINE SEMI-MANGROVES
RIVERINE TRANSITIONAL MANGROVES
SUNDARBAN AND MAHANADI DELTA
SEA
ESTUARINE MANGROVE
RIVERINE TRUE MANGROVES
RIVERINE SEMI-MANGROVES ABSENT
RIVERINE TRANSITIONAL MANGROVES
GODAVARI, KRISHNA DELTA, TAMIL NADU, KARNATAKA, GOA, MAHARASTRA, ANDAMAN & NICOBAR ISLAND
SEA
ESTUARINE MANGROVES
RIVERINE TRUE MANGROVES ABSENT
RIVERINE SEMI-MANGROVES ABSENT
RIVERINE TRANSITIONAL MANGROVES ABSENT
GUJARAT COAST

number of rivers, distributories and less fresh water supply. Only in certain estuarine and backwater parts of Maharashtra, Goa, Karnataka, Kerala and Gujarat where favourable conditions prevail, mangrove vegetation develops densely along those regions. However, the species diversity along the West coast is much less than that of the East coast formations.

Mangrove vegetation of Maharashtra covers 300 sq. km area along tidal river creeks and backwaters of Achara, Deogadh, Vijaydurg, Ratnagiri, Kundalica and Mumbra-diva of Mumbai region. Vegetation structure in some parts of this area is well developed and consists of estuarine mangroves like *Avicennia marina, Lumnitzera racemosa, Porteresia coarctata*; riverine true mangroves with *Rhizophora apiculata, R. mucronata, Kandelia candel, Ceriops tagal, Sonneratia alba, Bruguiera gymnorrhiza, B. cylindrica, Aegiceras corniculatum* and riverine transitional mangroves with *Excoecaria agallocha, Clerodendrum inerme, Derris heterophylla* and *Acanthus ilicifolius*. Many areas in the state of Maharashtra under mangrove vegetation have been degraded and lost due to land reclamation, over exploitation and coastal industrial pollution. The species of *Lumnitzera, Rhizophora* and *Bruguiera* which were once common in Bandra areas have almost disappeared. This area is now represented with very low vegetation cover of *Avicennia marina* and *Acanthus ilicifolius*. Speciality of the mangrove vegetation in the Ratnagiri coast is the luxuriant growth of *Sonneratia alba*.

Mangroves of Goa coast

The total mangrove vegetation area along the Goa coast is estimated about 200 sq. km (Anon., 1987; Dwivedi *et al.*, 1974), of which 90% mangroves occur along the Mandovi-Cumbarjua canal-Zuari estuarine complex and other parts of Galgibag, Talpona, Sal, Chapora and Terekhol rivers mouth. The vegetation structure is also developed in three developmental stages with *Avicennia marina* along the estuarine mouth, *Rhizophora mucronata, Rhizophora apiculata, Kandelia candel, Avicennia officinalis, Sonneratia alba, Aegiceras corniculatum* in the riverine true mangrove phase and *Excoecaria agallocha, Derris heterophylla, Acrostichum aureum, Acanthus ilicifolius* along the riverine transitional phase. The mangrove flora of Goa regions comprises of 15 to 18 species.

Mangroves of Karnataka

The mangrove vegetation of Karnataka covers an area of about 90 sq. km, spreading along river Kalinadi, Belamdar nadi, and in the areas of Danga valley, Agnashini, Sharavati, Karki, Haldipur, Dhareswar, Honavar and Coondapur. The formation of mangrove vegetation is mainly of fringe type and occurs along the inter tidal regions of estuaries, backwaters and other inter tidal protected areas. The structure of vegetation here also develops in three phases like Maharashtra and Goa. The dense vegetation of *Avicennia marina* and *Avicennia alba* along with *Lumnitzera racemosa* are dominant in the estuarine mangrove zone. *Rhizophora mucronata, Rhizophora apiculata, Kandelia candel, Aegiceras corniculatum, Sonneratia alba, Sonneratia caseolaris, Excoecaria agallocha, Ceriops tagal* and others are found in the riverine true mangrove zone. *Acanthus ilicifolius, Derris uliginosa, Derris scandens, Cerbera manghas, Thespesia populnea* and *Acrostichum aureum* are dominant in the riverine transitional mangrove zone. Hanovar and Coondapur represent the good areas of mangrove vegetation with rich floristic diversity. Species like *Ceriops tagal, Cerbera manghas* and *Sonneratia alba* grow luxuriantly and interesting features of the vegetation. The fern *Acrostichum aureum* grows densely along the back mangrove areas and along the banks of backwaters.

Mangroves of Kerala

The mangrove vegetation of Kerala covers an area of about 17 sq. km, spreading over the entire backwater system, lagoons and some of the inter tidal areas of Cochi, Vembanad, Quilon, Trivandrum, Kannanor, Kozhikod and Kottayam. The general structure of the mangrove vegetation has been repeatedly damaged due to agriculture, coconut plantations, pisciculture and other over exploitation activities. Due to some private ownership of the mangrove forest areas, the total mangrove areas of Kerala state have been much reduced. The present vegetation structure along the Cochi, Quilon, Kannanor and Kottayam reveals that it forms three developmental stages similar to that of Karnataka state. The dominant species are *Avicennia officinalis, A. marina, Bruguiera cylindrica, B. parviflora, B. gymnorrhiza, Rhizophora apiculata, R. mucronata, Sonneratia caseolaris, Ceriops tagal, Cerbera manghas, Dolichandrone spathacea, Acanthus ilicifolius, Derris heterophylla* and others.

Mangroves of Lakshadweep

The Lakshadweep comprises 36 islands. Due to absence of clay materials the ecological conditions are not suitable for the growth of mangroves in these islands. However, there is a small patch of *Bruguiera parviflora* in the Minicoy islands.

Mangroves of Andaman and Nicobar islands

The mangrove vegetation of the Andaman and Nicobar islands covers an area of 1190 sq. km. These oceanic islands are surrounded by sea water. The source of fresh water in these regions is mainly due to heavy rainfall and the water from the small rivers and streams flowing from the adjacent hill ranges. Mangrove vegetation of these islands also shows three types of developmental phases. But the structure of vegetation is completely different as compared to that of mainland mangroves. The luxuriant growth of *Rhizophora apiculata, R. mucronata, Bruguiera parviflora, B. cylindrica, Sonneratia griffithii, Heritiera littoralis, Nypa fruticans, Phoenix paludosa* and *Xylocarpus granatum* are very interesting. The detail study on the growth pattern and the impact of ecological factors require urgent attention. The speciality of this vegetation is the impenetrable formation of *Nypa fruticans* and *Rhizophora apiculata* along the inner side of the creeks and canals and the occurrence of *Xylocarpus moluccensis, Lumnitzera littorea, Scyphiphora hydrophyllacea, Heritiera littoralis, Acanthus ebracteatus,* which are not common in the inland mangrove vegetation.

Mangroves of Gujarat coast

According to Forest Survey of India 1997 report, total area of mangrove vegetation is 991 sq. km. But in recent survey it is estimated as 1324 sq. km (Singh, 1999). According to this estimate, the areawise mangrove vegetation cover in Gujarat stands second after the Sundarbans. The large part of the mangrove along the Gulf of Kutch and the Gulf of Khambat is in a different ecological situation as compared to other mangrove areas of the country. Climatically the area is influenced by open coastal environment with formation of coastal desert or arid open mudflats. Restricted flow of the rivers and construction of several dams inhibit the flow of freshwater to the mangrove vegetation. Majority of the old forest areas are destroyed due to several anthropogenic factors. Areas like

Jamnagar, Pirotan island, Tapi river mouth are dominated by estuarine mangrove formation with very little trace of riverine true mangrove type, but throughout the gulf of Khambat and western side of the Gulf of Kutch up to border of Pakistan, the vegetation forms a climatic climax and except the estuarine mangrove formation it is dominated by a single species, *Avicennia marina*. The Gulf of Khambhat and western side of the Gulf of Kutch are dominated by *Avicennia marina* and its varieties with the association of *Urochondra setulosa*, a grass forming pure community along the tidal creeks and shallow mud flats. Besides this formation of *Avicennia marina*, some upland areas are completely covered with salt marshes, dominated *by Atriplex stocksii, Salicornia brachiata, Suaeda fruticosa, Tamarix troupii* and others. Areas along Jamnagar, Tapi river mouth, and eastern part of the Gulf of Kutch are dominated by *Avicennia marina* along with sparse distribution of *Avicennia officinalis, Rhizophora apiculata, Aegiceras corniculatum, Sonneratia apetala, Acanthus ilicifolius* and others.

GEOGRAPHICAL DISTRIBUTION, AREA AND SPECIES DIVERSITY

Distribution

Mangrove forests are circum tropical in distribution and found along the intertidal regions of the tropical and sub-tropical areas of the world extending from 24°N to 38°S. Geographical extension of mangroves can be divided into two groups: 1) New World Group which includes mangroves of North, Central and South America and West Africa, 2) Old World Group which includes mangroves of Persian Gulf, Madagascar group, Indo- Malaysian group and Australian group.

The New World mangroves extend essentially to the shore of America, West Indies and West coast of Africa. The Old World mangroves extend from East Africa up to the Red Sea, across the Indian Ocean to Australia, northwards to the Philippines and southern Japan and southwards to New Zealand. The New World mangroves are dominated by only 10 species, which have no affinities with the Old World mangroves. Not a single species of the New World mangroves is found in the Old World group. These 10 species are *Rhizophora mangle, R. harrisonii, R. racemosa, Avicennia germinans, A. bicolor, A. africana, A. schaueriana, Laguncularia racemosa, Pelliciera rhizophora* and *Conocarpus erecta.*

The Old World mangroves are dominated by 66 species and the composition, by and large is found maximum along the Indo-Pacific region. The number of species found in India has significant affinity with those reported for Malaysia and Indonesia. Presence of *Rhizophora apiculata, Bruguiera sexangula* and *Aegiceras corniculatum* shows affinity to the flora with the Australian and Papuan groups.

Mangroves in India are typical of the Malay Peninsula, Polynesia, Indo-China, Australia, Ethiopia, Sri Lanka and of other Old World's Indo-pacific elements. Mangrove area in India is so called as extension from the Persian Gulf around the coast of India, Pakistan and Sri Lanka to Myanmar (Burma) including Andaman and Nicobar Islands.

The major mangrove areas along the East coast of India are found in the Gangetic Sundarbans regions in West Bengal, the Mahanadi deltaic complex in Orissa, the Godavari-Krishna deltaic system in Andhra Pradesh and Couveri estuarine complex in Tamil Nadu. These east coastal mangrove areas are considered to be the best habitats and commonly harbour about 63 mangrove species out of the total 66 species found in India. The associated mangrove flora in the area belongs to the so-called "Indo-Pacific" origin from Malaysia, Australia and East Africa, and the phytodiversity is appreciably more rich and diversified than that of 'Australia' or 'Atlantic' region.

Along the West coast, major deltas are not found except the small estuaries of the Narmada and the Tapi river and a few other hyper saline shallow estuaries in Saurashtra, Gulf of Khambat and Gulf of Kutch. Mangroves are confined here towards the small pockets of backwater system such as Mandovi-Zuaria estuarine in Goa, along the intertidal creeks and canals of Kalinadi in Karowar, Coondapur, Honover and Malpe in Karnataka, 8 minor lakes in Kerala, Cochi, Vembanad, Quilon, Trivandum, Cannanore, Kozhikode, Kottayam and along some creeks and estuaries in Maharashtra.

Area

Total mangrove area in different parts of the world is not properly known. However, it is estimated from various publications that the total mangrove area of the world is approximately 17109000 ha or 171090 sq. km as shown in table I.

Table I
Approximate mangrove areas in various countries

Asia	Area (ha)	Africa	Area (ha)	America	Area (ha)
Australia	1,162,000	Angola	50,000	Belize	75,000
Bangladesh	410,000	Benin	3,000	Brazil	2,500,000
Brunei	7,000	Cameroon	273,000	Colombia	307,000
Fiji	20,000	Gabon	250,000	Costa Rica	19,000
India	675,000	Guinea	260,000	Cuba	448,000
Indonesia	2,500,000	Guinea Bissau	243,000	Dominican	9,000
Kampuchea	10,000	Gambia	60,000	Republic	
Malaysia	674,000	Kenya	45,000	El Salvador	36,000
Myanmar	812,000	Liberia	40,000	Ecuador	196,000
Pakistan	345,000	Mauritania	Few ha	French Guiana	55,000
Papua New Guinea	553,000	Madagascar	320,000	Guadeloupe	3,000
Philippines	240,000	Mozambique	85,000	Guatemala	50,000
Sri Lanka	4,000	Senegal	440,000	Guiana	150,000
Thailand	288,000	Sierra Leone	100,000	Haiti	18,000
Vietnam	320,000	Nigeria	973,000	Honduras	145,000
		Tanzania	96,000	Jamaica	7,000
		Zaire	20,000	Martinique	2,000
				Mexico	660,000

Asia	Area (ha)	Africa	Area (ha)	America	Area (ha)
				Nicaragua	60,000
				Panama	486,000
				Peru	28,000
				Surinam	115,000
				Trinidad & Tobago	4,000
				U.S.A (Florida & P. Rico)	178,000
				Venezuela	260,000
	8,020,000		3,258,000		5,831,000

GRAND TOTAL: 17,109, 000 ha or 1,71090 sq. km

Major areas of mangrove forests in different states in India (Table II) have been published by the Ministry of Environment & Forests in December 1987. The Forest Survey of India also published the State of Forest Report 1997, regarding the areas of mangrove forests of different states.

Table II
Area wise distribution of mangroves in India

State/Union Territory	Area *	Area **	Area ***
West Bengal (Sundarbans)	4200	1619	2123
Anadaman & Nicobar Isls.	1190	770	966
Maharashtra	330	138	124
Gujarat	260	1166	991
Andhra Pradesh	200	480	383
Tamil Nadu	150	90	21
Orissa	150	187	211
Karnataka	60	19	3
Goa	200	5	5
Kerala	16	16	17
Total	6756	4490	4844

Note: The area has been rounded to the nearest 10 sq. km.

* Status reports on mangroves in India, Government of India, Ministry of Environment & Forests, December 1987.

** Indian Remote Sensing Data 1993

*** State Forest Report, 1997; Forest Survey of India, Government of India.

Surveys undertaken in various mangrove areas of India is represented in the following table.

Areas	% of survey
Sundarbans - West Bengal	40%
Mahanadi Delta - Orissa	80%
Godavari-Krishna Delta - Andhra Pradesh	80%
Cauvery Delta - Tamil Nadu	30%
Backwaters of Kerala and Cochi	55%
Karnataka Mangroves	80%
Mangroves of Goa	80%
Mangroves of Maharashtra	65%
Mangroves of Gujarat	62%
Mangroves of Andaman & Nicobar Islands	45%

SPECIES DIVERSITY

Angiosperms are represented by various trees, shrubs, herbs and absence of epiphytes. Among the climbers, *Derris, Finlaysonia, Tylophora, Mucuna, Sarcolobus* and *Flagellaria* are common. *Acrostichum aureum* is the only fern species present in the mangroves.

The species diversity in Indian mangroves is related to its available ecological conditions from the Sundarbans towards Gujarat. The richness of the species decreases from the East coast towards the West coast and finally form monotypic strand in the western part of the Gulf of Kutch. In the East coast, there are 30 families, 43 genera and 68 species. On the West coast there are 23 families, 25 genera and 35 species, and in Andaman & Nicobar islands there are 25 families, 32 genera and 45 species. There are about 28 mangrove species, which show restricted distribution only along East coast. Similarly, there are 1 or 2 mangrove species, which have been reported only from West coast. In Andaman & Nicobar islands, there are atleast 6 species restricted in the oceanic mangrove environment and are not distributed either in East coast or West coast. Similarly, 22 species which occur in the East coast, have not been found in the Andaman & Nicobar islands. The status of families, genera and species is provided in the table III.

Table-III
Status of families, genera and species

	India	East coast	West coast	Andaman & Nicobar Is.
Families	30	30	23	25
Genera	43	43	25	32
Species	68	68	35	45

Ten dominant families in India showing number of species in East coast, West coast and Andaman & Nicobar islands are given in table IV.

Mangrove diversity depends on the habitat where mixing of fresh and salt water is maximum. The case is evident in the Mahanadi delta in Orissa where mangrove area is 215 sq. km. Probably due to above factor, Mahanadi delta possesses maximum number of mangrove species (63) with one new species and several new records. Sundarbans with 4,200 sq. km mangrove land have 61 mangrove species, out of 68 species known from India. The Godavari, Krishna, Cauvery delta and West coastal mangroves show less number of mangrove species.

Table IV
Dominant families

Family	No. of Species		
	East coast	West coast	Andaman & Nicobar Islands
Rhizophoraceae	10	6	6
Avicenniaceae	3+1 (var.)	3+1 (var.)	3
Sonneratiaceae	4	2	1
Meliaceae	3		3
Sterculiaceae	3		1
Arecaceae	2	-	2
Papilionaceae	5	2	4
Caesalpiniaceae	5	2	4
Asclepiadaceae	5	-	3
Poaceae	2	3	

The distribution of mangrove taxa in New and Old World is presented in table V.

Table V
World distribution of mangrove species

Family	Genus	Species	Structure	Geographical regions	
				New World	Old World Indian Subcontinent
1	2	3	4	5	6
Acanthaceae	*Acanthus*	*ebracteatus*	Shrub	-	**10**
		ilicifolius	Shrub		**1,2,3,4,5,6,7,8,9,10**
		volubilis	Climber		**1,2,10**
Apocynaceae	*Cerbera*	*manghas*	Tree		**1,2,5,6,10**
Arecaceae	*Nypa*	*fruticans*	Shrub		**1,10**
	Phoenix	*paludosa*	Tree		**1,2,10**
Asclepiadaceae	*Finlaysonia*	*obovata*	Climber		**1,2,4?,10**
	Sarcolobus	*globosus*	Climber		**1,2,3,10**
		carinatus	Climber		**1,2,3,10**
	Tylophora	*tenuis*	Climber		**1,10**
Avicenniaceae	*Avicennia*	*alba*	Tree		**1,2,3,6,7,8,10**
		bicolor	Tree	+	-
		germinans	Tree	+	-

1	2	3	4	5	6
		integra	Tree	+	-
		marina	Tree	+	1,2,3,4,5,6,7,8,9,10
		var. *australasica*	Tree	+	-
		var. *eucalyptifolia*	Tree	+	-
		officinalis	Tree		1,2,3,4,5,6,7,8,9,10
		rumphiana	Tree		-
		schaueriana	Tree	+	-
Bignoniaceae	*Dolichandrone*	*spathacea*	Tree		1,2,5,10
Bombacaceae	*Camptostemon*	*philippinensis*	Tree		-
		schultzii	Tree		-
Caesalpiniaceae	*Caesalpinia*	*bonduc*	Tree		1,2,3,10
		crista	Tree		1,2,3,10
	Cynometra	*iripa*	Tree		1,2,10
		ramiflora	Tree		1,2,5
	Intsia	*bijuga*	Tree		1,2,10
Combretaceae	*Conocarpus*	*erectus*	Tree	+	-
	Laguncularia	*racemosa*	Tree	+	-
	Lumnitzera	*littorea*	Tree		10
		racemosa	Tree		1,2,3,4,6,8,9,10

1	2	3	4	5	6
Convolvulaceae	*Ipomoea*	*tuba*	Climber		1,2,3
Cyperaceae	*Fimbristylis*	*ferruginea*	Herb		1,2,3
	Scirpus	*littoralis*	Herb	-	1,2,3,6
Euphorbiaceae	*Excoecaria*	*agallocha*	Tree		1,2,3,4,5,6,7,8,10
		indica	Tree		-
		ovata	Tree	-	-
Flagellariaceae	*Flagellaria*	*indica*	Climber	-	1,2,5,10
Lythraceae	*Pemphis*	*acidula*	Tree	-	5,10
Malvaceae	*Hibiscus*	*tiliaceus*	Shrub	-	1,2,3,4,5,6,7,8,10
	Thespesia	*populneoides*	Tree	-	1,2
Meliaceae	*Aglaia*	*cucullata*	Tree	-	1,2
	Xylocarpus	*granatum*	Tree		1,2,3,4,10
		mekongensis	Tree	-	1,2,10
		moluccensis	Tree		10
Myrsinaceae	*Aegiceras*	*corniculatum*	Shrub		1,2,3,5,6,7,8,9,10
		floridum	Shrub		-
Myrtaceae	*Osbornia*	*octodonta*	Shrub		-

1	2	3	4	5	6
Papilionaceae	*Dalbergia*	*spinosa*	Tree		1,2,3
	Derris	*scandens*	Tree		1,2,3,5,6,7,8,10
		heterophylla	Tree		1,2,3,5,6,7,8,10
	Mucuna	*gigantea*	Tree		1,2,5, [illegible]
Pelliciераceae	*Pelliciera*	*rhizophorae*	Tree	+	-
Plumbaginaceae	*Aegialitis*	*rotundifolia*	Tree		1,2,3
		annulata	Tree		-
Poaceae	*Myriostachya*	*wightiana*	Herb		1,2,3,5
	Porterasia	*coarctata*	Herb		1,2,3,4,5,6,7,8,
	Urochondra	*setulosa*	Herb		9
Pteridaceae	*Acrostichum*	*aureum*	Herb		1,2,7,8,10
		danaeifolium	Herb		-
		speciosum	Herb		10
Rhizophoraceae	*Bruguiera*	*cylindrica*	Tree		1,2,3,4,6,7,8,10
		exaristata	Tree		-
		gymnorrhiza	Tree		1,2,3,4,56,7,8,10
		hainesii	Tree		-
		parviflora	Tree		1,2,6,10
		sexangula	Tree		1,2,10

1	2	3	4	5	6
	Ceriops	*australis*	Tree		-
		decandra	Tree		**1,2,3,4,10**
		tagal	Tree		**1,2,5,7,8,9,10**
	Kandelia	*candel*	Tree		**1,2.3,5,6,7,8,10**
	Rhizophora	*apiculata*	Tree		**1,2,3,4,5,6,7,8,10**
		harrisonii	Tree	+	-
		mangle	Tree	+	-
		mucronata	Tree		**1,2,3,4,5,6,7,8,910**
		racemosa	Tree	+	-
		samoerisis	Tree		-
		stylosa	Tree		**2,10**
Rubiaceae	*Scyphiphora*	*hydrophyllacea*	Shrub		**3,10**
Rutaccae	*Merope*	*angulata*	Shrub		**1,2**
Sonneratiaccac	*Sonneratia*	*alba*	Tree		**2,4,5,6,7,8** .
		apetala	Tree		**1,2,3,4,7,8,9**
		caseolaris	Tree		**1,2,5,6,7,8,10**
		griffithii	Tree		**1,2,10**
		lanceolata	Tree		-
		ovata	Tree		-

1	2	3	4	5	6
		xgalngai	Tree		-
		xurama	Tree		-
Sterculiaceae	*Heritiera*	*fomes*	Tree		1,2
		globosa	Tree		-
		kanikensis	Tree		2
		littoralis	Tree		2,4,6,10
Tiliaceae	*Brownlowia*	*tersa*	Shrub		1,2
Verbenaceae	*Clerodendrum*	*inerme*	Shrub		1,2,3,4,5,6,7,8,10
31	47	95			

1 Sunderban (West Bengal), 2 Orissa, 3 Andhra Pradesh, 4 Tamil Nadu, 5 Kerala, 6 Karnataka, 7 Goa, 8 Maharashtra, 9 Gujarat, 10 Andaman & Nicober islands

ENDEMIC SPECIES

From the world distribution record and extensive surveys from different parts of India the following 10 mangrove species (Table VI) are found as endemic to India.

Table VI
Endemic mangrove species

Botanial name	Family
Acanthus ebracteatus	Acanthaceae
Acanthus volubilis	Acanthaceae
Brownlowia tersa	Tiliaceae
Dalbergia spinosa	Fabaceae
Finlaysonia obovata	Asclepiadaceae
Heritiera fomes	Sterculiaceae
Phoenix paludosa	Arecaceae
Sonneratia apetala	Sonneratiaceae
Thespesia populnea	Malvaceae
Urochondra setulosa	Poaceae

RARE AND THREATENED MANGROVES

The mangrove ecosystem itself is vulnerable and fragile. There are many species, restricted to localized areas due to special ecological factors or some species are threatened due to excessive demographic pressure, over utilization, exploitation and loss of habitat. Some of the rare and threatened species of Indian mangroves are presented in the table VII.

SIGNIFICANT USES OF MANGROVES

The utility of mangroves and the mangrove ecosystem are exploited by the coastal people. Majority of the people inhabiting in and around the mangrove forests use mangrove woods as fuel. *Avicennia* spp. are used as fuel even in green condition.

Table VII

Rare and threatened species of Indian mangroves

Botanical name	Distribution	Status
Acanthus volubilis	Only in one population in Sundarbans.	Rare due to loss of habitat
Aegialitis rotundifolia	Restricted only in East coast up to Krishna delta.	Threatened due to over utilization.
Brownlowia tersa	Restricted in Sundarbans, Orissa and Andamans.	Threatened due to over exploitation.
Bruguiera sexangula	Restricted only in Sundarbans, Orissa and Goa.	Rare due to lack of ecological condition.
Cryptocoryne ciliata	Restricted in Sundarbans and Orissa.	Rare due to over-exploitation.
Cynometra iripa	Only one or two plants are found in Sundarbans, Orissa and Andamans.	Rare due to over exploitation.
Dolichandrone spathacea	Restricted in Orissa, Kerala and Andamans. Probably also collected from Bangladesh Sundarbans.	Rare due to over exploitation.
Finlaysonia obovata	Monotypic, only in Sundarbans and Orissa.	Rare due to loss of habitat.

Botanical name	Distribution	Status
Heritiera fomes	Restricted only in Sundarbans and Orissa.	Threatened due to changed habitat conditions and over exploitation.
Heritiera kanikensis	Restricted only in Orissa (new species).	Threatened due to over exploitation.
Intsia bijuga	Restricted only in Orissa. Previously reported from Sundarbans.	Rare due to loss of habitat.
Lumnitzera littorea	Restricted only in Andamans.	Rare due to loss of ecological conditions.
Merope angulata	Though recorded from Sundarbans but collected only from Orissa.	Threatened due to over exploitation.
Mucuna gigantea	Reported only in Orissa and Kerala.	Rare due to loss of habitat.
Nypa fruticans	Restricted only in one pocket of Sundarbans and many places in Andamans.	Threatened due to changed ecological condition and over utilization.
Phoenix paludosa	Restricted only in West Bengal, Orissa and Andamans.	Threatened due to excessive demographic pressure for over utilization.
Rhizophora stylosa	Only recorded from Orissa.	Rare due to loss of habitat.

Botanical name	Distribution	Status
Sarcolobus carinatus	West Bengal, Orissa, Godavari delta and Andamans.	Rare due to over exploitation.
Scyphiphora hydrophyllacea	Restricted only in Godavari mouth and Andamans.	Rare due to over exploitation.
Sonneratia alba	Restricted only in the West coast and one population in Orissa.	Threatened due to over exploitation.
Thespesia populneoides	Restricted only in Sundarbans and Orissa.	Rare due to lack of special ecological conditions.
Tylophora tenuis	Only found in Orissa, though reported from Sundarbans but not collected	Very rare due to changed ecological conditions.
Xylocarpus granatum	Restricted in Sundarbans, Orissa and up to Godavari delta and Andaman islands.	Threatened due to over utilization.
Xylocarpus mekongensis	Restricted only in Sundarbans and Orissa.	Threatened due to over utilization.
Xylocarpus moluccensis	Restricted only in Andaman islands.	Rare due to over exploitation.

In addition, mangroves are potential sources for charcoal and alcohol. Production of alcohol from a *Nypa fruticans* can be used as transport fuel. Many species of mangroves produce good timber utilized in plywood industry, furniture making, boat and ship building and other constructional purposes like bridges, mining pits, beams, pools etc. Almost all the members of Rhizophoraceae produce heavy tannins, adhesives and glues. Species of *Heritiera* produce synthetic fibres (rayon) and durable flooring and paneling materials for ships. Species of *Aglaia* and *Xylocarpus* produce beautiful household articles and furniture. Species of *Excoecaria* and *Sonneratia* produce paper-pulp and various types of soft wood. *Nypa* leaves provide very long lasting thatching materials and matting articles due to presence of waxy coating on its leaves. It is observed that roof thatched from *Nypa* leaves could last for 10 years or more. Decoction from the fruits of *Xylocarpus* is said to give good remedy for breast cancer. The decoction of bark of *Rhizophora* produces medicine for diarrhoea, dysentery, neck inflammation and leprosy. Bark and sap of *Cerbera* are purgative, its fruits and seeds produce medicinal oil for rheumatism. Pneumatophores of *Bruguiera parviflora* produce perfume. *Ceriops decandra* is well known for production of maximum quantity of tannin. Leaves of *Avicennia* are good fodder for domestic buffaloes to increase their milk production. Leaves of *Sonneratia* are good fodder for deer; their fruits are used as vegetables, in jam and jelly preparations. Fruits of *Avicennia* and *Sonneratia* are good food for fishes.

Environmentally and ecologically, the major amenities provided by the mangrove communities are so much that it is not possible to evaluate the cost in terms of monetary value. Mangrove serves as natural protective barrier for reducing coastal erosion, to dampen storm surges, cyclonic floods and high winds.

Along the river banks and estuarine mouth, lining of mangroves with their stilt root system function as tide-breaker to prevent the high speed of saline tide water flow and winds for protecting inland vegetation and properties. They help in soil formation by trapping debris, protect rich organic soil washed down through river system to the sea and provide rich nursery ground of many marine fishes, invertebrates, molluscs, birds, reptiles and crustaceans.

In the estuarine ecosystem, mangroves create sea river interphase and, buffer high salinity, regulate rich organic-laden water flow, stabilize the alluvial soils brought from the rivers and fix the sediments of the sea with detritus. Thus, it produces one of the richest productive ecosystem for supporting valuable sustenance of the marine and estuarine biodiversity.

THREATS AND CONSERVATION MEASURES

In recent times the problems of conservation have become more serious due to increased population pressure, political division of the country, encroachment of land for rehabilitation, development of different industries, thermal and hydroelectric power projects, diversion and blockage of natural canals and creeks, resettlements, aquaculture and agricultural activities, construction of new ports and conversion of mangrove land to urban developmental schemes along the coastal belt. Increased population pressure and exploitation over the last hundred years have led to noteworthy reduction of both floristic components as well as the areas of mangrove cover in India. The Kerala back water system was once supported by luxuriant growth of mangrove formations but now very few mangroves are seen in the midst of coconut plantations. During the last 2-3 decades the mangrove forest areas in Sundarbans have been seriously reduced due to agricultural and aquacultural practices. The remote sensing study indicates reduction of 20 sq. km of area of mangrove forests during last 10 years in Orissa. In Saurashtra, Gulf of Kutch and Gulf of Khambat the significant reduction of mangrove forests was seen due to constant pressure for fodder, fuel and camel grazing. Mangroves in Maharashtra, Andaman and Nicobar islands and Sundarbans are facing major problems of land acquisition for Urban Development Schemes and for agricultural practices.

The significance of mangrove ecosystem has been realized throughout the world. Many countries like Australia, Thailand, Malaysia, Vietnam, Indonesia, Pakistan, Bangladesh, USA, Cuba, Colombia, Panama and other countries have developed their own conservation and management plans. Some of the International organizations viz. International Society for Mangrove Ecosystem (ISME) based at Okiniwa, Japan, Food and Agricultural Organization (FAO) United Nation, Head Quarter at Rome, Italy and Mangrove Action Plan (MAP) in Western United States have also come up to promote and coordinate the conservation and management activities of mangrove ecosystem.

In India, Ministry of Environment and Forests has set up the National Mangrove Committee envolving scientists, forest personnel, researchers and administrators for considering various problems on conservation and management of mangrove ecosystems. This Committee recommended few vital points for R & D and conservation of mangroves in India. These are, mapping of mangrove areas, quantitative and qualitative survey along with the climatic and other environmental parameters, selections of reserve forests, large scale afforestation programme and research on flora, fauna and microbial organisms of the mangrove ecosystem. On the basis of the National Mangrove Committee, 15 mangrove areas were selected for providing proper management and conservation in India. These 15 areas are Sundarbans, Bhitarkanika, Mahanadi Delta, Krishna Delta, Ratnagiri, Kundapur, Goa, Vembanad, Point Calimore, Pichavaram, North Andaman, Nicobar island, Gulf of Kutch, Gulf of khambat and Jamnagar. For the management and conservation of the above mangrove areas the Ministry of Environment & Forests has notified all mangrove areas in India in first priority list of Coastal Regulation Zone (CRZ) and also established different Biosphere Reserves, National Parks and Sanctuaries.

The conservation and management activities of the Sundarban forests have received much attention and good number of national and international organisations and some NGOs are involved. Some of these organisations are Sundarbans Development Board and Forest Department, Government of West Bengal, Department of Science and Technology, New Delhi, various institutions of ICAR, different Universities of West Bengal, Bose Research Institute, Calcutta, Zoological Survey of India, Indian Statistical Institute, Bidhan Chandra Krishi Viswavidyalaya, Ramakrishna Ashram, Nimpith, Tagore Society, Rangabaria, Lok Siksha Parisad - Ramakrishna Mission Ashram, Narendrapur, etc. Moreover, the major areas of Sundarban Forests are under the control of Project Tiger, Crocodile Breeding and Rearing Project and under Man and Biosphere Project.

The Sundarbans Biosphere is a best example of conservation efforts made so far. The population of animals like tigers, fishing cats, estuarine crocodiles and Olive Ridley, etc. has significantly been increased. However on the other hand, the population of *Heritiera fomes*, has been diminished due to lack of fresh water flow whereas other mangrove genera viz., *Avicennia, Excoecaria, Phoenix* etc., are flourshing well in natural conditions. In the Bhitarkanika mangrove Sanctuary it has been reported that natural population of *Heritiera, Excoecaria, Avicennia* and *Sonneratia* has been gradually increasing.

In the Godavari Krishna estuary, 'Coringa' Mangrove Reserve has been successfully restored with many mangrove species due to large-scale afforestation programme. In Pichavaram Mangrove Reserve, 80% of the natural mangroves have been restored. In Ratnagiri, Vembanad and Kundapur areas, Eco-restoration, development of mangrove nurseries and afforestation programmes have been successfully developed. In Gujarat coastal mudflat, waste mangroves of the Gulf of Kutch and mangroves in the Marine National Park of Jamnagar have been successfully protected and restored.

CONSERVATION STRATEGIES

Ever-ending demand for enhancing the socio-economic structure associated with changing environmental conditions have led planners to formulate recommendations regarding conservation and management of the mangrove ecosystem. In 1990, Ministry of Environment & Forests issued guidelines regarding the involvement of village communities and voluntary agencies in the protection and development of degraded forest areas on the basis of taking a share of benefit from the areas that they agree to protect and develop. In 1998, Government of India reformed the National Forest Policy and involved people as a partner in the development, protection and management of forest resources. These Joint Forest Management (JFM) practices have become acceptable and its model for managing the mangrove ecosystem is very successful. However, considering development of biotechnological activities, information technology, large scale demand from forest resources due to population pressure and other developments like Intellectual Property Right (IPR), General Agreement on Trade and Tariff (GATT) and Convention on Biological Diversity (CBD), a new approach for Joint Forest Management for sustainable utilization, conservation and protection of forest resources is required to be formulated in future plans.

Their must be a holistic approach and man's need has to be addressed properly keeping in mind the requirements for sustainable development. Management of forest ecosystem based on biological components and genetic resources must have to be more people oriented for obtaining desired results. It is possible with the help of Joint Forest Management Programme when the management plans are owned and understood by all the relevant local groups of protagonist including Districts, Mouzas, Panchayats, Administrators and even the Private enterprises.

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WETLANDS

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Wetlands are important ecotones between open waters and terrestrial systems. These are endowed with specific structural and functional attributes executing unique ecological roles. The U.S. Fish and Wildlife Services defines wetlands as "transitional areas between aquatic and terrestrial systems where the water table is usually at or near the surface or the land is covered with shallow water" The Convention on Wetlands of international importance especially as waterfowl habitat was held in 1971 (Ramsar Convention) for their scientific management and conservation. India is a signatory to this convention. This convention defines wetlands as "areas of marshes, fens, peatlands or water whether natural or artificial; permanent or temporary; static or flowing;.fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed six metres" This definition specifies water depth in case of marine areas not to exceed six metres but for other habitats there is no mention of depth. Marshes, swamps, floodplains, lakes, tanks, running streams, canals and littoral zones of large water bodies are some known wetland types. Water level in wetlands changes with season and recedes during dry period. With changes in water level the biota particularly the lower groups undergoes successive displacements maintaining annual rhythms. Depending on the water requirement and the relative position of the various parts in water, macrophytes are classified into two groups (Sculthorpe 1967; Spence 1964; Wetzel 1975) - hydrophytes attached to substratum and free floating macrophytes. The former is further divided into 1) submerged macrophytes, 2) floating-leaved macrophytes and 3) emergent macrophytes. The submerged plants mostly belong to the families Hydrocharitaceae, Najadaceae and Potamogetonaceae and may occur up to 3 metre depth. The members of the Nymphaeaceae, Nelumbonaceae and Aponogetonaceae are mostly floating-leaved species but rooted below in the substratum and extend still deeper. The emergents such as cattails (*Typha* spp.), reeds (*Phragmites* spp.), rushes (*Juncus* spp. and *Arundo donax*), sedges (*Carex* spp.) and grasses and limit themselves to littoral zones. Free floating species (mostly members of the Araceae, Lemnaceae and Pontederiaceae may occur in any situation irrespective of depth. A fifth category consists of trees resistant to water-logged soils and near to shores of various water bodies.

Wetlands serve as suitable habitats for a variety of amphibians, fish, reptiles, waterfowl and migratory birds. They provide shelter, required food and ideal nesting sites. The high biodiversity value associated with biological productivity makes them significant habitats. Teal and Teal (1969) projected the net primary productivity of different ecosystems in which freshwater wetlands are shown figures equivalent to that of tropical rainforests. Wetlands play a major role in flood control, ground water recharge, over all regulation of hydrological regime and pollution abatement.

Wetland extent and distribution: There are varying estimates with regard to the total extent and distribution of wetlands. The Ministry of Environment & Forests, Govt of India, in its report (Anonymous 1992) estimated that India has about 4.1 mi ha of wetlands (excluding paddy fields and mangroves) of which 1.5 mi ha are natural and 2.6 mi ha are man-made. In this enumeration a total of 2167 natural wetlands and 65283 man-made wetlands are recorded. Estimates of different wetland types in India are given below (Scott 1989).

Area of wetlands in India

Wetland type	mi ha
Area under paddy cultivation	40.9
Area suitable for fish culture	3.6
Area under capture fisheries	2.9
Mangroves	0.4
Estuaries	3.9
Backwaters	3.5
Man-made impoundments	3.0
Rivers- 28,000 km	
Canals, irrigation channels -1,13,000 km	

Total area of wetlands (excluding rivers and channels) 58.2 mi ha (Scott 1989)

WETLAND CLASSIFICATION/DIVERSITY

Indian wetlands are distributed in a wide range of climates from the cold Kashmir and Himachal Pradesh to those of humid north-eastern India, dry Rajasthan and Central India and to the humid southern peninsula. Based on geographical location wetlands can be grouped into (1) wetlands of the Himalayan mountains (2) wetlands of the Gangetic Plains (3) wetlands of the Peninsular uplands (4) coastal wetlands and (5) wetlands of the oceanic islands (Kaul 1995). Based on the origin and nature of dominant vegetation they harbour, wetlands may be differentiated into marshes, swamps, lakes, floodplains, streams, canals etc. There are many publications on different wetland habitats and a review by Fernando (1984) emphasizing the salient features of various standing water habitats in southeast Asia is worth mentioning.

Marshes

Marshes are shallow water areas where herbaceous emergent vegetation such as reeds (tall grasses with slender often prominently jointed stems), rushes (tufted plants of genus *Juncus* (Juncaceae) with cylindrical and often hollow stems) and sedges (tufted marsh plants of the Cyperaceae differing from grasses in having achenes and solid stems) flourish. Marshes may be freshwater or of salt water. Freshwater marshes are unfortunately amongst the most threatened of wetland types as they are drained extensively for cultivation. Keoladeo Ghana in Bharatpur is a man-made freshwater marsh and is one of the important waterfowl habitats in the world with good plant diversity (Prasad 1988). The Terai in the Himalayan foothills supports marshes that shelter several species of mammals many of which are threatened. The Jaldapara Wildlife Sanctuary, located on the alluvial plains of Torsa river in Jalpaiguri district, W. Bengal, is seasonally inundated. Emergent communities here are dominated by species of *Phragmites*, *Saccharum* and *Imperata*. This sanctuary supports many species of mammals including the Indian one-horned rhinoceros (*Rhinoceros unicornis*). Similarly in NE. India Kaziranga and Manas possess freshwater marshes harbouring a number of aquatic species (Baishya 1998; Hajra and Jain 1995). Most of the plains in the Indravati Tiger Reserve in Madhya Pradesh is wet and marshy especially during the monsoon. Important plant species here include *Aponogeton natans*, *Cyperus compressus*, *C. iria*, *C.platystylis* *Lagarosiphon alternifolia*, *Ludwigia octovalvis*, *Nymphoides* *hydrophylla, Panicum paludosum, Tenagocharis latifolia, Utricularia bifida, U. exoleta, Vallisneria natans* etc. Some rare species of Madhya Pradesh flora from this tiger reserve are *Arundinella benghalensis, Calycopteris floribunda, Canscora heteroclita, Cyperus platystylis, Elatostemma cuneatum, Fimbristylis argentea, Heterophragma quadriloculare, Hygrophila balsamica, Rhinacanthus nasutus* and *Scleria annularis* (Anand Kumar 1998a). A number of aquatics and semiaquatics occur in marshes in the Melghat Tiger Reserve in Maharashtra. These include *Aeschynomene indica, Ammania baccifera, Crinum defixum, Elaeocharis capitata, Rotala serpyllifolia, Sesbania bispinosa, Smithia conferta* etc. (Venkanna 1998). The Valmiki Tiger Reserve in Bihar has numerous freshwater marshes colonised by *Cyperus corymbosa* and *Typha angustata* along the margins. *Caldesia parnassifolia, Cyperus alopecuroides, C. globosus, C. platystylis* and *Scirpus supinus* occur in the inner portions (Banerjee 1998a).

Salt-marshes are characterised by a range of highly adaptive salt-tolerant species. The coast of Gujarat has a number of significant tidal salt-marshes. Principal species in them are *Cyperus* spp., *Saccharum spontaneum, Scirpus* spp., *Typha angustata* etc. The endemic *Cyperus dwarakensis* is found near Dwaraka. Similarly *Tephrosia jamnagarensis* is endemic to this area. The Rann of Kutch is a vast expanse of mud-flats inundated by sea during monsoon and rich in soluble salts. On mud-flats *Arthrocnemum indicum, Peplidium maritimum, Salicornia brachiaria, Salvadora persica, Sesuvium portulacastrum, Suaeda fruticosa, S. maritima* and *S. nudiflora* are present. A little interior where the soil is less sandy and saline, species like *Alhagi maurorum, Atriplex stocksii, Capparis decidua, Cassia italica, Corchorus depressus, Cressa cretica, Indigofera oblongifolia, Juncus maritimus, Lycium barbatum, Malachra capitata, Salvadora persica,* and *Trianthema triquetra* along with sedges and grasses like *Aeluropus lagopoides, Cenchrus biflorus, Chloris villosa, Cyperus bulbosus, Diplachne fusca, Fimbristylis cymosa, Scirpus tuberosus, Sporobolus maderaspatanus* and *Urochondra setulosa* occur in small or large, pure or mixed colonies (Guha Bakshi 1969; Shah 1978). In the Sundarbans salt-marshes occur in between mangrove swamps. They are inhabited by *Aeluropus lagopoides, Arthrocnemum indicum, Heliotropium curassavicum, Salicornia brachiata, Scirpus littoralis, Sesuvium portulacastrum, Suaeda maritima, S. monoica, S. nodiflora, Tamarix troupii* etc. (Banerjee 1998b).

Swamps

Swamps harbour woody shrubs and trees in contrast to marshes which are dominated by sedges, reeds and rushes. Mangroves are swamp forests comprising trees of many unrelated genera and families and share the common ability to grow in saline and coastal environment. India harbours rich mangrove swamps and they are located in the deltas of rivers such as the Ganges, Mahanadi, Godavari, Krishna and Cauveri as well as on the Andaman and Nicobar group of islands. On the W. Coast there are some good patches of mangroves too. There are variable estimates of the extent of mangrove forests. The total area in India is estimated to be about 6700 sq. km which constitutes about 7% of the mangroves in the world. Sidhu (1963a) estimated that the total mangrove area in the Indian territory is about 7000 sq. km. However, as per the State Forest Report (Anonymous 1998-'99) the total area is estimated at about 4827 sq. km. The largest stretch lies in W. Bengal in the Sunderbans where the mangroves cover an area of 4200 sq. km (Anonymous 1992). Three of the important mangrove habitats under biosphere reserves are the Sunderbans, the Gulf of Mannar and the Great Nicobar while many others are under other protected areas or in revenue lands. The Sunderbans was designated as a world heritage site as well. The forests spread over here are intersected from north to south by several rivulets and creeks. The entire area is subjected to sea water inundation during spring high tides and extensive flooding of freshwater during monsoon season. Mangrove vegetation here can be divided into two major types. In the outer estuarine vegetation *Aegialitis rotundifolia, Avicennia alba, A. marina, Bruguiera cylindrica, B. parviflora, Ceriops tagal, Phoenix paludosa and Sonneratia griffithii* occur. The inner estuarine riverine zone is occupied by *Aegiceras corniculatum, Kandelia candel, Rhizophora apiculata and R. mucronata*. Common associates in this zone include *Avicennia officinalis, Bruguiera gymnorhiza, Ceriops decandra, Excoecaria agallocha, Xylocarpus granatum* and *X. moluccensis* (Banerjee 1998b). In southern Tamil Nadu coast the islands totalling 19 in the Gulf of Mannar Biosphere Reserve possess good mangrove vegetation. Mangroves are present on most islands. Species present include *Aegiceras corniculatum, Avicennia marina, Bruguiera cylindrica, Ceriops tagal, Excoecaria agallocha, Lumnitzera racemosa* and *Rhizophora apiculata*. In all there are 8 mangrove species and 15 associated species (Daniel 1996, 1998). The other notable works in this area include that of Rao (1964) and Rao *et al.* (1963a,b). The mangrove forests of the Andaman and Nicobar

Islands exhibit high floristic richness, complexity index and biomass production. They are better formed in Andaman Islands than in Nicobar Islands. Mangroves of both the Andaman and Nicobar Islands constitute 1200 sq. km. Many researchers have made intensive studies on these mangroves. Important contributions among them are that of Balachandra (1988), Chapman (1976), Dagar *et al.* (1991), Ellis (1986,1987), Mall *et al.* (1985a,b, 1987), Mukherjee (1975), Sahni (1953, 1958), Singh and Garge (1993) and Thothathri (1962, 1977). The characteristic associations seen here include *Archidendron clypearia* with *Ardisia solanacea, Bruguiera gymnorrhiza, B. parviflora, Carallia brachiata, Nypa fruticans, Rhizophora apiculata, R. conjugata, R. mucronata, Syzygium samaragenio* and *Xylocarpus granatum*. Stretches of mangroves are found in Andhra Pradesh, Gujarat, Maharashtra, Orissa and Tamil Nadu. On the Orissa coast mangroves are found in the deltas of Mahanadi, Baitarani, Brahmhani and Dhamra rivers. Bhitarkarnika mangroves are situated in the deltas of Dhamra and Mahanadi rivers covering an area of 141.44 sq. km. The coastal wetlands especially the mangroves of the Orissa coast have been studied in detail (Banerjee and Rao 1985; Patnaik *et al.* 1991; Rao and Sastry 1974). Other important publications concerning mangroves of Andhra Pradesh, Gujarat, Maharashtra and Tamilnadu include that of Krishnamurthy (1979), Navalkar (1951), Raju (1968), Rao (1958), Rao (1971), Rao *et al.* (1965, 1966), Sidhu (1963a,b), Thirumalraj (1957) and Venkatesan (1966). Untawale *et al.* (1973) studied the mangroves of Goa. And he prepared a bibliography of Indian mangroves (Untawale 1980).

Riverine swamps are spread all over the country. The Dudhwa National Park in Uttar Pradesh, the Namdapha National Park of Arunachal Pradesh and some others along the Bramhmaputra Valley in NE. India are known for their rich diversity. Fishing cat, tiger, leopard, clouded leopard, sea leopard and a new species, the Namdapha flying squirrel, occur in the Namdapha National Park. Characteristic tree species in swamp forests are *Bischofia javanica, Celtis tetrandra, Drypetes roxburghii, Ficus racemosa, Glochidion assamicum, Litsaea polyantha, Syzygium cumini, Terminalia arjuna, Trema orientalis* and *Trewia nudiflora*. On the edges of swamps are found *Barringtonia acutangula* and *Salix tetrasperma*. Important shrubs are *Ardisia solanacea, Daedalocanthus nervosus, Hyptianthera stricta, Ficus heterophylla and Phlogacanthus thyrsiflorus*. There are numerous swamps in the Manas Tiger Reserve. Free floating hydrophytes such as *Azolla pinnata, Eichhornia crassipes* and *Monochoria hastata* dominate the vegetation. Clumps of the tall *Typha elephantina*, *Lasia spinosa* and several sedges including *Cyperus* spp. and *Kyllinga* spp. occur in close association with other hydrophytes. *Ipomoea carnea* ssp. *fistulosa* is the most obnoxious weed forming thickets in marshy lands. Wild animals feed on the leaves of *Alpinia allughas, Hygroryza aristata, Musa* spp., *Saccharum spontaneum* and *Typha elephantina* (Baishya 1998). Keibul Lamjo in Manipur is another important freshwater swamp with floating mats ('phumidi') covering much of its surface. The swamp lies in the northeast corner of the Loktak lake and is connected with the lake by a channel. A 'phumidi' is composed of decaying vegetation and varies in thickness from 0.33 m to 1.33 m. It floats on water and is capable of supporting the weight of large animals. At low water level in February and March, the peripheral areas of 'phumidi' comes to rest on the ground. With the onset of monsoon much of the park is covered with water and with the rise of water level the 'phumidi' begins to float again. Plant species in this swamp include *Alpinia alupas, Erianthus revennae, Phragmites karka, Saccharum latifolium, S. munja* and *Zizania latifolia*. The Kanha Tiger Reserve in Madhya Pradesh is traversed by the rivers Halon, Sulkum and Banjar. The river banks support *Centella asiatica, Crinum pratense, Ficus racemosa, F. semicordata, Homonoia riparia, Rotala aquatica, Salix tetrasperma, Syzygium cumini, Terminalia cuneata, Toona ciliata, Polygonum* spp. and *Pouzolzia pentandra*. In swamps species of Cyperaceae, *Amischophacelus axillaris, Bacopa monnieri, Blyxa octandra, Dopatrium junceum, Hypericum laxum, Monochoria vaginalis* etc. are found. Barasinga in the reserve grazes on *Eleocharis dulcis, Equisetum diffusum* and *Nelumbo nucifera* (Anand Kumar 1998b; Maheshwari 1963). There are numerous freshwater swamps in the Ranthambhore Tiger Reserve located in the Aravallis and the Vindhyan Ranges in Rajasthan. *Blyxa echinosperma* and *Vallisneria spiralis* are the main submerged but anchored species and *Nymphaea nouchali, N. stellata* and *Nymphoides cristatum* are the floating-leaved but anchored species. Other noteworthy species in these swamps are *Amischophacelus axillaris, Bacopa monnieri, Desmodium triflorum, Hackelochloa granularis, Hemarthria compressa, Murdannia vaginata* etc. (Shiva Sharma 1998). In SW. Ghats, Kerala, *Myristica* swamp forests are dominated by the members of Myristicaceae family. These are unique ecosystems and subjected to inundation throughout the year.

Floodplains

Floodplains are flat lands adjacent to streams and rivers and are subjected to natural periodic flooding. Floodplain wetlands constitute about 1.1 mi ha in the country and are extensive in the lower reaches of river systems. India's 14 large, 44 medium and many minor rivers possess diverse floodplains. Banks of rivers and streams at higher altitudes provide an ideal habitat for a number of endemic species of the Balsaminaceae, Cyperaceae, Fumariaceae, Poaceae and Podostemaceae. The aquatic flora of the low lying lands of the Gangetic plains was studied by Misra (1976) and Naskar (1990) and of the Damodar Valley by Kachroo (1959). Floodplains are characterised by water level changes and these play a key role in the development of particular plant communities. The floodplain vegetation is generally dominated by trees and shrubs and is often called an alluvial or riparian forest.

Deltaic reaches of various rivers in W. Bengal have numerous floodplains. The river course passes through alluvial plains in low gradients resulting in extensive changes in floodplain configuration. The rivers also frequently change their course forming depressions, swamps and residual channels. Such resultant water bodies are situated along the rivers Bhagirathi, Hooghly, Jalangi, Purnabhaba and Ichamati. They together constitute an area of 42500 ha and are distributed mainly in the districts of Cooch Bihar, W. Dinajpur, Malda, Murshidabad, Nadia, South 24-Parganas and Hooghly. In Bihar floodplains occur as numerous saucer-shaped depressions and are locally known as 'chaurs'. Vaishali and Dharbhanga districts have considerable coverage of these wetland types (Rai and Datta Munshi 1982). In Uttar Pradesh floodplains cover an area of 225302 ha. They are situated close to rivers such as the Ganga and Yamuna and are locally known as 'jheels'. Floodplains in Assam are known as 'beels' and cover an area of 100000 ha and serve as important fishing reservoirs. There are 1392 in number in the state, the maximum being in Nagaon district followed by N. Cachar, Lakshimpur and Jorhat. Dipor is one of the largest 'beels' in lower Assam. Important floristic accounts on floodplains include that of Das *et al.* (1994), Mohanty and Choudhury (1984) and Patnaik and Patnaik (1956) from Orissa; Gupta (1966) and Inamdar (1968) from Gujarat; Jha (1965) from Bihar; Sen(1960), Singh and Tomar (1981) and Trevedi and Sharma (1965) from Uttar Pradesh; Kaushik (1969), Maheshwari (1960) Seervani (1962) and Unni (1967) from Madhya Pradesh; Karthikeyan *et al.* (1982), Mirashi (1954, 1958) from Maharashtra and Thomas (1976) from Kerala.

Lakes and Ponds

Lakes are lentic water bodies and compared to rivers they are stable. Lakes and ponds develop through several processes. Unlike swamps and marshes lakes have distinct vegetational zones, the littoral zone extends from the shore just above the influence of waves and spread to a depth where light is barely sufficient for rooted aquatics. The aphotic zone extends below the littoral and photic zones to the bottom of the lake. Both lakes and ponds have lentic environonment. However, in lakes wind plays a dominant role in mixing while in ponds convective mixing is more prevalent. By definition ponds are shallow but often with thermally stratified waters and abundant growth of rooted and floating aquatic macrophytes (Goldman and Horne 1983). Members of the Aponogetonaceae, Cabombaceae, Hydrocharitaceae, Nelumbonaceae, Nymphaeaceae, Potamogetonaceae and Ranunculaceae inhabit in diffeent zones of the lake environment.

Lakes may be either freshwater or saline. Permanent natural freshwater lakes of appreciable depth occur in the Himalayan belt particularly Kashmir Himalayas (Kaul 1981; Zutshi *et al.* 1980; Zutshi 1989) and those in the Kumaun region (Singhal and Singh 1978). Ladak has some remarkable lakes. Pangong Tso and Tso Morari are the two large lakes in trans-Himalayan zone. In the Kashmir Valley Dal, Wular, Haigam Rakh, Mirgund and Hokarsar are the notable natural lakes. Several lakes occur both in the Deccan and the Gangetic plains. Freshwater lakes from other parts of the country include Chandertal, Renuka and Pong Dam lake in Himachal Pradesh; Kanjli, Sukhana and Harike in the Punjab; Kabar in Bihar; Loktak in Manipur; Nalasarovar in Gujarat; Pichola and Fataesagar in Rajasthan; Gujar, Gorakhpur and Surahatal in Uttar Pradesh; Sagar and Bhoj in Madhya Pradesh; and Kolleru and Kondakarla in Andhra Pradesh. The estuarine lakes located on the E. and W. Coasts are Vembanad and Ashtamudi in Kerala; Pulicat in Tamil Nadu and Andhra Pradesh and Chilka in Orissa. These are partly freshwater. In the arid western part of Rajasthan Sambhar, Deedwana and Pachpadra lakes represent permanent natural salt water bodies. Earlier investigations on important lakes in the country are those of Mukherjee (1921, 1926) and, Biswas and Calder (1936). Ecological studies including analysis of the habitat factors and the vegetation dynamics were made for the first time by Misra (1944, 1946). Since then there have been several publications dealing with such habitats all over the country but most of them deal mainly with floristics, zonation and production aspects

(Ambasht and Ram 1976; Billore and Vyas 1982; Gopal 1968; Gupta 1966; Jha 1965; Kaul 1970, 1981, 1995; Kaul *et al.* 1976; Kaul and Zutshi 1967; Mall 1961; Mitra 1964; Mukherjee 1921, 1926; Patnaik 1973; Prakasam 1991; Sahai and Sinha 1968,1969; Seshavatharam and Venu 1978; Singh and Swarup 1980; Sinha 1969; Srivastava 1951, 1973; Srivastava and Sahai 1976; Vyas 1965; Zutshi 1968,1989; Zutshi *et al.* 1980).

Estuaries

An estuary is the place where a river meets the sea. Estuaries have fewer plant or animal species than fresh/sea water but may have larger number of individuals of the species present. An estuary may be defined as a partially enclosed body of water of variable salinity with freshwater inflow at one end and sea water introduced by tidal action at the other (Goldman and Horne 1983). Thus estuaries provide important zones of contact between freshwater and marine environment. Tidal action is an important biophysical regulator in salinity variation. Estuarian ecosystems are important habitats for spawning, feeding and nursing areas by marine fish. The mangroves in the W. Coast estuaries were listed by Navalkar (1951) and, Puri and Jain (1958) and that of the E. Coast by Banerjee and Das (1974), Rao (1958), Rao and Mukherjee (1972), Raju (1968), Sastry and Rao (1976), Subba Reddy (1982) and Venkateswarulu (1944, 1946). Important plant species in the esturian communities include *Avicennia marina, A. officinalis, Rhizophora mucronata, Bruguiera gymnorhiza, Ceriops decandra, Sonneratia apetala* and *Xylocarpus granatum.*

Lagoons

Estuary outlets may be more or less completely blocked by sand bars, sand pits or sand dunes resulting in the formation of lagoons which in turn may lead to limited access to the sea. In other words, the partial closure of an estuary outlet to the sea creates a lagoon. Chilka (Orissa), Pichavaram and Pulicat (Tamil Nadu and Andhra Pradesh) are some important lagoons. Most of the lagoons harbour extensive mangrove swamps and were well studied (Krishnamurthy *et al.* 1983; Patnaik 1973; Rajagopalan 1952).

Reservoirs, Tanks and Fish-ponds

India receives most of its precipitation as rainfall during the monsoon season. Numerous reservoirs are built to meet water requirement in irrigation, drinking water and generation of electricity. They are created by impounding rivers, streams or by excavating land. Today man-made reservoirs are more extensive than natural wetlands. With depletion in area and the number of natural wetlands, these man-made water bodies replicate the functions of natural ones. Two of India's six notified Ramsar Sites, viz., Harike and Keoladeo Ghana are man-made. Larger reservoirs such as the Pong dam and Gobind Sagar were created by damming rivers in hilly areas. Reservoirs created by damming rivers and streams may prove beneficial in that new wetlands are created, some providing excellent waterfowl habitats. Nevertheless, their downstream and upstream impacts affecting the ecology of the adjoining floodplains, interference with fish migration patterns and exacerbating siltation are scarcely understood (Anonymous 1992). Small tanks, ponds and lakes are created by physically digging out a depression in which rain water is collected. The Deccan Plateau is studded with numerous small water storage reservoirs and tanks in villages. In Maharashtra the relatively higher rainfall supports large irrigation schemes, several of which contain reservoirs which are important for migratory bird species particularly when drought affects wetlands in the north.

Canals

India is estimated to have a total canal length of 113000 km (Anonymous 1992). They represent man-made lotic habitats. Most of them are uncemented on either side and serve as suitable habitat for many aquatic plant species particularly members of the Amaranthaceae, Araceae, Elatinaceae, Polygonaceae and Scrophulariaceae while running waters harbour members of the Ranunculaceae and Podostemaceae.

Paddy fields

Paddy is cultivated extensively in the states of Andhra Pradesh Karnataka, Orissa, Tamil Nadu and W. Bengal. Paddy fields in fact cover an area of 41 mi ha and constitute far in excess of all other wetlands put together. In most instances paddy fields have been developed from areas which were once either marshy or shallow water bodies. Some publications exclusively deal with the flora of these wetlands (Mahapatra *et al.* 1974; Oza 1974; Seshavatharam 1974).

AQUATIC PLANTS

Aquatic plants have been defined variously and these definitions have been subjected to different independent interpretations. Arber (1920) was the first to use water plants to denote all species that grow in water. Reid (1961) defined aquatic plants as those which normally grow and develop seedlings in water and have at least a part of their life-cycle in water. However, Cook *et al.* (1974) defined aquatic plants as those whose photosynthetically active parts are permanently or, at least for several months each year submerged in water or float on the surface of water. These definitions exclude a number species which appear near to watery situations and can also tolerate/flourish in water-logged situations. The subject on wetlands and wetland plants has been reviewed by Gopal (1990). Cook (1998) considerd a wetland as a place where inundation occurs for at least 14 days and saturation for at least 60 consecutive days. India blessed with good monsoons generate such habitats temporarly if not permanantly in different regions. Because of differences in the definition and in interpretations, there are no clear estimates as to the total number of aquatic species. Cook (1990) recognised 407 genera from 87 families of vascular plants as being aquatic in the world. He considerd that estimates at the level of species are difficult but put the figures between 1 and 2% of the total species. Based on earlier definitions Biswas and Calder (1955) described 117 species including lower groups from British India. This was followed by another work by Subramanyam (1962) who listed an equal number of species but all being angiosperms. Naskar (1990) listed 270 species of aquatic angiosperms representing 76 families for the lower Gangetic delta alone. Lavania *et al.* (1990) compiled a list of 470 aquatic plants from the Indian subcontinent. Rao (1994) enumerated ca 300 aquatic plant species belonging to 69 families from India. Cook (1996) described 685 species and heterotypic subspecies of aquatic and wetland plants for the Indian subcontinent. These belong to 187 genera and 67 families. An effort is underway by the authors to prepare a checklist of aquatic and wetland plants of the country. *A Directory of Indian wetlands* (Anonymous 1993), *A directory of Asian wetlands* (Scott 1989), and *Handbook of wetland management* (Gopal 1995) are some of the major sources of information on aquatic plants of India. Some families exclusively/ majorly with aquatic genera such as the Nymphaeaceae, Nelumbonaceae, Cabombaceae (Mitra 1993a,b,c), Aponogetonaceae (Raghavan 1996) and Podostemaceae partly (Matthew and Satheesh 1997; Nagendran and

Arekal 1981) were revised. The Araceae, Hydrocharitaceae and Podostemaceae are under revision. Aquatic plants show a wide range of tolerance towards habitat. Some are sufficiently plastic to become widely disseminated while others are exacting in their requirement. The family Podostemaceae, a special group of plants occurring in riverian rocks, is represented by 9 genera and 20 species, most of which are localised in the W. Ghats while only 4 species are found in Assam and adjoining regions. A number of reports have appeared on the floristics of different wetlands in the country. Lavania *et al.* (1991) for the first time reviewed the work done on systematics, general ecology and distribution of aquatic macrophytes in the Indian subcontinent. Detailed autecological studies of some dominant aquatic species were documented and these include that of *Ceratophyllum* spp.(Sehgal and Mohan Ram 1981), *Hydrilla verticillata* (Mitra 1964), *Hygrophila auriculata* (Gupta 1968), *Ipomoea aquatica* (Datta and Biswas 1973), *Limnanthemum cristatum* and *L. indicum* (Mitra 1955), *Ottelia alismoides* (Ramprabhu 1962) and *Pistia stratiotes* (Mitra 1966). Some aspects of reproduction and specifically on seed germination were reported on *Eichhornia crassipes* and *Spirodela polyrhiza* (Das 1968, 1969; Das and Gopal 1969), *Marsilea minuta* (Gopal 1966), *Salvinia molesta* (Gopal 1976) and *Salvinia natans* (Zutshi and Vass 1971) and *Typha angustata* (Gopal and Sharma 1978).

ECONOMICALLY USEFUL PLANTS

A few comprehensive reviews on economically important wetland species were presented by Gupta and Lamba (1976), Matai (1976) and Seshavatharam (1990). Some economically more important species are described below.

Crops

A number of aquatic plants are grown as food crops in various parts of India for local consumption and in some cases even for exports. Some of the crops yield raw materials to support cottage industries.

Aeschynomene aspera : Commonly known as 'sola' in Bengali, this is one of the most exploited species for its lighter wood. The plant grows up to 3.6 m high. The stem is white, soft, spongy and very light and commonly called 'pith'. The 'pith' has insulating properties and can be split into thin sheets. The best quality pith is obtained from W. Bengal. It is utilised in making hats, toys, floats for fishing nets and decorative items during Puja festivals and in marriage celebrations in N. India.

Colocasia esculenta: This species is grown under swampy conditions. The tuberous roots and long petioles are edible.

Euryale ferox : Locally known as 'makhana' in N. India, it is a stemless prickly aquatic herb. The orbicular and above 1 m across leaves supported by strong spiny ribs float on water surface. Fruits are round and prickly with the size of an orange containing 8 - 20 seeds, of the size of a pea or a cherry and are eaten raw or roasted (Mitra 1993a). When roasted in hot sand the seed coat swells and can be easily peeled off. The seeds are sold in local markets.

Ipomoea aquatica : Known as 'kalmisag', it is a relished green by people in Bihar, Orissa, Tamil Nadu, Uttar Pradesh and W. Bengal. Nutritionally gaining significance for its good mineral content its organised cultivation has attained significance both in Bengal and Bihar. Village ponds and puddles close to railway tracks are seen with wild growth of this species. It is a runner with medium-sized cordate leaves and purple or pale pink flowers. Rooted slips or cuttings are used in cultivation. Maintenance of proper water depth is important for its successful cultivation (Satpathy 1964). Its tender twigs and leaves are used as greens. If water is inadequate, the plant becomes woody and inedible.

Nasturtium officinale: The 'watercress' grows along streams submerged or spreading over mud surfaces in hilly areas. It is essentially used as a salad. The chopped leaves are mixed in fruit and vegetable juices.

Nelumbo nucifera : This floating-leaved species, commonly known as "bhen", is much valued for its young leaves, petioles and flowers and is eaten as a vegetable (Mitra 1993c). The torus is sold for the edible carpels. The carpels are eaten after removing the outer covering and the bitter embryo. The rhizomes which are starchy are collected and sold as a vegetable in different parts of India. Flowers and seeds are reported to be used as medicine. Organised cultivation of this species is restricted to north Bihar, eastern Uttar Pradesh , Punjab and Tamil Nadu (Malik 1961).

Nymphaea stellata : Various parts of the plant such as rhizomes, tender leaves and pedicels are edible.

Schumannianthus dichotoma : Called 'sitalpati' grows in low lying areas in W. Bengal. The stem is a source of raw material for mat-making. The mats ('sitalpati') when kept above bedding sheets in hot sultry weather give a cool feeling. The quality of the mat depends on the texture and smoothness of the stem. This mat-making industry is confined to about 3000 families in W. Bengal. A mat of 2.5 m by 0.5 m, woven in a day, can get a net income of Rs. 50/-. The fibre from the plant is used in hat-making. A large number of farmers in Cooch Bihar are engaged in the cultivation of 'sitalpati'. Its cultivation extends to the district of Goalparah of Assam in E.India. In low lying areas this shrub can be cultivated more profitably by replacing rice as profit per unit area and employment generation in rural areas are two positive aspects for growing this species.

Trapa natans : *Trapa* is a unispecific genus represented by *T. natans*, a polymorphic species with a number of varieties. Of these, var. *bispinosa* is economically the most important (Daniel *et al.* 1983). It is extensively grown in Bihar, Orissa, Uttar Pradesh and W. Bengal (Malik 1961). Panchayats owning large areas of wetlands cultivate this crop. Several types exist in cultivation. The fruits are known as "singhara" and the sweet, tender, delicious and nutritious kernels are eaten both fresh and dry. Dried kernel is ground into flour for various preparations.

***Typha* spp.** : Cattails are hardy and large perennial herbs and grow gregariously in shallow and marshy places. The young shoots, anthers and rhizomes are eaten in different forms. The fibre obtained from some species can be substituted for cotton, wool and jute. It is also suitable for paper-making. The aerial parts are mixed in mortar and used as structural material (Seshavatharam 1990). Cottage industries in Bihar, Punjab, Rajasthan, Uttar Pradesh and W. Bengal commercially exploit the leaves (Saha 1968).

Fodder

Echinochloa colonum and *Hygroryza aristata* are grown in water-logged situations. Valued as fodder they are relished by cattle. The grain is eaten by the poor in times of scarcity. *Avicennia* spp., *Phoenix paludosa* and *Sonneratia cascolarias* are used for human consumption and as a fodder.

Other uses

Farmers in W. Bengal use dry hyacinth (*Eichhornia crassipes*) as fuel. The dried material is burnt along with jute sticks and refuse as fuel. The resulting ash is used as a manure. The plant's potential use in paper-making and other purposes was emphasized by Jayaraman (1981) and Sharma (1971). Economic significance of certain *Scirpus* spp. was discussed by Zafar (1976). *Halophila ovalis*, a submerged seagrass, washed ashore along with other seaweeds after its growth period in Chilka lake, is used as a manure in plantations. A variety of products are derived from the mangroves (Damania and Deshmukh 1996). An alcoholic beverage is obtained from *Nypa fruticans*. Some tree species such as *Heritiera fomes*, *Excoecaria agallocha* and *Ceriops* spp. are important timber yielding trees.

ENDEMIC PLANTS

A taxon confined to a particular restricted area or a region and usually separated or isolated from related taxa by geographical or temporal barriers is considered as endemic. Endemism in both aquatic and wetland plants is low as they occupy rather uniform habitats and tend to have a wide distribution. This is due to the fact that water is a uniform medium over large geographical areas (Sculthorpe 1967). Rao (1994) contended that the Indian region has approximately half of world's aquatic flowering plants and listed ca 300 aquatic species belonging to 69 families. Forty two of them are reported endemic. Families with good number of endemics include Podostemaceae (10 species), Lentibulariaceae (8 species), Aponogetonaceae (6 species), Lythraceae (4 species) and, Isoetaceae (10 species) and Marsileaceae (8 species) from lower groups. Lavania *et al.* (1990) compiled a list of 470 aquatic species belonging to 59 families from the Indian subcontinent and 8 dicotyledonous and 11 monocotyledonous families were recognised by them as exclusively aquatic. Cook (1996) listed 685 aquatic and wetland species of which 203 taxa are designated as endemic (29.6%). Cook (1998) segregated the total endemic aquatic and wetland plants state-wise in India and concluded that W. Ghats harbour more number of species and specifically towards south. Considerable number of endemics belong to the families Balsaminaceae, Lythraceae, Lentibulariaceae, Podostemaceae, Araceae, Cyperaceae and Poaceae. Many species of *Impatiens* prefer wet places close to streams, river banks or the vicinity of water spray zones. Of the 203 species reported from

India, 22 grow in or near wet places and excepting one, all are endemic either to W. Ghats or W. Himalayas (Vivekananthan *et al.* 1997). The Lythraceae in India is represented by 8 genera and 59 species of which only 3 are aquatic endemics and are restricted to peninsular India. The genus *Rotala* has 14 species in India. *Rotala malampuzhensis* occurs in wet places in coastal Kerala. Other endemic species are *R. fimbriata* and *R. illecebroides.* Likewise many species of *Utricularia* (Lentibulariaceae) are restricted to the W. Ghats and notable among them are *Utricularia albo-caerulea, U. cecilii, U. furcellata, U. lazulina, U. malabarica, U. nayarii, U. praeterita, U. purpurascens, U. smithiana, U. subramanii* and *U. wightiana* (Janarthanam and Henry 1992). In Podostemaceae species such as *Farmeria indica, Indotristica tirunelveliana, Willisia selaginoides* and *Zeylanidium maheshwarii* are endemics (Rao 1994). Cook (1998), on the other hand, listed six endemic genera in this family and include *Zeylanidium* (3 species), *Farmeria* (2 species), *Indotristica* (2 species), *Griffithella* (1 species), *Hydrobryopsis* (1 species) and *Willisia* (1 species). As many as 8 species of Podostemaceae restricted to W. Ghats were reported by Nayar (1996). These include *Farmeria indica* (SW. Ghats), *Griffithella hookeriana* (N. and CW. Ghats), *Hydrobryopsis sessilis* (CW. Ghats and NE. Ghats), *Indotristica ramosissima* (rivers of Malabar plains), *I. tirunelveliana* (Tirunelveli hills), *Podostemon barberi* (rivers of peninsular India), *Polypleurm dichotomum* (SW. Ghats), *P. filifolium* (Trichur, Parmbikulam, Kerala) and *Willisia selaginoides* (SW. Ghats).

Of the 25 genera and 138 species of the Araceae approximately 22% of species are endemic. Those endemics to peninsular India are *Cryptocoryne cognata* (W. Ghats, Konkan), *C. cognatoides* (W. Ghats, N. Kanara), *C. consobrina* (SW. Ghats, Travancore, Palghat, Malappuram and Coimbatore), *C. wightii* (W. Ghats of Karnataka; Kerala), *Lagenandra meeboldii, L. nairii* (Kerala) and *Theriophonum fischeri* (C. Kerala; C. and S. Tamil Nadu). The family Eriocaulaceae is represented in India by a single genus *Eriocaulon* with 74 species. 33 taxa are endemic to peninsular India. Some important aquatic endemics include *Eriocaulon breviscapum* (W. Ghats, N. Kanara, Shimoga), *E. conicum* (E. Ghats, Ganjam, Mahendragiri hills; W. Ghats, Mysore, Gudalur and Nilgiris), *E. nairii* (SW. Ghats, Anamalais), *E. minutum* (Mt. Abu in Rajasthan; W. Ghats, Konkan, Kanara and Nilgiris) and *E. odoratum* (W. Ghats, Konkan, southwards to Travancore, Anamalai and Palni hills).

The Cyperaceae with 22 genera and 446 species in India has 58 endemic species and 7 varieties. The genera with the higher representation in peninsular India are *Fimbristylis* (29), *Cyperus* (14) and *Carex* (7). (Ahmedullah and Nayar 1987). The former two genera though represented by good number of aquatics *Cyperus* (42 species) and *Fimbristylis* (38 species) are represented by a few. They include *Fimbristylis tortifolia* (Madurai district, Tamil Nadu), *F. crystallina* (Coimbatore district, Tamil Nadu), *F. kingii* (W. Ghats, Bangalore, Shimoga, Nilgiris, Palni hills and Attapadi valley, 1650 - 1800 m), *F. latinucifera* (SW. Ghats, Nilgiris) and *F. pustulosa* (Coimbatore and Madurai districts) and *Cyperus flavidus* var. *nilgiricus* (SW. Ghats).

180 species and 21 varieties of the Poaceae are endemic to peninsular India (Ahmedullah and Nayar 1987). Some endemic taxa restricted to peninsular India or specifically to W. Ghats include *Arundinella leptochloa* (Belgaum, Bijapur and Chikmagalur), *A. quartinianus* (Nilgiris), *Bothriochloa foulkensii*, *Coelachne perpusilla* (SW. Ghats, Nilgiris, Parthimund 2300 m), *Cryptococcum longipes* (W. Ghats, Chikmagalur, Coorg, Mysore, Shimoga, S. Kanara, Nilgiris and Palni hills), *Dimeria acutipes* (Tamil Nadu), *D. orissae* (NE. Ghats, Orissa), *Isachne bourneorum* (Nilgiris), *I. oreades* (SW. Ghats, Nilgiris), *Ischaemum nilagiricum* (SW. Ghats), *I. fluminum* (Maharashtra, Karnataka and Tamil Nadu) and *Iselima anthephoroides* (Maharashtra and Karnataka).

Other families which have fewer endemics include the Asteraceae (*Anaphalis leptophylla*, *A. wightiana*, *Emilia zeylanica*, and *Vernonia ramaswamii*, Aponogetonaceae (*Aponogeton appendiculatus* and *A. satarensis*). Cook (1998) included many other species such as *Salvinia cucullata* (Salviniaceae), *Geissapis tenella* (Fabaceae), *Ammannia desertorum* (Lythraceae), *Heliotropium keralense* (Boraginaceae), *Dopatrium lobelioides* and *Ramphicarpa longiflora* (Scrophulariaceae), *Crinum viviparum* (Amaryllidaceae), *Commelina hasskarlii*, *Cyanotis cucullata*, *Murdannia wightii* (Commelinaceae), *Wiesneria triandra* (Alismataceae) and *Trithuria konkanensis* (Hydatellaceae).

A few tree species which grow near river banks such as *Calophyllum apetalum* (Clusiaceae), *Dipterocarpus bourdillonii*, *Hopea parviflora*, *Hopea ponga* and *Hopea utilis* (Dipterocarpaceae) are endemic to different regions in India. Thus Indian wetlands harbouring rich diversity and high % of endemism in aquatic and wetland plants place themselves as priority areas of conservation.

THREATENED PLANTS

Wetland reclamation and destruction are the factors responsible for the loss of the rich plant diversity in these habitats. Vast stretches of wetland areas in India were converted for cultivation. The Kolleru lake in Andhra Pradesh has lost 34,000 ha of wetland area to agriculture. Deepar bil in Assam and Hokarsar lake in Kashmir are some of the other wetlands that have shrunk on account of reclamation for agriculture. Reclamation of part of the Yamuna floodplains in Delhi, destruction of coastal and mangrove ecosystems around Bombay and uncontrolled urban development in the backwaters of Kerala are some examples of human interference with wetland habitats. A number of species of these habitats show depletion in their populations and are under different degrees of threat. Some of the species listed in the Red Data Books of Indian Plants (Nayar and Sastry 1987, 1988, 1990) are given under indicating a few salient points of each species.

Ammania desertorum (Lythraceae)

Rare. Grows in wet and marshy places in association with *Ammania baccifera* and *Cyperus* spp. Known from Gujarat and Rajasthan.

Amorphophallus longistylus (Araceae)
A. oneophyllus (Araceae)

Rare. Occur in the fringes of evergreen forests along water courses and endemic to S. Andaman Island. Their potential as a wild genetic resource is to be ascertained.

Aneilema glanduliferum (Commelinaceae)

Vulnerable. Grows on wet rocky slopes adjoining river banks at ca 1800 m and possibly endemic to Arunachal Pradesh. It is of great phytogeographical botanical and evolutionary interest.

Aponogeton appendiculatus (Aponogetonaceae)

Indeterminate. Occurs mostly in brackish water and is endemic to Kerala, Maharashtra and Tamil Nadu. May be found at 3 m depth as in the Vembanad lake. Flowers only when the brackish water inundates the rice fields during post monsoon. Inflorescence found at great depth when water is very turbid. Tubers form part of diet in Kerala and two year old tubers are used by local farmers as food.

Aponogeton satarensis (Aponogetonaceae)

Vulnerable. A plant of shallow stagnant ponds in the Mavashi plateau. The plant occurs at a depth never exceeding 60 cm and the tubers are rooted in mud along the periphery where the depth is less than 20 cm. Endemic to Satara district in Maharashtra. *A. satarensis* is the first report of a dioecious species from Asia. Closely allied to *A. decoryii* of Madagascar. The Indian species is unique in that plants of both sexes look similar morphologically.

Begonia burkillii (Begoniaceae)

Rare. Reported to occur on rocks by streams between 300 - 1000 m in outer hills in dense evergreen forests. Restricted to the Abor hills in Arunachal Pradesh

Begonia rubrovenia var. *musneri* (Begoniaceae)

Rare. Grows in between moist rocks, usually along stream banks at 1000 m. Restricted to the Khasi hills, Meghalaya. This species is of phytogeographical and botanical interest.

Cryptocoryne cognata (Araceae)

Indeterminate. Endemic to Konkan in Maharashtra. Interesting from phytogeographical viewpoint.

Cryptocoryne cognatoides (Araceae)

Vulnerable. Inhabits moist rocks in streams. Endemic to N. Canara in Karnataka and Sindhudurg in Maharashtra.

Cyathocline lutea (Asteraceae)

Rare. An erect herb of open wet situations. Endemic to parts of Pune and Thane districts in Maharashtra.

Cyperus dwarkensis (Cyperaceae)

Rare. A plant of coastal marshy places in Gujarat. So far known only from the type locality, Dwaraka in Saurashtra.

Didymocarpus missionis (Gesneriaceae)

Rare. Found in dense evergreen forests often by riversides on wet rocks. Endemic to southern end of the W. Ghats. Rediscovered by Henry and Swaminathan (1980) after a lapse of 100 years.

Eriocaulon humile (Eriocaulaceae)

Vulnerable. Grows among grasses in marshy open situations. Endemic to W. Ghats in Maharashtra.

Glyphochloa santapaui (Poaceae)

Rare. Found on marshy lateritic hill tops and is endemic to the W. Ghats in Maharashtra.

Hubbardia heptaneuron (Poaceae)

Presumed to be extinct due to loss of habitats. Endemic to the Gersoppa falls of the Sharavati river in N. Canara district, Karnataka. Collected between rocks moistened with the spray of the falls. Requires a special niche surcharged with water spray in the neighbourhood of falls. Only representative of the tribe Hubbardieae with spikelet structure not found in any known grass; of immense botanical interest. Diversion of the river water for hydroelectric scheme seems to have reduced the flow of the water falls resulting in its disappearence.

Impatiens johnii (Balsaminaceae)

Endangered and possibly extinct. This endemic species with highly restricted distribution is yet to be re-collected after the original discovery. A Occurs along stream beds in dense evergreen forests at 1250 m in Idukki district, Kerala. The populations are depleted due to large scale destruction of evergreen forests.

Impatiens munnarensis (Balsaminaceae)

Endangered. Occurs on edges of streams and in marshy places at ca 1300 m in Idukki district, Kerala.

Indotristicha tirunelveliana (Podostemaceae)

Vulnerable. Grows on rocks in running streams in Tirunelveli hills in SW. Ghats. This species is peculiar and botanically interesting.

Limnopoa meeboldii (Poaceae)

Vulnerable. Inhabits tanks, floodplains and water-logged marshy areas near rivers and is known from Ernakulam, Kasargod and Trichur districts in Kerala (Henry *et al.* 1978; Ved Prakash and Jain 1983). Plants form a thick mass of tangled stems on the surface of water. Extremely rare but wherever found, it occurs in a few hundreds. This species is taxonomically important because this is the lone representative of a distinct tribe.

Neanotis oxyphylla (Rubiaceae)

Rare. Occurs in swampy soils up to *ca* 1800 m. Plants often remain submerged. Reported from the Balphakram Wildlife Sanctuary, Nokrek Biosphere Reserve and some sacred groves in Meghalaya.

Ochreinauclea missionis (Rubiaceae)

Vulnerable. This species is of particular phytogeographical significance as it represents a unispecific endemic genus. Occurs in C. and SW. Ghats along banks of rivers or streams between 600 and 2000 m. Fragmented populations are found in widely separated localities which are threatened by various anthropogenic factors. Powdered bark and its decoction are used for curing cutaneous diseases. Reduces rheumatic pain when externally applied; sometimes used as a purgative. Much exploited by the local people for its purported medicinal value.

Phyllanthus talbotii (Euphorbiaceae)

Rare. Grows near water courses. Endemic to N. Kanara and Shimoga districts in Karnataka. Potential value not yet known.

Plectranthus bourneae (Lamiaceae)

Indeterminate. Occurs along streams in ravines and under rocks at *ca* 2000 m. Restricted to the Palni and Nilgiri hills, Tamil Nadu.

Poeciloneuron pauciflorum (Bonnetiaceae)

Indeterminate. Known to grow along river banks or water courses. Endemic to Travancore and Tirunelveli hills of SW. Ghats.

Pogostemon paludosus (Lamiaceae)

Endangered. In wet places at ca 2000 m. Endemic to the Nilgiri hills in W.Ghats, Tamil Nadu.

Rotala ritchiei (Lythraceae)

Vulnerable. Margins of temporary shallow ponds with flowering branches emerging out of the surface of water. Endemic to the W. Ghats, Belgaum (Karnataka) and Pune (Maharashtra) districts. A taxonomically interesting species.

Salacia beddomei (Celastraceae)

Rare. Occurs near water sources in W. Ghats. Endemic to Anamalai hills in Tamil Nadu and Palghat hills in Kerala.

Scutellaria andamanica (Lamiaceae)

Rare. On rocks in stream beds in S. Andaman Islands. Threats to its habitat include pressures of urbanisation and logging operations.

Syzygium travancoricum (Myrtaceae)

Endangered. Confined to swampy places in S. Kerala. Taxonomically this species is not allied to any of the known species of *Syzygium* (Henry *et al.* 1978; Vajravelu 1983).

Weisneria triandra (Alismataceae)

Rare and very scattered. Grows in water-logged areas and in small ponds. Endemic to Sindhudurg district in Maharashtra, and Goa.

Willisia selaginoides (Podostemaceae)

Rare. On wet rocks in swift-flowing river beds in Anamalai hills; shoots resemble *Lycopodium selago*. Over-collecting by students and loss of habitat are the identified threat factors.

ECOLOGICAL ISSUES CONFRONTING IMPORTANT INDIAN WETLANDS

The important issues concerning aquatic systems are soil erosion, weed infestation, human encroachment, pollution and aquaculture (Kaul 1995). Large number of people living in and around wetlands encroach upon these areas for habitation. Vast areas of floodplains are drained for agriculture, urban expansion and other similar purposes. Aquatic weed problems in general were discussed by Varshney and Singh (1976). The Wular lake is silting up rapidly due to run-off from its denuded catchment and shrunk to about a quarter of its original size. Dal and Manasbal lakes in Jammu & Kashmir face problem of eutrophication. Dal lake is a multi-basioned oxbow lake formed by the changing course of the Jhelum river. This lake is subjected to high rate of eutrophication and siltation. Siltation has increased significantly since a number of streams and rivulets were dammed or filled. Besides, the volume of pollutants and sediments increases during summer months when over 1700 houseboats and hotels support an extra 50,000 people every year. Gilsar and Khushalsar lakes in Srinagar city are under severe biotic pressure as the surroundings of these lakes are undergoing rapid urbanisation. Tso morari (12000 ha) is the largest high altitude trans-Himalayan lake situated entirely within the Indian territory. The water is alkaline. Small islands near the north and south of this lake are a breeding ground for waterfowl. There has been an increase in the salinity of the lake water because of closure of the inlet. The Tso Kar is a hypersaline lake of 2200 ha. Adjacent freshwater meadows support a mixture of *Carex* spp. and *Ranunculus* spp. This lake catchment is subjected to heavy grazing by cattle of the surrounding villages. The Renuka lake in Himachal Pradesh is subjected to similar problems related to soil erosion. Pichola lake in Rajasthan receives excess domestic drainage. Kabartal is the largest freshwater lake in northern Bihar. There is a report of contamination of the lake water with pesticides and fertilisers used by farmers in the catchment. The entire lake surface is infested with *Eichhornia crassipes* and this aggravates anoxic conditions in the lower layers of the lake. Ducks, coots and other waterfowl are netted in large numbers every year. Rapid siltation of the lake due to denuded catchment is another serious problem confronting this lake. In Loktak an area of about 4000 ha of the lake margins was reclaimed for paddy cultivation. The catchment of Loktak lake suffers from severe deforestation and concomitant soil erosion resulting in increased siltation. Shifting cultivation on the surrounding hill slopes aggravates the problem of siltation. The lake is also being increasingly threatened by the inflow of domestic sewage and, fertiliser and pesticidal residues from the catchment enhancing eutrophication. Increasing size of floating islands and growth of the noxious water hyacinth are the other problems.

The Chilka lake in the Orissa coast is subjected to the influence of a variety of human activities. More than 9000 fishing boats operate in the lake and there are over 15 mechanised ferries transporting people between various points. At least 25% of the littoral zone of the Chilka lake has been taken over for prawn culture operations. A huge number of cattle and buffaloes graze in and around the lake. Local villagers gather reeds and grasses for thatching purposes. The drainage basin is heavily polluted. Stone quarrying in the hilly terrain is common. An area of 1600 ha of the lake has been reclaimed for paddy cultivation. Apart from some towns, the shore has 122 fishing villages with a total population of 100000. Chilka lake is seriously threatened by increasing siltation, decreasing salinity and rapid growth of the *Potamogeton pectinatus* that hinders navigation. Reduced inflow of sea water has resulted in a progressive decrease in salinity favouring the growth of noxious *Potamogeton pectinatus*. The average salinity has dropped from 22.3 ppt (1957-58) to 13.2 ppt (1990-91). The reduction of tidal impact and possibly the increased nutrient inflow from agricultural run-off have caused an explosive growth of freshwater macrophytes, increasing their occupied area from 2000 ha in 1973 to an estimated 44,000 ha in 1988 (Anonymous 1993). The area of the lake has also shrunk from 116500 ha to 91600 ha. As a solution to the salinity problem, the Zoological Society of India recommended that the channel linking the lake with the Bay of Bengal be widened. There is also constant pressure to drain parts of lake for agricultural purposes, and 1600 ha have already been reclaimed for paddy cultivation.

Similarly vast areas of the Kolleru lake are reclaimed for agriculture during summer. Besides, numerous fish ponds constructed in the lake proper adversely affect the lake hydrology. Many villages located in and around the lake which are known as bed- and belt-villages totally depend on the lake resources. Village populations which are ever on the increase generate pressure of various kinds. There are twenty inlets to release effluents into the lake. Some of these carry industrial effluents while others bring in agricultural run offs. Thus, the lake faces the problem of eutrophication with enhanced nitrogen and phosphorus inputs. Hussain sagar located in the heart of the twin cities of Hyderabad and Secundrabad receives enormous amounts of industrial effluents and muncipal sewage. Fish-kills were recorded in this lake and a study on the pollution of the lake revealed that a heavy load of pollutants, containing soluble and insoluble salts (nitrates, nitrites and phosphates of calcium) enter through various inlets. The irony is that such a lake supplies drinking water to residential areas in Hyderabad city.

CONSERVATION MEASURES

Recognising the importance of wetlands a scheme was introduced in the VII Five Year Plan for conservation of wetlands. A National Wetland Committee was constituted to advise the government on policy guidelines of wetlands for intensive conservation and monitoring the implementation of management action plans. Likewise, keeping in view their special features and importance, a National Mangrove Committee was also constituted for the conservation of mangroves. In 1992 a single National Committee for wetlands and mangroves was constituted. At the state level steering committees were constituted consisting of members drawn from the State Govt. departments concerned with wetlands and experts in the subject. The National Wetland Committee has identified 21 wetlands for conservation based on four criteria viz., (i) representativeness and uniqueness (ii) value of ecological and hydrological features (iii) socioeconomic importance and (iv) significance to human and wildlife. Action plans for 10 wetlands namely Pichola and Fateh Sagar(Rajasthan), Kanjli and Harike (Punjab), Wular (Jammu & Kashmir), Bhoj (Madhya Pradesh), Loktak (Manipur), Chilka (Orissa), Kolleru (Andhra Pradesh), Sukhna (Chandigarh) and Renuka (Himachal Pradesh) have been prepared based on the problems identified in these wetlands (Table I).

Table I
Wetlands selected for conservation by the National Wetland Management Committee

Wetland	State	University identified for collaboration
Kolleru	Andhra Pradesh	Osmania
Wullar	Jammu and Kashmir	Jammu & Kashmir
Chilka	Orissa	Utkal
Loktak	Manipur	Manipur
Bhoj	Madhya Pradesh	Bhopal
Sambhar	Rajasthan	Jodhpur
Pichola	Rajasthan	Udaipur
Ashtamudi	Kerala	Kerala
Harike	Punjab	Punjab Agricultural,
Ujni	Maharashtra	Pune
Sukhana	Chandigarh	Punjab Agricultural,
Sasthamkotta	Kerala	Kerala
Renuka	Himachal Pradesh	Himachal
Kabar	Bihar	Bhagalpur
Nalsarovar	Gujarat	Gujarat
Kanjli	Punjab	Punjab Agricultural,
Ropar	Punjab	Punjab Agricultural,
Chandertal	Himachal Pradesh	Himachal, Shimla
Pongdam	Himachal Pradesh	Himachal, Shimla
Tso Morari	Jammu & Kashmir	Jammu & Kashmir
Salt Lake Swamp	W. Bengal	Kolkata

(Source: Kaul 1995)

Subsequently in 1993 a National Lake Conservation Plan (NLCP) was carved out of the wetland programmes to focus attention on urban wetlands threatened by pollution and other anthropogenic activities. The major lakes covered by the NLCP totaling 21 were given by Kaul (1995). As many as 11 of them are situated in W.Bengal and in the vicinity of Kolkata and Howrah cities. Certain lakes such as the Sukhana in Chandigarh and the Bhoj lake in Madhya Pradesh are also included under the National Lake Conservation Plan and as well as in the list of lakes selected for conservation by the National Wetland Management Committee. Various river waters are also under continious monitoring for some specified parameters. The Central Pollution Control Board (CPCB) in collaboration with State Pollution Control Boards (SPCBs) is monitoring river systems globally under Global Environmental Monitoring and at the national level under Monitoring of the Indian Aquatic resources since 1977. The monitoring programme began with a mere 17 monitoring stations on the river Yamuna and extended steadily over the years. By 1996, the monitoring network had 495 stations covering almost all the major river basins.

The Ramsar Convention is an inter-governmental treaty which provides a framework for international cooperation for the conservation of wetland habitats.

Under the convention there is a general obligation to formulate and implement plans to promote the sustainable use of wetlands. A second obligation is the designation of wetlands for inclusion in a list of 'Wetlands of International Importance' (Ramsar Sites). Finally the contracting parties are obliged to promote the conservation of wetlands in their territory through establishment of nature reserves.

India acceded to the convention in 1981 and designated the Chilka lake (Orissa) and the Keoladeo Ghana National Park (Rajasthan) as Ramsar Sites. Four additional sites, the Wular lake (Jammu & Kashmir), Harike lake (Punjab), Loktak lake (Manipur) and Sambhar lake (Rajasthan) were designated in March 1990.

The two notifications - Wetlands as ecologically fragile areas and Coastal Regulation Zone (CRZ) under the Environmental Protection Act (1986) promote conservation efforts of various wetland habitats particularly bays, estuaries, creeks, rivers and backwaters. Under the Wildlife Protection Act (1972) several protected areas were set up and many wetlands now come under sanctuaries, national parks and tiger reserves. Thus, these habitats are covered under different annual action plans of these protected areas. These conservation aspects were discussed in greater detail by Kaul (1995).

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Dr. A.D. Sobhnaraj

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BOTANIC GARDENS

N.P. Singh
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Botanic gardens are scientifically planned collections of trees, shrubs, herbs, climbers, ferns, etc. from different phyto-geographical regions. The role of botanical gardens is well known in the conservation of plant diversity. They primarily serve scientific functions by supplying plant materials for research and help in comparative studies on modern taxonomy and experimental botany. Botanic gardens provide adequate facilities for plant introduction and their acclimatization work and thus, are an important tool for promotion of economic plants. They are potentially well equipped for research into aspects of plant propagation, seed physiology, vegetative reproduction, etc. They are also well placed to conduct research on breeding behaviour, pathology, symbiotic relationships and minimum viable population sizes for both *in situ* and *ex situ* conservation.

In the context of environmental degradation and ecological imbalance, botanic gardens play an important role as living repository of plants, conserving rare, threatened and endemic plants, germ plasm as well as plant resource centre, in promoting educational and training programmes, serving as data bank for information and documentation of holdings in botanical gardens of the country or region and in creating public awareness regarding the value of plants. According to Ashton (1984), "*Botanic gardens have an opportunity, indeed an obligation which is open to them alone, to bridge between the traditional concerns of systematic biology and the returning needs of agriculture, forestry and medicine for the exploration and conservation of biological diversity.*" They differ from public parks and gardens which are primarily meant for aesthetic beauty and recreation. However, a well-planned botanic garden may also act as centre of aesthetic attraction.

The botanic gardens with their elaborate facilities of green houses and glass houses provide shelter to many rare and endangered plant species of the world, which for various reasons are facing danger of extinction in their natural habitats. Besides, some special sections *viz.* Arboretum, Pinetum, Orchidarium, Bambusetum, etc. are also attached with many famous and well planned botanic gardens of the world that act as resource centres for conservation, research and development.

a. *Arboretum (*Arboreta): Botanic gardens or parts of botanic gardens where the main collections of woody species grow are called arboreta. However, small areas in forests, set aside for conserving arborescent species, can also serve the function of arboreta.

b. *Bambusetum* (Bambuseta): It is a kind of botanic garden or part of a botanic garden where mainly bamboos are grown.

c. *Orchidarium* (Orchidaria): Collections of orchids in a garden form an orchidarium. Conservation of orchids has very much warranted the study of their taxonomy, biology, horticultural aspects etc. in order to maintain their germ plasm for hybridization, multiplication, etc. This can be possible only through *ex situ* conservation and hence orchidaria are mostly associated with botanic gardens. In India, 3 National Orchidaria at Howrah, Shillong and Yercaud and the chain of Experimental botanic gardens under the aegis of regional circles of Botanical Survey of India at Dehradun, Pune, Shillong, Coimbatore, Gangtok, Itanagar and Port Blair located at different altitudes have made commendable contributions in propagation, conservation and carrying out scientific research on orchids. Regional Plant Resource Centre, Bhubaneswar; Tropical Botanic Garden and Research Institute, Thiruvananthapuram, Orchid Research and Development Centre, Tipi, Arunachal Pradesh are also actively engaged in research on orchids through orchidaria.

d. *Pinetum* (Pineta): It is a kind of arboretum where the main collections are of conifers. One such pinetum is situated at one of the botanic gardens in California, where 70 species of genus *Pinus* are conserved. In Indian Botanic Garden, Howrah also, a pinetum is being maintained.

e. *Green house*: The growth of natural vegetation is greatly influenced by the physiological and climatic conditions of an area. Occasionally, plants of one climatic region are difficult to grow in other conditions. To overcome such problems, Green house becomes essential where plants are grown artificially outside their natural habitat. Thus, a green house can be defined as a house provided with means of obtaining artificial climatic conditions and protecting plants from unfavorable weather conditions. The Green houses are primarily used for introduction, propagation, acclimatization, cultivation and conservation of plants away from their natural habitats.

Green houses are covered usually with glass so these are also called glass houses, but glass house is quite different from green house in function as well as its objectives. Plants remain green, grow well, produce normal flowers and fruits and finally complete their life cycle. In these houses, tropical plants are grown successfully. The sunrays penetrate the house through glass panes and in severe winter, plants are protected from chilled weather. In India, a number of green houses exist in different botanic gardens under Botanical Survey of India and also some other botanic gardens of the country.

HISTORICAL BACKGROUND

The historical development of botanic gardens dates back to 1500 AD. Between 1545 and 1550 AD, the collections of medicinal plants were established in Italy and thus, it can be said that the earliest botanic gardens were planned for scientific purposes. Thereafter gardens were established in Holland and Germany, followed by other countries. The oldest botanic gardens those established in Europe were in Pisa (1543), Padua (1545), Florence (1545), Bolonga (1545), Zurich (1560), Leiden (1577), Lepzig (1579), Paris (1597), Oxford (1621), Upsala (1655), Berlin (1679), Edinburgh (1670), Amsterdam (1682), Leningrad (1713), Kew (1759), Viena (1754), Budapest (1771) etc. The founder of first botanic garden of Pisa was Luca Ghini who was lecturer in the Simplicum University and thereby laying the foundation of modern Pharmacognosy and the introduction of herbarium (Atkinson, 1955). At present, an estimated number of about 35,000 plant species are being conserved in 1500 botanic gardens all over the world. Royal Botanic Gardens, Kew (England) alone has *ca* 25,000 conserved plant species, of which *ca* 2700 are of rare and threatened nature. In recognizing the conservation role of botanic gardens, International Union for Conservation of Nature and Natural Resources (IUCN) in 1987 established a Botanic Gardens Conservation Secretariat (BGCS) to mobilize the world's botanic gardens into an effective force for conservation.

INDIAN SCENARIO

India with its varied phyto-geographical conditions harbours a wide variety of floral wealth and it is reported that 1500-1750 (*ca* 10%) species of the recorded flowering plants are considered as endangered. For the study and conservation of diverse and rich floristic wealth a number of botanic gardens were established throughout the country. Henderson (1983) has documented only 15 botanic gardens from India, whereas Chakraverty and Mukhopadhyay (1990), recorded 52 Government gardens, 46 parks and gardens of public and academic interest, 39 university botanic gardens. According to a recent report prepared by the scientists of Botanical Survey of India, more than 5000 plant species are being conserved in 38 important botanic gardens and arboreta, distributed in different bio-geographical zones of India. Among these, premier one is the Indian Botanic Garden at Howrah, under the Botanical Survey of India and 9 other associated regional Experimental botanical gardens at Pauri (Dehra Dun), Allahabad, Yercaud (Coimbatore), Barapani (Shillong), Dhanikeri (Andaman & Nicobar), Mundhwa (Pune), Sankie view (Itanagar), Gangtok and Jodhpur. Besides, Horticultural Experimental and Training Centre, Saharanpur, Lalbagh Botanic Garden, Bangalore, Government Botanic Garden, Ootacamund, Lloyd Botanic Garden, Darjeeling, State Botanical Garden, Barang are also some of the important botanical gardens of India. A few botanical gardens are associated with research institutions namely, National Botanical Research Institute, Lucknow; Forest Research Institute and Colleges, Dehra Dun; Tropical Botanical Research Institute, Thiruvananthapuram, and Regional Plant Resource Centre, Bhubaneswar. These Gardens are actively engaged in the conservation of germ plasm of different groups, introduction and conservation of rare, threatened, endangered and endemic species of their respective regions, introduction of exotic plants, carrying out experimental, taxonomic and horticultural studies to fulfill the diversified aims and objectives of the botanic gardens. A brief history, location, functions along with their conservation strategies are being briefed hereunder.

Indian Botanic Garden, Howrah

Indian Botanic garden, formerly known as Royal Botanic Gardens, Calcutta (now Kolkata) is perhaps the largest and oldest of its kind in south-east Asia and was established in 1787. It covers an area of 126 ha, of which 16 ha was given to Bengal Engineering College (Bishop College) in the year 1825. This garden had played an important role in the economic development of India by first introducing, improving and distributing *Camellia sinensis* (Tea), *Corchorus capsularis* (Jute), *Swietenia mahagoni* (Mahagoni), *Solanum tuberosum* (Potato), etc. and other important economic and horticultural plants which boosted the economy of India. The garden serves as a living repository of *ca* 12,000 trees, shrubs and climbers representing over 1400 species together with a large number of wild and cultivated herbs. These include palms (109 spp.), Bougainvilleas (14 cultivars in 2 species); Bamboos (28 spp.); Orchids (2500 sets in 80 species), Water lilys (4 species in nearly 30 varieties), Cacti and Succulents (200 spp.), Medicinal plants (*ca* 450 spp.), Jasmins (25 spp.) etc. Besides above collections, ferns, green house plants, *Pandanus*, gymnosperms, arboricultural/foliage, bulbous and annual plants are also grown here.

This garden is famous for Great Banyan tree (*Ficus benghalensis*), which is the largest and oldest in India and covers an area of *ca* 22,165 sqm. With *ca* 2890 prop roots and *ca* 230 years of age, it looks like a miniature forest and is the main attraction for the local public and tourists.

The other important plants found here are Bread fruit tree (*Artocarpus communis*), Double coconut (*Lodoicea maldavica*), Giant water lily (*Victoria amazonica, V. regia)*, Bird's nest fern (*Asplenium nidus*), Nutmeg (*Myristica fragrans*), Baobab tree (*Adansonia digitata*), Normanbya (*Normanbya normanbyi*), Naglingam (*Couroupita guianensis*) Cocain (*Erythroxylum coca*), Cacao (*Theobroma cacao*), *Elaeocarpus*, etc.

Among rare, threatened and endemic species cultivated are *Bentinckia condapanna, B. nicobarica, Cycas beddomei, C. pectinata., Dipteris wallichii, Eremostachys superba, Frerea indica, Ficus benghalensis* var. *krishnae, Hyphaene thebaica, Magnolia pterocarpa, Nypa fruticans, Pandanus anguifer, Platycerium wallichii, Podocarpus neriifolius, Psilotum nudum, Pterygota alata* var. *irregularis, Rauvolfia serpentina, Renanthera imschootiana, Santalum album, Wallichia densiflora, Gnetum ula, Dillenia retusa, Dalbergia latifolia, Phoenix rupicola, Pterocarpus santalinus, Dischidia benghalensis, Planchonia valida, Uvaria hamiltonii, Zamia floridana, Alstonia scholaris, Garcinia cowa,* etc.

Horticultural Experimental and Training Centre, Saharanpur

This garden was established in the year 1750 with an area of 67.9 ha as a botanic garden. The garden has been re-oriented on commercial lines to sell seeds and plants. It is now mainly engaged in carrying out researches on sub-tropical and tropical fruits, flowers, vegetables and maintains varieties of economic, medicinal and ornamental plants. Altoghther 1500 species are grown. Important species are *Gleditschia ferox*, *Haematoxylum campechianum*, *Ilex paraguensis*, *Koelreuteria paniculata*, *Macadamia ternifolia*, *Schotia brachypetala*, *Zamia latifolia* and many species of foliage, cacti, succulents and fruit yielding plants.

Lalbagh Botanic Garden, Bangalore

It was established in the year 1760 with an area of about 100 ha. Its prime aim is to grow and conserve ornamental plants including rare, interesting and endangered species of the area particularly from Karnataka and other southern states. About 1850 species and 890 varieties/cultivars or ornamental, flowering foliage and interesting and medicinal plants have been successfully grown. Important interesting plants are *Colvillea racemosa*, *Amherstia nobilis*, *Guaiacum officinale*, *Agathis robusta*, *Araucaria cookii*, *Phoenix canariensis*, *Tecomella undulata* and two trees of *Mangifera indica*, planted by Hyder Ali are of immense importance.

Government Botanic Garden, Ootacamund (Udhagamandalam)

This garden was established in the year 1848 with an area covering 22 ha in Nilgiri hills and presently controlled by the Government of Tamil Nadu. The aims and objectives of this garden are to encourage horticulture, provide aids to students of botany, introduce and cultivate plants of exotic, ornamental as well as of economic importance, seeds/plants for distribution, to provide information to sister institutions related to plant science, and supply of botanical specimens. It has about 1050 species of plants which include gymnosperms (12 spp.) and rare (300 cultivars) plants. The other rare and important taxa are *Alsophila latebrosa*, *Acer caudatum*, *Alnus nepalensis*, *Araucaria bidwillii*, *Exbucklandia populnea*, *Cupressus funebris*, *C. macrocarpa*, *Melaleuca styphelioides*, *Podocarpus elongata*, etc.

Lloyd Botanic Garden, Darjeeling

Established in 1878 as a subsidiary garden to the Kolkata botanic garden (presently Indian Botanic Garden) at Darjeeling in an area of about

16.7 ha with the broad aim to introduce and cultivate temperate plants. It has about 1800 species of exotic, indigenous and threatened plants. Some important ones are *Abies spectabilis*, *A. delavayi*, *Ginkgo biloba*. Species of *Magnolia*, *Picea smithiana*, *Streletzia reginae*, the *Metasequoia glyptostroboides* a living fossil, other conifers, and more than 2500 sets of orchids.

Government Botanic Garden, Thiruvananthapuram

This garden was established in 1858 as a museum in an area of about 22 ha with the basic aim to develop botanical cum zoological garden. This has more than 1000 species of tropical and ornamental flowering trees, shrubs and other interesting plants.

Botanical Garden, Forest Research Institute and Colleges, Dehra Dun

This garden was established in 1943 with an area covering about 50 ha. The main aim of the garden is to introduce and carry out research on the forest wealth of the country. About 1200 varieties are being cultivated here and it has one of the richest live collections of woody taxa. The arboretum here is well maintained. Garden includes bamboos, gymnosperms, *Eucalyptus*, shade loving ornamental plants, rare/threatened and interesting species like *Acacia karroo*, *Agathis robusta*, *Araucaria columnaris*, *Betula cylindrostachya*, *Cupresssus cashmeriana*, *C. sempervirens*, *Dendrocalamus giganteus*, *Elaeocarpus sphaericus*, *Juniperus bermudiana*, *J. phoenicea*, *Pinus greggii*, *Tetraclinus articulata*, *Liquidambar formosana*, *Metasequoia glyptostroboides*, etc.

National Botanical Research Institute, Lucknow

Formerly known as Sikander Bagh, established in the year 1800 with an area of about 25 ha, was re-named as Botanic Garden in the year 1953, and now controlled by the Council of Scientific and Industrial Research (C.S.I.R.) with an objective to explore and utilize economic plant resources of the country. It is now an important centre for plant introduction, conservation, documentation, propagation, protection and utilization of plants, particularly of tropical and subtropical regions. More than 6000 species and cultivars are grown that include *Bougainvillea*, *Canna*, *Callistemon*, *Coleus*, *Chrysanthemum*, *Erythrina*, *Ixora*, cacti and succulents, etc.

Among threatened and rare plants are *Commiphora wightii, Cupressus cashmeriana, C. macrocarpa, C. sempervirens, Erythrina resupinata, Hydnocarpus pentandra, Lodoicea maldavica, Rosa clinophylla, Tecomella undulata, Zamia floridana, Z. furfuracea*, etc.

Tropical Botanical Garden and Research Institute, Thiruvananthapuram

Established in 1979 covering an area of 121.23 ha with a view to introduce and cultivate plants of diversified nature from Kerala including endemic, rare, threatened, endangered, exotics, medicinal, economical germplasm of other species and aid to students of botany in carrying out research, etc. This Institute is governed by an autonomous body. Important plants include *Bulbophyllum neilgherrense, Gnetum ula, Justicia beddomei*, etc.

Botanical Garden, Pondicherry

This garden covering an area of about 11 ha, was established in the year 1826. It is under the control of state Government. It provides place for studying the behavior pattern of plant species and conservation of rare plants of about 500 species.

State Botanical Garden, Barang, Orissa

Established in the year 1963, covers an area of 72.1 ha on hill top. Garden cultivates plants of eastern region, particularly of state of Orissa. It has about 1500 species. Important ones are *Asplenium nidus, Bentinckia nicobarica, Cupressus macrocarpa, Platycerium alcicorne*, etc.

Regional Plant Resource Centre, Bhubaneswar

This centre was established as an autonomous organisation under the Department of Science, Technology and Environment, Govt. of Orrisa in the year 1985 and covers an area of 197.08 ha with the aim to introduce, conserve, propagate and genetically upgrade plants of non-agricultural importance. About 3250 species of native and exotics are grown that include timber (122 spp.), fast growing and fuel plants (41 spp.), palms (108 spp.), bamboos (61 spp.), oil yielding plants (22 spp.), medicinal and aromatic plants (160 spp.), orchids (220 spp.), Pandanus (4 spp.), cycads

(10 spp.) cacti and succulents (*ca* 1050 spp.), etc. This centre is a treasurer of very good collection of cacti and succulents. About 200 new intergeneric and intraspecific hybrids and cultivars have been successfully evolved and grown in a series of polyhouses. This centre is actively engaged in the propagation of plants through tissue culture. Important plants grown here are *Acacia holosericea*, *Adansonia digitata*, *Aquilaria malaccensis*, *Arenga englerii*, *Attalea speciosa*, *Cassia speciosa*, *Erythrina abyssinica*, *Grevillea excelsior*, *Hyphaene dichotoma*, *Joannesia princeps*, *Latania commersonii*, *Linospadix minor*, *Michelia kisopa*, *Parthenium argenteum*, *Pterodon pubescens*, *Tibouchina granulosa*, *Tipuana tipu*, etc.

Experimental Botanical Gardens under Botanical Survey of India

Realizing the need of plant conservation and to grow diversified plant species particularly plants of rare, endangered, threatened and endemic nature, to cultivate the germplasm of economically important plants from different phyto-climatic regions of the country that may serve as progenitors for evolution of new plants, introduce and acclimatize exotics of economic and horticultural importance, Botanical Survey of India established nine more Experimental Botanical Gardens (other than Indian Botanic Garden, Howrah) in different climatic zones of India to conserve plant species of eastern himalayan region at Barapani, Eastern circle, Shillong; of western himalayan region at Pauri, Northern circle, Dehra Dun; of decan and western parts at Mundhwa, Western circle, Pune; of southern India at Yercaud, Southern circle, Coimbatore; of gangetic plains at Allahabad, Central circle, Allahabad; of Arunachal region at Sankie-viewArunachal field station, Itanagar; of Gangtok, Sikkim himalayan circle; of Andaman & Nicobar Islands at Dhanikhari, Andaman and Nicobar circle, Port Blair and of desert region at Jodhpur-arid zone circle.

Northern circle at Dehra Dun maintains two Experimental gardens, about 180 km away from its headquarters. Established in the year 1975 at Nagdeo, Pauri in an area of about 14 ha, is presently designated as "National Gymnosperm Collection" which mainly corserves conifers and gymnosperms of about 21 species. The Khirsu garden, kept as "Nature Reserve" covers an area of 8 ha in which mainly species of *Quercus*, *Rhododendron*, many epiphytes, pteridophytes, bryophytes, lichens, orchids and rare himalayan plants grow. About 250 species are being conserved in these two gardens. Important ones are *Agathis lanceolata*, *Berberis* *aristata*, *Cryptomeria japonica*, *Cupressus torulosa*, *Ginkgo biloba*, *Picea smithiana*, *Pinus echinata*, *Pinus gerardiana*, *Pinus greggii*, *Pinus kesiya*, *Pinus nigra*, *Pinus patula*, *Pinus roxburghii*, *Pinus taeda*, *Pinus thunbergii*, *Pinus wallichiana*, *Taxodium* spp., *Taxus wallichiana*, *Trachycarpus takil*, etc.

A newly developed garden, attached with new office-cum-herbarium building at Kaulagarh road, Dehra Dun has been christened as the "Swarna Jayanti Uddyan" which harbours about 125 endemic, rare and threatened plants of the region besides other plants of botanical interest. They are categorised and planted in four major sectors. In the medicinal plant sector important species grown are *Berberis lycium*, *Celastrus paniculatus*, *Costus speciosus*, *Dioscorea deltoidea*, *Elaeocarpus sphaericus*, *Gloriosa superba*, *Taxus wallichiana*, *Tinospora cordifolia*, species of *Terminalia*, etc. In the wild plant sector species like *Boehmeria rugulosa*, *Grewia optiva*, *Celtis australis*, *Diploknema butyracea*, *Juglans regia*, species *of Cinnamomum*, *Flacourtia*, etc. grow. Similarly in the cultivated plant sector species of pomological importance such as *Casimiroa edulis*, *Eriobotrya japonica*, *Platanus orientalis*, *Prunus armeniaca* and in the general plant sector important species like *Aesculus indica*, *Cedrus deodara*, *Coriaria nepalensis*, *Dioscorea deltoidea*, *Eremostachys superba*, *Ginkgo biloba*, *Itea nutans*, *Mahonia nepalensis*, *Nepenthes khasiana*, *Naringi crenulata*, *Peucedanum nepalense*, *Pinus wallichiana*, *Pinus roxburghii*, *Paeonia emodi*, *Platycerium wallichii*, *Rauvolfia serpentina*, *Sapium sebiferum*, *Psilotum nudum*, *Sophora mollis*, *Taxus wallichiana*, *Trachycarpus takil*, *Wallichia densiflora*, etc. are grown. About 70 species of orchids are also grown in the newly laid green house under a project "*Ex-situ* conservation of endemic, rare, threatened and endangered orchids of N.W. Himalaya".

Experimental botanic garden at Mundhwa was established in the year 1964. It is about 5 km away from circle headquarters and covers an area of 17.8 ha. About 3000 plants in 500 species include rare and endemic plants from the state of Maharashtra besides economic, medicinal, germplasm of legumes, etc. Important species are *Arisaema caudatum*, *Argyreia elliptica*, *Belosynapsis vivipara*, *Flacourtia montana*, *Frerea indica*, *Gloriosa superba*, *Hoya ovalifolia*, *Ischaemum raizadae*, *Moullava spicata*, *Psilotum nudum*, etc.

Garden attached with circle office at Koregaon road (established in the year 1960) with an area of 2.1 ha, also conserves several important plants like *Dioscoreas*, members of Commelinaceae, *Iphigenia*, medicinal, economic and plants of pomological importance.

Experimental garden covering an area of 3 ha was established in the year 1960 adjoining to the office-cum-herbarium building at Central Circle, Allahabad. About 3000 species of ornamental, economic, medicinal, rare, threatened and endemic nature are grown here. *Rauvolfia serpentina* a plant of high medicinal value whose export totally banned due to over exploitation is grown in a large area of about 0.05 ha as a conservation measure. Other important species grown are genera of *Rosa* (*ca*250 cultivars), *Bauhinia, Codiaeum, Dracaena*, etc. Among rare, threatened and interesting plants are *Annona muricata, Christia vespertilionis, Commiphora wightii, Cycas circinalis, Dalbergia lanceolata, Euryale ferox, Ficus benghalensis* var. *krishnae, Hyphaene dichotoma, Santalum album, Zamia floridana*, etc.

Experimental botanical garden at Barapani located about 22 km away from Shillong near Umiam lake was established in the year 1966. Having an area of 10.4 ha, under the jurisdiction of eastern circle, the garden houses rich collection of many economic, rare and scientifically interesting plants of the north-eastern region and the germplasm of Musa, bamboos, etc. Besides, a circle garden and National orchidarium were also established in the year 1959 at 'Woodlands' with the aim to cultivate and have experimental studies on live plants of eastern region. About 3000 plants representing *ca* 500 species are grown in these gardens, which include about 210 species of orchids. Impotant species being grown are *Angiopteris evecta, Aesculus assamica, Bentinckia nicobarica, Clerodendrum colebrookianum, Coptis teeta, Cyathea spinulosa, Cycas pectinata, Panax pseudo-ginseng, Rauvolfia serpentina, Renanthera imschootiana, Taxus wallichiana*, etc. Plant propagation through tissue culture has been initiated in a Tissue Culture laboratory set up in the circle office.

Experimental garden, Yercaud was established in the Shevary hills of Salem district (Tamil Nadu) under the jurisdiction of southern circle, Coimbatore in the year 1964 on the existing premises of about 18.6 ha of land already earmarked for National Orchidarium (established in the year 1963) with the aim to introduce plant wealth occurring particularly in southern region. More than 5000 plants in about 1000 species (excluding naturally occurring within the area) and about 15,000 sets of orchids in *ca* 226 species are grown here. Many species of exotics viz. species of *Eucalyptus, Hakea laurina, Solanum aviculare*, etc. have been acclimatized. *Nepenthes khasiana* a pitcher plant, endemic to Khasia and Jaintia hills of Meghalaya is adapted well. Some important, rare, threatened and endemic species conserved are *Bentinckia condapanca, Bentinckia nicobarica, Cycas beddomei, Cycas pectinata, Crotalaria shevaroyensis, Drosera burmanni, Gnetum ula, Lilium wallichianum* var. *neilghirrense, Psilotum nudum, Psychotria andamanica, Santalum album, Vernonia shevaroyensis*, etc. Tissue culture laboratory has also been set up for plant propagation.

Experimental botanical garden 'Sankie View' was established in the year 1984 with an area of about 124 acres under the jurisdictiion of Arunachal field station, Itanagar with a view to study and grow plants of tropical and subtropical evergreen forests. A total of about 150 species grown include *Nepenthes khasiana*, species of *Platycerium, Rhododendron* and members of Melastomataceae, Orchidaceae and Zingiberaceae. Some rare, threatened and endemic species include *Aneilema glanduliferum, Acer sikkimense* var. *serrulata, Acer oblongum*, var. *microcarpum, Agapetes subansirica, Bulleyia yunnanensis, Begonia aborensis, Capparis pachyphylla, Coptis teeta, Hedychium longipedunculatum, Huodendron bicristatum, Ilex venulosa, Lysimachia santapaui, Meconopsis betonicifolia, Merrilliopanax cordifolia, Nomocharis synaptica, Nertera sinensis, Pauia belladona, Psychotria aborensis, Pternopetalum senii, Rhododendron santapaui, R. nuttalli* and *R. subansiriensis*.

Experimental garden, Dhanikhari situated along the stream of Dhanikhari dam at Nayshahr in Andamans, was set up in the year 1980 in an area of about 30 ha, 17 km away from Portblair, with the aim to introduce and conserve endemic, rare and threatened plants as well as germplasm of wild plants of Andaman and Nicobar Islands. About 250 species are grown, of which important ones are *Adenia heterophylla, Adiantum stenochlamys, A. tenerum, Aglaia andamanica, Alstonia kurzii, Amomum maximum, Amorphophallus longistylis, Antidesma andamanicum, Bentinckia nicobarica, Calamus andamanicum, Clematis smilacifolia, Codiocarpus andamanica, Cyrtandroemia marmerota, Daemonorops mannii, Dipterocarpus griffithii, Euphorbia epiphylloides, Globba pauciflora, Gnetum latifolium, Grewia calophylla, Knema andamanica, Ixora barbata, Mangifera* *andamanica*, *Myristica andamanica*, *Orophaea katschallica*, *Oryza indandamanica*, *Pandanus andamanensium*, *P. leram*, *Piper ribesioides*, *Pinanga manii*, *Planchonia valida*, *Pterocarpus dalbergioides*, *Psychotria kurzii*, *Terminalia mannii* and several species of orchids, etc.

Experimental botanical garden, Gangtok attached with the office-cum-herbarium building of Sikkim himalayan circle, covering an area about 3.5 acres was established in the year 1979 with a view to introduce and conserve interesting, rare, threatened, endemic plants, wild relatives of crop plants, wild plants of horticultural value and medicinal plants of the Sikkim himalayan region. Over 400 plants in 174 species have been introduced here that include *Abies densa*, *Asplenium nidus*, *Bergenia ciliata*, *Brainea insignis*, *Cephalotaxus griffithii*, *C. mannii*, *Cyathea spinulosa*, *Digitalis purpurea*, *Ginkgo biloba*, *Helwingia himalaica*, *Lilium nepalense*, *Nepenthes khasiana*, *Panax pseudo-ginseng*, species of *Aeschyananthus*, *Phlegmariurus*, *Primula*, *Pinus roxburghii*, *Platycerium alcicorne*, *Rhododendron arboreum*, *Taxus wallichiana*, *Tsuga dumosa* and some orchid species etc.

Experimental botanical garden, Arid zone circle, Jodhpur, was established in the year 1990. Plants introduced there include *Commiphora wightii*, *Ephedra foliata* and other species.

It is essential to have following points in mind while laying out a botanic garden. The proposed area should be 100 to 150 ha or more. It should be located near a city or town and readily approachable. Soil should have enough fertility with sufficient mineral nutrients. It should have a source of perennial water and 1/10th of the total area should be covered with water to maintain atmospheric humidity and also for irrigation purposes. It should have a designated section to represent each family- (systematic garden) for students and other sections like economic, medicinal, germplasm, exotics, arboretum, etc., Nurseries should be kept isolated from the reach of common public. Green houses, conservatories, propagation chambers are also parts of a well planned botanic garden in order to grow and conserve plants from different phyto-climatic regions. Herbarium, a well-equipped laboratory possibly with tissue culture facilities and a library are also essential for research, reference and to keep the knowledge of recent advancement up to date. Common public amenities like pavilions, boating, medical aids, drinking water, toilets, etc. are essential for visiting public. The staff quarters should be isolated from the garden area.

CONSERVATION MEASURES BY BOTANICAL SURVEY OF INDIA

It is estimated that 1500 to1750 species of flowering plants are considered to be rare or have fallen under various threatened categories of Red data as proposed by IUCN. In recent years Botanical Survey of India has played a very significant role and published 3 volumes of Red data books where about 814 species were documented along with their details. Efforts were made to locate these species from the wild and rehabilitate them in different botanic gardens under the Botanical Survey of India. To some extent, it has been succeeded and many endangered species were multiplied in National orchidaria, Green houses and gardens through their vegetative propagation and tissue culture techniques. Species like *Nepenthes khasiana, Dendrobium chrysotoxum, D. nobile, D. transparens, Cymbidium mastersii, Paphiopedilum* spp., have been successfully multiplied through tissue culture at Shillong and subsequently some of them are released in nature. Many species banned under CITES (Convention on International Trade of Endangered Species of wild fauna and flora) were also successfully grown in the gardens of the survey. Under a project "POSSCEF" (Project on Study, Survey and Conservation of Endangered Species of Flora), about 1000 endangered species were collected from the wild and their behaviour was studied in order to evolve conservation strategies. Based on field observations and subsequent recommendations by the survey, some specific measures were also taken to conserve individual species in nature, thereby paved the way for establishment of *Nepenthes* and *Citrus* sanctuaries in Meghalaya, orchid and Rhododendron sanctuaries in Sikkim, Darjeeling himalaya, *Frerea indica* sanctuary in Maharashtra, etc. The National Gymnosperm collection at Nagdeo, Pauri and Natural Reserves at Khirsu were some of the important steps already taken by the survey under Botanic gardens conservation programmes.

Further, a list of about 1097 species of rare, threatened and endangered plants is available at all the circle offices of Botanical Survey of India with a view to collect and conserve these species in their respective Experimental botanical gardens. In addition, in order to create public awareness programmes like sit and draw, essay competitions, flower shows, tree plantation programmes, plants distribution, lectures, seminars, workshops, distribution of pamphlets, etc. are also organized and popularized every year. The Government of India through the Ministry of

Environment & Forests also provides liberal financial assistance under botanic garden assistance programme to various organizations and sick gardens for their proper development and conservation of plants facing threat and extinction.

Several publications related to this field have also been published by the Botanical Survey which include Threatened plants of India-a-state-of art report, Red data book of Indian plants (3 vols.), Conservation of tropical plant resources, Endemic plants of the Indian region, An assessment of threatened plants of India, Lady's slipper orchids, Botany of Silent valley, Insectivorous plants of Khasi and Jaintia hills of Meghalaya, Materials for a catalogue of threatened plants of India, Threatened and endemic orchids of Sikkim and north east India, etc. These publications provide the basic knowledge about the species, which is very much essential for its conservation.

CONCLUSION

It is well known fact that plants and human beings are intricately related to each other. Man's greed towards nature, un-proportionate exploitation of plant resources and continuous environmental degradation due to various factors caused a great damage to the floristic wealth in general and certain species in particular. It is necessary to evolve effective conservation strategies of plants so that they can be conserved and used sustainably in the interest of humanity. The role of botanic gardens in this context cannot be ignored and today they are viewed as resource centres for conservation, research and development as stated earlier.

In a vast country like India with different phyto-climatic regions, it is apparent that, the botanic gardens fall far short of needs. Therefore, more experimental botanic gardens are required to be established in different phyto-geographical regions of the country with elaborate facilities of green houses, tissue culture laboratory, etc. for plant introduction, propagation and multiplication. Further, the existing botanic gardens in the country are required to be upgraded on the modern lines to meet the challenges of today and also in future. It is required to generate public awareness highlighting the significance of preservation of rare, endangered and economically important plant species through botanic gardens. Finally, the eco-friendly attitude of the people and people participation will pave the way for conservation of phyto-diversity.

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Shri Subhash Ghosh, Howrah

Robert Kyd's monument - Indian Botanic Garden, Howrah.

A view of National Orchidarium - Indian Botanic Garden, Howrah.

Heliconia marginata

Asplenium nidus

Psilotum nudum

Platycerium alcicorne

Cycas revoluta

Cycas rumphii

Cycas pectinata - an endemic gymnosperm.

Frerea indica - rare and endemic.

Theobroma cacao - a source of beverage and milk chocolate.

GREEN HOUSE

D.S. Pandey
N.P. Singh

A green house is necessary in any well planned garden. The main objectives of the green houses are conservation, introduction, propagation, acclimatization and cultivation of plants in controlled climatic conditions. It is meant for keeping plants for decoration, to save them from unfavourable weather conditions and at the sametime forcing them to grow out of season. Thus, the green house can be defined as a house provided with means of obtaining artificial climatic conditions and protecting plants from excessive heat and other unfavourable weather conditions. If it is a cool green house no heat is required. In a green house the temperature can be easily regulated as per need.

The use of green houses in India seems to have begun quite long back. In England, it started in 1699 and in America in the year 1806. In temperate regions, green houses are covered usually with glass to maintain normal temperature and in these green houses due to normal temperature plants remain green, grow well, produce normal flowers, fruits and complete their life cycle. In these houses, tropical plants are grown successfully. The sun rays penetrate the house through glass panes and in severe winter also, plants are protected from chilled weather. Thus, the main objectives of the green houses of cold countries are: (a) to grow long season crops where summer is short by increasing the length of growing season, (b) to make it possible to produce the crop earlier by planting seeds ahead of its normal schedule. Conservatory, the forcing house and the propagation pits are all synonyms of green house, but they have different roles. Conservatory is a place where plants are kept for display. In warm house or forcing house plants are forced to grow at other times than their normal season. The propagation pits or chambers are also warm houses in which tropical plants are grown. Thus, in general, the word glass house is used for green houses, but there are other houses known as glass houses which are used for other purposes.

The shape and size of a green house mostly depend on the need of the gardener, climate, availability of water, temperature device system, financial position, etc. Width, height and length of green houses depend on the size of the plants grown within. However, in normal cases 13 to 20 m wide and 30 to 100 m long green houses are most suitable and convenient. Based on characteristics of roof, green houses may be divided into two types. a) Attached green house, also called ridge and furrow type which is built side by side, attached through gutters and is suitable to cultivate plants of similar nature on a large scale. However, these types of houses are unsuitable in the areas having snow fall as snow accumulates in between the houses. There is a possibility of structures to collapse due to heavy weight. b) Different types or detached houses which are further divided into four types. i) Lean green house consists of a single span of roof, built against the south wall of a house, but in propagation house these may be attached to the north side of the building. These houses are simple and less expensive, ii) Even span green house here the sides of the roof are equal in width and pitch. This is the most common type, iii) Uneven span green house - these types have one side covering 2/3 or 3/4th of the width of the structures and are used on sloping grounds and iv) Curved cave or curved linear green house - these types of houses are attractive and expensive in which curved sash bars and curved glasses are used.

Based on temperature requirements green houses can be grouped into following three types:

1. **Hot house**

The temperature of this green house is usually maintained between 15^0C and 21^0C. Hot-house is expensive due to heavy fuel consumption. But in India, the temperature never goes much down and is regulated by providing shade over the houses. In these houses, during summer season, the day temperature is maintained from 21^0C to 31^0C and in the night from 18^0C to 20^0C. During winters, the day temperature is maintained from 18^0C to 24^0C and in the night from 16^0C to 18^0C. These houses are more or less constructed in open places and have designed roof.

2. **Temperate or Intermediate**

These green houses are constructed in temperate areas where temperature is normally low. In these green houses temperature is maintained between 12^0C and 21^0C throughout the year, depending upon the season and requirements of temperature in day and night.

3. Cold house

In these houses heating apparatus is not required, but in our country cooling is done artificially. An oil lamp or electric radiator may be used to keep severe frost away. The excess heat can be manipulated through the aid of ventilators and pulling down canvas cloth all along the walls of houses. The temperature of cold house is maintained during the summer days from 15°C to 18°C, and in the night from 12°C to 15°C. During winter days it is maintained from 12°C to 15°C and in the night from 7°C to 10°C.

However, the climatic conditions in India are different than those of western countries. Here, we have the problems of high temperature which can be controlled by constructing special structures, providing shade and checking the hot winds.

The green house should be located in an open place facing east and north-east direction. If it is constructed near a building, it should be connected by pergola. In parks, it should be near main entrance. Planting of big trees near glass houses is generally avoided to save the plants from their drips. Green house should be constructed slightly on elevated ground to provide drainage.

Management of green house

The management of green house depends mainly on the types of plants grown in it. The following are some general principles for management of green houses.

1. **Temperature:** The requirement of temperature varies from species to species. Usually the temperature of a green house should not be below 4°C during winter months and an average of 18°C in summer months with occasional rise to 32°C. The temperature can be regulated by using heating apparatus. Too much artificial heat promotes plants to grow tall and leaves become yellow. The temperature can also be regulated by skillfull use of sun heat. In cold weather, the ventilators may be opened throughout the day and should be closed about an hour before the sun set. A statically controlled thermo-heating apparatus and one maximum and minimum thermometer should be installed in the green house to record the correct temperature. Both, excessive heat and cold are very disastrous for plant growth. In case of large

green houses, hot water pipes are used, in which hot water is passed to increase the temperature. In India, usually artificial heating is not practised except in hilly areas.

2. **Ventilation:** The main aim to provide proper ventilation in a green house is to control the volume of fresh air so that the ratio of oxygen and carbon dioxide is proportionally maintained for the process of photosynthesis. Proper aeration also controls room temperature as well as atmospheric humidity. The opening and closing of ventilators mostly depend on the weather conditions and kind of plants.

3. **Watering:** The quantum and frequency of irrigation mostly depend on the type of plants and season when they are grown. Usually plants need more water during spring and summer than winter and rainy seasons for their better growth. Watering should be done during morning hours. Big leaved plants should be watered carefully as they do not get well irrigated by rain water due to their phyllotaxy.

4. **Shading of green house:** The green house should be covered with leaves and thatch or climbers which should be allowed to spread on it to protect from direct sun-heat and this is essential particularly during summer season. Sometimes the top floor is painted. Leafy shades should be removed before rainy season.

5. **Care of pots:** Pots after planting must be well cleaned, washed and have proper drainage before they are placed in the green house. Older pots should always be washed with formaline solution (40% in 8 gallons of water) to kill the germs etc. Pots should be re-potted as and when required according to size and type of plants.

6. **Fumigation:** Spraying of insecticides and fungicides at regular intervals on plants is very much essential in green houses. This can be done during evening by shutting the ventilators and main entrance and keeping as such throughout the night. Ventilators and other doors may be gradually opened in the morning to allow fresh air to get in. The fumigation is usually done by nicotine and calcium cynamide gas.

Display of objects and planting materials should be done keeping the aesthetic sense in mind. A rockery, placed in the centre forms a very attractive feature. Hanging baskets, earthen pots, tubs and vases with irregular shapes and forms planted with decorative plants and placed suitably add much more beauty to the green house. Cistern inside the green house provides better enjoyment, keeps the house cool and maintains humidity for plant growth.

Plant of similar nature should be kept together for mass effect and easy maintenance. Climbers should be allowed to grow on rustic branches and pillars. The deciduous species should not be planted at one place to avoid gap after leaf fall. Position of pots is required to be changed time to time to provide proper light, to keep plants erect and for their symmetrical growth. Dead and dried leaves should be removed and proper manuring should be done. Oil cake and ammonium sulphate once in fifteen days are recommended for healthy growth. Iron pillars and frames should be painted regularly.

The following group of plants can be grown successfully in the green houses.

Seasonal plants

Aster, Calendula, Chrysanthemum, Cineraria, Sweet Pea (*Lathyrus*), *Lobelia, Primula, Torenia*, etc.

Ornamental foliage plants

Species and varieties of *Aglaonema, Alocasia, Alpinia, Ananas, Anthurium, Asparagus, Araucaria, Aspidistra, Billbergia, Codiaeum, Coleus, Cyclanthus, Dieffenbachia, Dracaena, Fittonia, Musa, Pandanus, Pillonia, Peperomia, Philodendron, Pilea, Pothos, Rhoeo, Tillandsia, Zebrina*, etc.

Ornamental shrubs

Azalea, Gardenia, Magnolia, Euphorbia and various ornamental varieties of *Rosa*.

Ferns (Pteridophytes)

Among these, species like *Adiantum cuneatum, A. peruvianum, Alsophila* spp., *Angiopteris evecta, Asplenium nidus, Pityrogamma* *calomelomos*, *Lygodium* spp., *Osmunda regalis*, *Polypodium* spp., *Pteris* spp., *Selaginella* spp., etc. are successfully cultivated.

Bulbous plants

Species of *Agapanthus*, *Amaryllis*, *Anemone*, *Anthurium*, *Begonia*, *Caladium*, *Costus*, *Hedychium*, *Polianthes*, *Crinum*, *Haemanthus*, *Hippeastrum*, *Zeyphyranthes*, etc. are grown.

Palms and Cycads

Most members of Arecaceae (Palm family) and cycads are shade loving, hence they are successfully grown in green houses. Among palms, species of *Archantophoenix*, *Bactris*, *Calamus*, *Caryota*, *Chrysalidocarpus*, *Heterospathe*, *Latania*, *Licuala*, *Livistona*, *Pinanga*, *Pritchardia*, *Ptychosperma*, *Rhaphis*, *Thrinax*, *Trachycharpus*, *Wetchia*, *Wallichia*, etc. and in gymnosperms and cycads, species of *Abies*, *Callitris*, *Cedrus*, *Cupressus*, *Cycas*, *Cryptomeria*, *Dioon*, *Encephalortes*, *Gnetum*, *Larix*, *Microzamia*, *Pinus*, *Podocarpus*, *Taxodium*, *Thuja*, *Tsuga* and *Zamia* are grown in the green houses.

Orchids

Almost all the species of family Orchidaceae are successfully grown in green houses.

Cacti and Succulents

Members of families Agavaceae, Euphorbiaceae, Cactaceae and Asclepidaceae such as *Agave*, *Aloe*, *Acanthocereus*, *Acanthocalycium*, *Aporocactus*, *Ariocarpus*, *Astrophytum*, *Browingia*, *Coryphantha*, *Cereus*, *Echinocereus*, *Echinocactus*, *Echinopsis*, *Ferocactus*, *Gymnocalycium*, *Haageocereus*, *Harrisia*, *Lophophora*, *Mammillaria*, *Melocactus*, *Opuntia*, *Pachycereus*, *Parodia*, *Pereskia*, *Rebutia*, *Stenocereus*, *Euphorbia*, *Frerea*, *Sansievieria*, *Stapelia* and *Yucca* are suitable for cultivation in the glass houses.

Beside aforesaid plants of floricultural, rare, endemic, threatened and economic importance, the pomological and olericultural crops are also successfully grown in the green houses specially constructed for the purpose.

All together 11 green houses are available in the Indian Botanic Garden, Howrah. In these houses important medicinal, economic, endemic, rare and threatened plants including curious and several species of exotic origin have been introduced, acclimatized and conserved very successfully. A total of 7 green houses are in nursery no. 1, situated within division 6. One large open green house is almost covered with about 150 years old *Derris scandens*. In this house, many species of family Arecaceae, foliage and pterodophytes are grown. In other 4 green houses orchids, pteridophytes, cacti and succulents are grown. In the remaining 2 green houses rare, endangered, curious and ornamental foliage plants are conserved. These houses are covered with *Antigonon leptopus*. In large palm house several species of pteridophytes, gymnosperms and foliage plants including many species of family Arecaceae are very successfully grown. Among several interesting plants, 'Double Coconut' (*Lodoicea maldivica*), more than one hundred years old and having the largest seed in the entire plant kingdom is conserved in this house. Small plam house is in division no. 16, where several species of palms, ornamental foliage and *Cinnamomum zeylanicum* are conserved. It is covered with *Bougainvillea* and *Macfadyena unguiscati*. A hexagonal dome-shaped glass conservatory is situated in division no. 22, where about 250 species/ varieties of cacti and succulents are grown successfully.

In these green houses, several other interesting plants viz. *Adenium obesum, Adiantum farleyense, Asplenium nidus, Archantophoenix alexandrae, Bentinckia condapanna, B. nicobarica, Camellia sinensis, Cinnamomum camphora, C. tamala, Cycas beddomei, C. pectinata, Dendrobium chrysotoxum, Dischidia benghalensis, Elaeis guineensis, Ficus benghalensis* var. *krishnae*, *Frerea indica, Ginkgo biloba, Livistona jenkinsiana, Myristica fragrans, Orbignya cohune, Oncidium ampliatum, Paphiopedilum fairieanum, Pholidota imbricata, Platycerium alcicorne, Psilotum nudum, Pterocarpus santalinus, Podocarpus gracilior, Rhopaloblaste augusta, Theobroma cacao* etc. have also been conserved.

Green/glass houses also exist in some other gardens of the circle offices of Botanical Survey of India, where plants of respective regions are conserved.

CONCLUSION

The significance and the role played by the green houses in conservation of plant diversity cannot be ignored. These are the houses where numerous rare, threatened, endemic, medicinal, horticultural, floricultural, economically important species brought from different climatic regions are being conserved successfully throughout the world. Therefore, a well planned botanic garden must have sufficient number of green houses with modern facilities for introduction, propagation, acclimatization, cultivation, and conservation of present dwindling phytodiversity.

Large palm house - Indian Botanic Garden, Howrah.

Glass conservatory - Indian Botanic Garden, Howrah.

TISSUE CULTURE

A.A. Mao
D.K. Singh
P. Tandon

Plants are a valuable environmental and economic resource for supporting natural system and for improving human welfare. Everyone has benefited when people have treated forests as renewable resources, protected them to preserve biodiversity, or transformed them to support economic activities on a sustainable basis. On the other hand, destructive exploitation of the forests has caused serious economic, social, and environment losses, Hence, the need for conservation of phytodiversity cannot be overemphasised for the survival of mankind.

It is estimated that there are about 17,500 flowering plants in India. However, the ever increasing human population of our country and the various anthropogenic activities, coupled with natural calamities,have resulted into loss of habitat, thereby threatening a number of taxa with extinction. The gravity of the situation in India can be assessed by the fact that approximately 15-20% of the 17,500 flowering plant species are of concern, and possibly many of these may be lost in the next few decades unless proper attention is given for their conservation. It is feared that many of the species may be lost without being utilised or, even worst, before they are known to science.

Today, global efforts are being made to check the alarming erosion of phytodiversity. Two main approaches being used to conserve phytodiversity losses are *in situ* and *ex situ* conservation. *In situ* conservation is of primary importance for maintaining the broadest range of plant diversity. As a supplement to this approach *ex situ* conservation plays an important role in backing up taxa which are particularly threatened or are rare in the wild. Traditionally, botanical gardens, arboreta, seed and spore banks provided a valuable safeguard against loss of many rare species (Laliberte, 1997). However, in recent years, tissue culture (*in vitro* culture) offers the potential of extending these traditional *ex situ* conservation and propagation methods to an even broader range of taxa and tissue types. These techniques have been developed primarily for agricultural and horticultural species, but are increasingly being applied to propagating and evaluating rare and endangered plant germplasm as well.

Plant Tissue Culture (*In vitro* culture)

The term "plant tissue culture" was a precise one in the early days when tissue culture was mostly carried out with excised tissues. However, today the term has come to cover a great diversity of culture methods, including embryo, organ, protoplast, and suspension culture. In a broad sense, plant tissue culture can be described as a set of techniques for growing plant tissue isolated from parent plants in a defined nutritional and controlled environment under aseptic conditions (Bonga & Von Aderkas, 1992).

History of *in vitro* propagation of rare and endangered plant species

International

The earliest programmes to use *in vitro* propagation methods for rare and endangered species was the Micropropagation Unit at the Royal Botanic Gardens, Kew, established in 1974. Since then, several countries around the world have adopted the technology and have used successfully for prorpagation of many rare, endangered and endemic plants. Laboratories in Australia, Spain, USA and Hawaii have propagated their endemic floras (Clemente, 1991; Dixon, 1994; Iriondo & Perez,1991a; Koob, 1993), while laboratories in England, Denmark, Spain and elsewhere have also directed attention to propagating the endemic flora of islands such as St. Helena, Gran Canaria, and Rodriques (Fay, 1992; 1989; Krogstrup *et al.*, 1990; Ramsay, 1997). Other programmes around the world have applied *in vitro* propagation techniques to a wide variety of native and exotic endangered species. Several reviews have been published on the use of *in vitro* micropropagation of rare and endangered plants (Fay, 1992, 1994; Fay & Gratton, 1992; Wochok, 1981; Pence, 1999).

National

The Ministry of Environment and Forests, Governmentof India, realizing the importance of conservation of Indian flora, initiated a major All India Co-ordinated Project on Conservation of Plants in1985. This programme dealt with the seed biology and tissue culture of rare and endangered plants. Several Universities and National Laboratories have participated in this programme. National Bureau of Plant Genetic Resources (NBPGR) established the National Facility for Plant Tissue Culture Repository (NFPTCR) at its headquarters located at Pusa Campus, New

Delhi in 1986 with funding from the Department of Biotechnology, Government of India (Anon, 1999). Other important centres engaged in *in vitro* conservation of plants are Indian Institute of Spices Research,Calicut; Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow; National Botanical Research Institute (NBRI), Lucknow; National Chemical Laboratory (NCL), Pune; Gobind Ballabh Pant Institute of Himalayan Environment and Development (GBPIHED), Almora; Tropical Botanical Garden and Research Institute (TBGRI), Thiruvanantpuram; M.S. Swaminathan Research Foundation, Madras; Regional Plant Resources Centre (RPRC), Bhubaneshwar; Indian Council of Forestry Research and Education (ICFRE) Dehra Dun; Botanical Survey of India BSI, Eastern Circle, Shillong and several Universities in the country. The Department of Biotechnology, Government of India has given tremendous impetus to conservation of plants using biotechnological approaches by establishing two micropropagation Technology Park, one each at NCL, Pune and Tata Energy Research Institute, New Delhi; 4 hardening facilities for tissue cultured plants at J.N. Vyas University; RPRC, Bhubaneshwar and Kolkata, and GBPIHED; 4 national gene banks of medicinal and aromatic plants at CIMAP, TBGRI, NBPGR and Regional Research Laboratory, Jammu and also by funding a large number of R & D projects. As a result of the Government of India's initiative *in vitro* propagation techniques have been used successfully for a number of rare and endangered species by different research institutions and universities. Some such examples of work in India are shown in table 1.

Objectives of *in vitro* propagation of endangered species

The objectives of *in vitro* propagation of rare and endangered species are as follows:

(i) The primary objective for which *in vitro* propagation of endangered plant species is undertaken is to increase the numbers of individual species of extremely rare and endangered species. For example, *Sophora toromiro* an endangered species which is extinct in the wild, and the few plants which have been maintained *ex situ* have been used for *in vitro* multiplication (Iturriaga *et al.*, 1994). If wild population becomes severely reduced or lost, *in vitro* propagated plants can be used for reintroduction. *Rubus humulifolius*, an endangered species of Findland, known from ten plants, was propagated *in vitro* to yield 1500 plants and was replanted in a site near its original locality (Tormala *et al.*, 1994). Several rare species including *Agave victoria-reginae, Artemisia granatensis, Bletia urbana,*

Table I
Use of tissue culture for conservation of endangered plant species in India.

Family	Botanical name	Causes Status	Propagation methods	References
Acanthaceae	*Adhatoda beddomei*	Over-coll., med., few seeds, and slow prop.	Shoot-tips	Sudha and Seeni (1994)
Apocynaceae	*Rauvolfia micrantha*	Poor germ., poor rooting and med.	Shoot tips, nodes	Sudha and Seeni (1996)
	Rauvolfia serpentina	Over-coll., med. and poor seed variability.	Nodes - microprop.	Sharma and Chandel (1992)
	Wrightia tomentosa	Over-coll.	Nodes	Purohit *et al.* (1994)
Aquifoliaceae	*Ilex khasiana*	Rare and endangered	Young leaves	Tandon and Kumaria (1997)
Aristolochiaceae	*Aristolochia indica*	Over-coll. and med.	Shoot-tip and nodes, leaf, adv. shoot.	Manjula *et al.* (1997)
Asclepiadaceae	*Holostemma annulare*	Rare and med.	Shoot tips, nodes	Sudha *et al.* (1998)
Asteraceae	*Saussurea costus*	Critically endangered and med.	Shoot tip microprop.	Arora and Bhojwani (1989);
Betulaceae	*Betula uber*	30 individuals	Buds	Vijaykumar *et al.* (1990)
Combretaceae	*Anogeissus rotundifolia*	Rare and endemic	IV germ. and microprop.	Singh and Shekhawat (1997)

Family	Botanical name	Causes Status	Propagation methods	References
Dioscoreaceae	*Trichopus zeylanicus*	Few seeds, slow seed maturation, hab. loss and med.	IV germ., microprop.	Krishnan *et al.* (1995)
Fabaceae	*Pterocarpus marsupium*	Rare	IV germ. and microprop.	Das and Chatterjee (1993).
	Trifolium stoloniferum	Two populations	Shoot tips	Singh *et al.* (1988).
Gentianaceae	*Gentiana kurrooa*	Over-coll. and med.	Shoot tips, nodes	Sharma *et al.* (1993).
	Swertia chirayata	Rare	Seedling stem, callus - adv. shoot.	Shrestha and Joshi (1992).
Lamiaceae	*Coleus forskohlii*	Over-coll., med.	Nodes	Sharma *et al.* (1991).
Liliaceae	*Allium tuberosum*	Over-coll.	Basal plate, adv. shoot.	Radhamani and Chandel (1992).
	Chlorophytum borivilianum	Over-coll., med. and seed germ. low.	Shoot bases, microprop., somatic embryo.	Purohit *et al.* (1994); Jain *et al.* (1997).
	Lilium mackliniae	Rare and end.	Bulb scale, bulblet segments, cotyledon, leaf and root.	Mao *et al.* (2000).
Lythraceae	*Woodfordia fruticosa*	Rare and med.	Shoot tips, nodes.	Krishnan and Seeni (1994).
Nepenthaceae	*Nepenthes khasiana*	Rare and med.	IV germ., microprop., shoot tips, nodes - microprop.	Latha and Seeni (1994); Seeni (1990); Rathore *et al.* (1991).

Family	Botanical name	Causes Status	Propagation methods	References
Nymphaeaceae	*Nymphaea tetragona*	Rare and end.	Rhizome segments, immature embryos, young leaves, nodal segments.	Tandon and Kumaria (1997).
Orchidaceae	*Aerides multiflorum*	Rare	Rudimentary embryos	Tandon and Kumaria (1997)
	Aerides vandarum (= *Vandopsis undulata*)	Rare	Rudimentary embryos	Tandon and Kumaria (1997)
	Bulbophyllum cosmosum	Rare	Rudimentary embryos	Tandon and Kumaria (1997)
	Cymbidium giganteum (= *C. iridioides*)	Rare	Rudimentary embryos, root tips, leaves.	Corrie and Tandon (1993)
	Dendrobium lindleyi	Rare	IV germ.	Kaur and Sarma (1997)
	Dendrobium wardianum	Rare	Shoot apices, root tips, leaves, young floral buds.	Sharma *et al.* (1992)
	Paphiopedilum spp.	Rare	Rudimentary embryos	Tandon and Kumaria (1997)
	Renanthera imschootiana	Over-coll., hab. loss, prop. for trade.	Leaf bases, adv. buds	Seeni and Latha (1992).
	Thunia alba	Rare and endangered	Rudimentary embryos	Tandon and Kumaria (1997)
	Sarcanthus pallidus	Rare and endangered	Rudimentary embryos	Tandon and Kumaria (1997)
	Vanda coerulea	Over-coll.	Leaf bases, adv. shoot	Seeni (1990).
	Vanilla walkeriae	Prop. for preserv	Nodes	Agarwal *et al.* (1992)

Family	Botanical name	Causes Status	Propagation methods	References
Papaveraceae	*Meconopsis paniculata*	Seed germ. low survival, and hab. loss.	Hypocotyl, cal., adv. shoots.	Sulaiman (1994).
	Meconopsis simplicifolia	Hab. loss and seedling mortality	Seedling explants - cal. - adv. shoots.	Sulaiman and Babu (1993).
Podophyllaceae	*Podophyllum hexandrum*	Over-coll. and med.	Shoot tips; Hypocotyl.	Arumugam and Bhojwani (1990); Nadeem *et al.* (2000).
Polygonaceae	*Rheum emodi*	Over-coll. and med.	Shoot tips.	Lal and Ahuja (1993).
Polypodiaceae	*Drynaria quercifolia*	End.fern.	Spores and rhizome	Hegde and D'Souza (1997).
Ranunculaceae	*Aconitum heterophyllum*	Over-coll. and med.	Shoot tips, microprop. leaf, petiole, cal., som. emb.	Giri *et al.* (1993).
	Delphinium malabaricum	Low seedset and seed dormancy.	Infl. nodes.	Agarwal *et al.* (1991).
	Coptis teeta	Rare and end.	Petiole, apical and axillary buds, rhizome segments, inflorescence stalk, hypocotyl.	Tandon and Rathore (1992).
Rutaceae	*Citrus assamensis* *Citrus indica,* *Citrus latipes*	Rare	Shoot tips, microprop.	Baruah *et al.* (1996).
	Feronia limonia	Rare and endangered.	Nodal explants, axillary bud.	Purohit and Kiran Tak (1992).

Family	Botanical name	Causes Status	Propagation methods	References
Scrophulariaceae	*Picrorhiza kurrooa*	Rare and med.	Shoot tips, nodes, microprop.	Lal *et al.* (1988). Upadhysy *et al.* (1989).
	Limnophila indica	Conserv.	Root tips.	Rao and Mohan Ram (1981)
Sterculiaceae	*Sterculia urens*	Over-coll.	IV germ., microprop.	Purohit and Dave (1996).
Velerianaceae	*Nardostachys jatamansi* (= *N. grandiflora*)	Over-coll. and med.	Petiole-cal., root, adv. shoot.	Mathur (1992).
	Valeriana wallichii	Rare and med.	Shoot tips, nodes, microprop.	Mathur *et al.* (1988).

Abbreviations:

Med = Medicinal value; Prop. = propagation; Over-coll.- over-collection; Germ.- germination; End.- endemic; Hab.- habitat; Preserv.- preservation; Conserv.- conservation; IV.= *in vitro*; Adv.- adventitious; Microprop.- micropropagation; Hypocotyl- hypocotyledon; Cal.- callus; Lf.- leaf; Sh.- shoot(s); Fl.- Flower; Som. emb.- Somatic embryos; Imm.- immature; Infl.- inflorescence.

Nepenthes khasiana, Mammillaria san-angelensis, Senecio hadrosomus, Cyanea pinnatifida and orchids (Clemente 1991; Tandon *et al.*, 1990; Martinez-Vazquez & Rubluo, 1989; Bramwell, 1990) have been multiplied *in vitro* and their reintroduction in natural habitats were attempted.

(ii) *In vitro* propagation can provide an alternate source of plants and alleviate pressure on wild populations when species have been over-collected by hobbyists or for medicine, food, or fragrance. Certain orchids, cacti, and wild flowers as well as a number of medicinal species have been propagated *in vitro* for this reason (Rubluo *et al.*, 1993).

(iii) When wild grown plants are difficult to propagate using traditional propagation methods, tissue culture techniques can be used for *ex situ* preservation in botanical gardens (Christenson, 1988; Pence *et al.*, 1997). The tissue culture lines themselves can be conserved for short-term and cryopreserved for long-term storage. Propagated plants might also be used for *ex situ* studies on the biology of endangered plant species. For example, the Center for Plant Conservation, in U.S.A., St. Louis, coordinates with different botanical gardens in that country to monitor and grow endangered species *ex situ* (Pence, 1999).

(iv) Tissue cultured endangered plant species can also be conserved *in vitro* for short and long terms.

***In vitro* propagation techniques**

The variety of approaches used by different laboratories around the world reflects the flexibility of tissue culture techniques. However, the different techniques used by different laboratories for *in vitro* propagation can be grouped into two (a) propagation using seeds and (b) These approaches are discussed below with few examples given in the specific context of rare and endangered species conservation.

I. PROPAGATION

a. In vitro propagation using seeds

When seeds of endangered species are available, they are generally preferred for propagation in order to maintain the maximum genetic diversity. *In vitro* seed germination has been applied to a number of rare orchids species, cacti and succulents, insectivorous plants and lilies by many laboratories (Boulay, 1995; Clayton *et al.*, 1990; Dixon & Keighery, 1992; Fay, 1992; Fay & Gratton, 1992; Rubluo *et al.*, 1993; Seeni & Latha, 1994; Simerda, 1990; Singh *et al.*, 1992, Tandon & Kumaria, 1997). Most endangered species produce seeds in some cases they are few in number, or they may be difficult to germinate. when very few seeds are *in vitro* germination is often used to produce sterile seedlings, which are then provide shoot tips and nodes as explants for micropropagation. This approach has been used for a number of species, including, *Gentiana lutea*, *Limonium* spp., (Martin & Perez 1995; Momcilovic *et al.*,1997 and many others (Pence, 1999).

Embryo culture is useful when conventional procedures, such as stratification, fail to break seed dormancy or the rate of germination is very low. Some forms of dormancy are overcome by removing the seed coat, as with *Trochetiopsis* spp. from St. Helena (Fay, 1992). Growth regulators are also used to stimulate germination, as with Western Australian rushes. Alternatively, growth regulators may be used to stimulate direct somatic embryogenesis or shoot formation from the embryo tissue or to produce embryogenic callus as with *Podophyllum hexandrum* (Arumugan & Bhojwani, 1990).

In some cases, seeds have particular requirements for germination which are not met by conventional germination procedures. For example, *Pholisma sonarae*, an endangered parasitic plant of South-Western United States, requires the presence of host root tissue for germination, and it has not been possible to germinate the seeds *ex situ* (Pence, 1999). Other root parasites have also been successfully germinated *in vitro* (Okonkwo, 1966).

Similarly, seeds of a number of rare orchids have been asymbiotically germinted *in vitro*, such as *Vanilla alkeriae*, *Paphiopedilum* spp., *Dendrobium lindleyi*, etc. (Agarwal, *et al.* 1992; Kaur & Sarma, 1997; Tandon & Kumaria, 1997). In cases such as *Spiranthes magnicamporum*, symbiotic cultures of seeds and fungus have been established *in vitro* (Anderson, 1991). Germinated orchid seeds have been used to initiate cultures for micropropagation (Christenson, 1988).

b. Propagation without seeds

Propagation by seeds may not be possible for some endangered species. Seed viability can be low, as with *Rauvolfia micrantha* (Sudha & Seeni, 1996), etc., while in some cases little or no seed is produced, such as *Haworthia* spp., *Paronychia chartacea, Adhatodha beddomei* and *Delphinium malabaricum* (Agrawal *et al.*, 1991; McKently & Adams, 1994; Rogers, 1993; Sudha & Seeni, 1994). When seeds are not available, *in vitro* propagation is accomplished by culturing shoot tips or nodes from field or greenhouse grown plants. The culture of preformed meristems is preferred for propagation because of their genetic stability.

The growth habit of some species is such that the culture of apical or vegetative lateral buds would irreversibly damage the plant. In the case of monopodial orchids, such as *Phalaenopsis*, the culture of dormant buds from inflorescence nodes has been used to overcome this problem (Reisinger, *et al.*, 1976). In case of *Delphinium malabaricum* also inflorescence nodes have ben used, since the single apical bud also grows at soil level, making it difficult to establish uncontaminated cultures (Agrawal *et al.*, 1991).

Although the culture of preformed meristems is generally preferred, because of their genetic stability there are situations where buds are not available or difficult to culture or where more rapid propagation methods are desired. Organogenesis or embryogenesis has been obtained from vegetative tissues of *Meconopsis simplicifolia, Dionea muscipula, Agave victoria-reginae*, and *Haworthia* spp. (Kukulczanka *et al.*, 1989a; Rodriquez-Garay *et al.*, 1996; Rogers, 1993; Sulaiman, 1994). Species in the Liliaceae and Amaryllidaceae are often propagated using bulb-scales or similar tissue (Drewes & van Staden, 1994; Kukulczanka *et al.*, 1989b; Pandey *et al.*, 1992; Mao *et al.*, in press), where procorm-like bodies have been produced from leaf segments of monopodial orchids (Tanaka & Sakanishi, 1977). In the case of *Nardostachys jatamansi,* which naturally forms buds from its roots, petiols callus was used to initiate adventitious roots *in vitro*, which were then stimulated to form buds (Mathur, 1992).

d. Rapid clonal propagation

Tissue culture is a powerful tool for rapid clonal propagation of a particular genetic line. The technique has revolutionised the orchid industry. It may appear to contradict the goal of preserving genetic diversity. However, genetic diversity is maintained by culturing each individual available for propagation as a unique and separate line.

A related concern is that of the introduction of genetic changes or somaclonal variation into an otherwise clonal line. Generally, plants obtained from preformed buds have a lower frequency of change than those from direct adventitious sources, while those from callus appear most likely to undergo changes (Karp, 1994). However, a number of factors are involved in developing a protocol for propagating an endangered species, and at times, buds cannot be used. In those cases, it may be necessary to regenerate adventitious shoots, but it may then be possible to propagate those shoots by axillary bud outgrowth. Another approach can be to grow on a minimal level of growth regulators, in order to minimise the potential of somaclonal variation. This approach has been carried out with the micropropagation of the rare *Hackelia venusta* from the northern United States (Edson *et al.*, 1996).

Increasing genetic diversity

When plant are regenerated from calli or through somatic embryogenesis or by adventitious shoot formation, it often happens that a new genotype arises. This phenomenon is called somaclonal variation and occurs in many plants (Larkin & Scowcroft, 1981). There are many possible causes, one of which is the naturally occurring variation within the plant, but it is enhanced by artificial conditions during the tissue culture.

Somaclonal variation has been suggested as a tool for increasing the genetic diversity in species with a very narrow genetic base, such as the Easter Island endemic, *Sophora toromiro* (Jacobsen & Dohmen, 1990).

II. *IN VITRO* CONSERVATION

In vitro conservation has been proposed as a safer alternative to the traditional methods for preserving plant germplasm, *ex situ* have included growing plants in botanical gardens, arboreta and banking the dried seeds and spore at refrigerator (4 °C) or freezer (-18 or -20°C) temperatures (De Langhe, 1984; Withers, 1984, 1991). Considerable interest has been shown in recent years on the application of tissue culture technology for the storage of plant germplasm. The main prerequisite of *in vitro* conservation is satisfactory storage and, in parallel to the seed bank, there is a need for both 'active' and 'base' in vitro storage technologies (Withers, 1991). Some of the most practical applications of in vitro conservation relate to germplasm acquisition and movement. Currently two methods are being used for *in vitro* conservation of plant germplasm. These are slow growth culture and cryopreservation.

Slow growth culture

For medium term storage of several months to several years, slow growth culture method is being used for preserving *in vitro* cultures of endangered species. Several strategies can be applied to slow the growth to maintain plant germplasm, for example: manipulating the basal medium, lowering the optimal nutrient levels; altering the physical conditions such as temperature, light regime and gas atmosphere; application to the medium of growth retardants (e.g. absicic acid) or osmoregulators (e,g. sorbitol, mannitol) (Dodds & Roberts, 1985). Most established slow-growth protocols have been applied to crop species (Dorion *et al.*, 1994; Benerjee & de Langhe, 1985) and few reports exists on the germplasm conservation of endangered plant species (Iriondo & Perez, 1991). Good survival has been reported to shoots of *Centaurium riguali* for three years, *Picrorhiza kurroa* for ten months, *Saussurea costus* for 12 months, and of *Coronopus navasii*, *Lavatera longifolia*, and *Centauriuim rigualii* for six months, when stored at 5°C (Arora & Bhojwani, 1989; Iriondo & Perez, 1996; Upadhyay, *et al.*, 1989). Similarly, *Drosera* spp. and *Dionaea muscipula* have been maintained for up to ten months at 0-6°C (Kukulczanka, 1991). *Rauvolfia serpentina* remained healthy after 15 months at 15°C, although lower temperatures were deleterious (Sharma & Chandel, 1992).

Cryopreservation

The development of cryopreservation, or storage in liquid nitrogen (at - 196°C), has provided a technology for long-term storage of living tissue. It has been developed as a suitable methods for long term germplasm conservation, through cessation of cell division, thus avoiding the possibility of genetic variation through *in vitro* cell division (Engelman, 1991). A wide variety of protocols have been developed for cryopreservation of vegetative material as well as seeds over the last two decades (George, 1993). Several laboratories have applied cryopreservation protocols to seeds of a variety of endangered species. In U.S.A., a co-operative agreement between the National Seed Storage Lab (NSSL) of the US Department of Agriculture and the Center for Plant Conservation was developed to store seeds of endangered US species at the NSSL facility (Falk, 1987), while seeds of endangered and threatened species of Ohio are cryopreserved at the Cincinnati Zoo and Botanical Garden (Pence, 1991). Cryopreservation is being applied to the seeds of the endangered and rare flora of Western Australia at Kings Park and Botanic Garden (Touchell & Dixon, 1994). In India, National Bareau of Plant Genetic Resources (NBPGR), New Delhi was developed to store seeds and tissue culture plant materials of economically important plant species of the country. Several other laboratories around the world have also developed cryogenic storage facilities for seeds and vegetative material of native flora.

However, the majority of species currently stored in liquid nitrogen are those with orthodox, or desication tolerant seeds. The dried, orthodox seeds generally survive liquid nitrogen exposure with little or no damage. In some cases, seeds may be orthodox and short-lived unless they are carefully dried and frozen either at -20^{0}C or in liquid nitrogen. *Plantago cordata* and *Salix myricoides*, listed as endangered and potentially threatened in Ohio, are two examples of the short-lived seeds which have been successfully dried, cryopreserved and banked in liquid nitrogen (Pence, 1998).

Species having 'recalcitrant', seeds cannot usually survive drying and in the hydrated state they do not survive exposure to liquid nitrogen. However, cryopreservation is being increasingly applied to the excised embryos of recalcitrant seeds from tropical tree species. New approaches to recalcitrant seeds cryopreservation are presently being considered. In general, still recalcitrant seeds do pose particular problems for long-term germplasm storage. Seeds of some large-seeded temperate trees, some wetland species and some climax species from the moist tropics fall into this category. Wetlands and moist tropical forests are two habitats that are particularly threatened. There is an increasing need for *ex situ* germplasm storage of species from these areas. Studies are underway at the National Seed Storage Laboratory (Ft. Collins, Colorado) to determine the extent of recalcitrance in seeds of endangered species from the rain-forests of Hawaii and by the Cincinnati Zoo and Botanical Garden, species from Ohio wetlands, so that seed storage protocols can be developed for these species. It appears that in both cases, the majority of the species under study are not recalcitrant (Pence, 1999).

Cryopreservation of 'non-seed' tissues, such as immature embryos or *in vitro* cultures offers an alternative approach to be used for the preservation of recalcitrant species. These procedures centre around the techniques of slow freezing (Withers, 1985), vitrification (Sakai *et al.*, 1990), and encapsulation-dehydration (Fabre & Dereuddre, 1990). Most commonly used tissue for cryogenic storage are: shoot tips from *in vitro* cultures, excised zygotic embryos and embryonic axes, somatic embryos and embryogenic or organogenic cell or callus lines (Pence, 1999). Cryopreservation of *in vitro* tissue from endangered species has been accomplished using a slow freezing protocol with shoot tips of *Grevillea scapigera* and organogenic callus of *Dioscorea caucasia* and *D. balcanica* (Chulafich *et al.*, 1994; Touchell *et al.*, 1992). Other species, which have been cryopreserved using encapsulation-dehydration, include *Centaurium rigualii*, endemic to the Iberian peninsula (Gonzalez-Benito & Perez, 1997), and *Cosmos atrosanguinensis*, which is cultivated but extinct in the wild (Wilkinson *et al.*, 1998).

Spores and gametophytes of pteridophytes and bryophytes can also be cryopreserved. Non-chlorophyllous fern spores are generally desiccation tolerant and adapt well to liquid nitrogen (LN) storage, although some are short-lived, such as those of the endangered tree fern, *Cyathea spinulosa*. These were dried and exposed to LN, with over 93 per cent recovery (Agrawal *et al.*, 1993). Chlorophyllous spores of at least some ferns, though generally short-lived, can also be dried and cryopreserved or cryopreserved using the encapsulation-dehydration technique (Pence, 1999).

Some gametophytes of mosses and liverworts are by nature desiccation tolerant and when this is the case, they can be air dried and frozen directly in liquid nitrogen (Leverone and Pence, 1993). When gametophytes are sensitive to drying, pre-culture with abscisic acid (ABA) is sufficient to induce desiccation tolerance in some species of bryophytes. In other cases the encapsulation-dehydration technique has been useful in preserving both tropical and temperate bryophytes and fern gametophytes through disiccation and subsequent liquid nitrogen exposure (Pence, 1999). Slow freezing has also been used to cryopreserve protoplasts of *Marchiantia* (Takeuchi *et al.*, 1980), while pre-culture with mannitol or ABA and proline has been shown to provide protection of moss tissues through slow freezing protocols (Christianson, 1998; Grimsly and Withers, 1983). These techniques should be readily transferable to rare or endangered bryophytes and pteridophytes.

However, cryopreservation technique necessitates specific technical equipment, not readily available in many laboratories in the developing countries. Hence, the use of slow-growth conditions by lowering the temperature is more commonly employed.

c. *In vitro* collection

In vitro collection, or IVC, is the initiation of tissue cultures in the field. It can be used to collect germplasm of species for which seeds are not available and for which cutting may be difficult to maintain or transport. IVC is a very flexible technique and can be adapted to a variety of situations. Either partial or full sterilization of the tissue is made on site and the tissue is transferred to containers of medium for transporting back to the lab. For example, tissues of *Cocos nucifera* have been collected with minimal treatments in the field (Assay Bah *et al.*, 1987). Once they were transported back to the lab, they were resterilized and dissected further for culture. In other cases, sterilization and dissection have been completed in the field, the growth and development of the cultures initiated at the point (Pence, 1996). IVC has been used to collect a variety of plant tissues, including orchid seeds (Warren, 1983), embryos (Assy Bah *et al.*, 1987), apical or nodal buds (Ruredzo, 1991; Yidana *et al.*, 1987), and leaf and stem tissue (Pence, 1996).

Different strategies have been used to minimize contamination in IVC cultures. In some cases, a portable glove box was used to reduce contamination from ambient sources (Sossou *et al.*, 1987), whereas in other cases the work has been done quickly in the open air. Internal contamination can be a more serious problem than ambient contamination, since many plants harbour endophytic fungi and bacteria. However, the use of fungicides and antibiotics in the medium can reduce this contamination to a workable level (Pence, 1996).

The intiation of *in vitro* cultures in the field can facilitate the transport of the tissues. Because of the small size of the explants, more material can be transported, compared to the transport of whole plants or cuttings. In addition, the cultures are initiated with fresh material which can begin the process of growth *in vitro* immediately, comparaed with whole plant materials which may undergo some deterioration in transport before they are planted *ex situ*. Finally, the transport of clean plant materials *in vitro* generally facilitates their movement through international border inspections.

IVC can be used as a source of material for both the propagation and preservation of endangered plant germplasm. For example, leaf and bud tissue collected by IVC from *Brunfelsia densifolia*, a rare Puerto Rican tree growing at the Fairchild Tropical Garden in Florida, was transported to the Cincinnati Zoo and Botanical Garden where plants were regenerated from the cultures and tissues were cryopreserved (Pence, 1990).

The limitation of IVC are those of tissue culture in general, since condition for growing some species *in vitro* have not yet been developed. However, the number and variety of species which have been successfuly propagated *in vitro* continues to grow, and this will, in turn, be reflected in the widening applicability of IVC techniques for the collection of rare or endangered plant germplasm.

Application of tissue culture in conservation in India

Application of tissue culture in *ex situ in vitro* conservation in India has been more or less restricted to economically important plant species which have become rare and endangered due to over-exploitation (see Table-1). It is also observed that most of the work done are on rapid mass multiplication and less on *in vitro* conservation either for short or long term conservation. Most of the work carried out are done in universities and they end up there when the project is over. Thus, the work is not carry over or the result is not being utilised by concern institutions or departments. A co-ordinated research and development is therefore, needed in rare and endangered plant species regardkess of its economic status, so that the finding of the research is properly utilised.

In India, the funding for R & D in the area of rare and endangered genetic resource conservation is also still very low and an area very much neglected when compare to economically important crop species. Some rare species may be relatively unknown, but could have horticultural or other value if enough materials is made available for breeding and development. Hence, the funding must be enhanced in order to carry out the work effectively.

More research on *in vitro* methods for multiplication and conservation have been conducted on orchids than any other group of plants in India. Sharma *et al.*, (1993) have presented a brief review of the orchid research work caried out by different workers in India. Currently, application of tissue culture techniques to conserve and commercialise Indian orchids is being assessed at Panjab University, Chandigarh, Botanical Survey of India, Shillong, North Eastern Hills University, Shillong; Orchid Research and Development Centre, Tippi, Arunachal Pradesh; Indian Institute of Horticultural Research, Bangalore and Tropical Botanic Garden and

Research Institute, Thiruvananthapuram. Attempts are being made at NBPGR, New Delhi, to conserve recalcitrant seeds of mango, coconut, jackfruit, litchi, sapota, walnut and other economic plants. Considerable success in cryopreservation of economic plant germplasm has been made at National Facility for Plant Tissue Culture Repository (NFPTCR) using seeds, pollen and *in vitro* cultures (Chudhury *et al.*, 1989). Successful cryopreservation, using desiccation of embryonic axes followed by rapid freezing, was achieved in tea, jackfruit, trifoliate orange, and almond. Effects of cryopreservation on seed germination of selected rare medicinal plants of India are being studied at Tropical Botanic Garden and Research Institute, Thiruvananthapuram.

Limitation of tissue culture in conservation of endangered species

The limited amount of plant material available is the controlling factor in tissue culture of rare endangered species. Generally, work with related, non-endangered species is used as a guide, therefore, the ability to test protocols and even to conduct replicated experiments may be severely limited (Campos & Pais, 1996; McComb, 1985). In addition, plants may be located in remote or difficult to access areas and collecting trips may be expensive. Permits are often required for any collection, as well as for transport. Also, the financial resources available for work with endangered species is often limited in comparison to that of economically important species. However, despite these limitations, a significant amount of work has been done with endangered plant species to solve specific problems in the areas of propagation, germplasm preservation, collection and analysis of genetic diversity (Pence, 1999).

CONCLUSION

As already mentioned in the text, a wide range of endangered plants has been successfully propagated in many countries using *in vitro* techniques. This has faciliated easy distribution of material of these species to other institutions around the world because of the cultures do not require quarantine due to their sterile nature. *In vitro* propagation has also allowed materials to be stored in *in vitro* gene banks, and this will increase with further developments in cryopreservation technology. However, in spite of these substantial advantages over conventional methods, there are certain inherent limitations which should be borne in mind. It is now well established that frequent genetic modifications are manifested as heritable mutations among the progeny of regenerated plants. This phenomenon is called somaclonal variation and is defined as genetic variability generated during tissue culture (Larkin & Scowcroft, 1981). This variations has obvious benefits as an adjunct to plant improvement but it poses serious problems for *in virtro* germplasm conservation and exchange.

Nevertheless, an increasing number of botanic gardens around the world have *in vitro* facilities and information on techniques is disseminated among botanic gardens. A newsletter called *Botanic Gardens Micropropagation News* was launched in 1990 and published by Royal Botanic Gardens, Kew, (U.K.) in association with Botanic Gardens Conservation International. This issue is also available on the World Wide Web:http://www.rbgkew.org.uk/science/micropropagation/bgmnews.html.

Apart from the above mentioned *in vitro* techniques, the greatest challenge of the millenium is the development of molecular techniques. Molecular technique has opened the door to a number of areas relevant to conservation, management and monitoring the stablity and diversity of endangered plant germplasm held *in situ* and *ex situ*. Molecular techniques, particularly RAPD analyses, are being used to monitor the genetic diversity of populations of rare species, as well as to define species themselves which is very important for endangered species management. For example, a high level of diversity was found for the ten known populations of *Banhsia cuneata*, an endangered species of South-western Australia (Maguire & Sesgley, 1997). RAPD analysis also indicated that the one known individual of *Eucalyptus graniticola* was a hybrid of two more common species, rather than an endangered relict species (Rosetto *et al.*, 1997). Thus, rather than reinforcing the population *in situ*, the species was backed up *ex situ*. The use of RAPDs can provide an even more precise tool for the detection of somaclonal variation in micropropagated endangered plants (Martin & Perez, 1994).

In preserving plant germplasm, DNA can be banked as a back-up or supplement to the storage of living tissues, or may be used when living tissues cannot be stored. Techniques for isolating DNA from dried tissue, as well as dried frozen material have been developed (Adams & Adams 1992), making collection and banking from wild, remote species a posibility. Libraries of DNA from rare or endangered species are being set up in many laboratories around the world to store this information for future use (Mattick *et al.*, 1992). Also, recommendations and guidelines for DNA banking have been made (Adams & Adams, 1992).

Further, molecular technologies offer the possibility of collecting ancient DNA from extinct species, as well. Within the past decade, the isolation of DNA fragments from dried herbarium specimens (Pyle & Adams, 1989) as well as from fossil materials (Rogers & Bendich, 1985; Suyama *et al.*, 1996) has been demonstrated. A fragment of DNA, identified as part of the RuBisCo gene, was obtained from a fossil leaf compression of the extinct *Magnolia ltahensis* (Golenberg *et al.*, 1990). This was compared with gene sequences from extant species. A portion of this same gene was also obtained from fossil *Taxodium* Soltis *et al.*, 1992).

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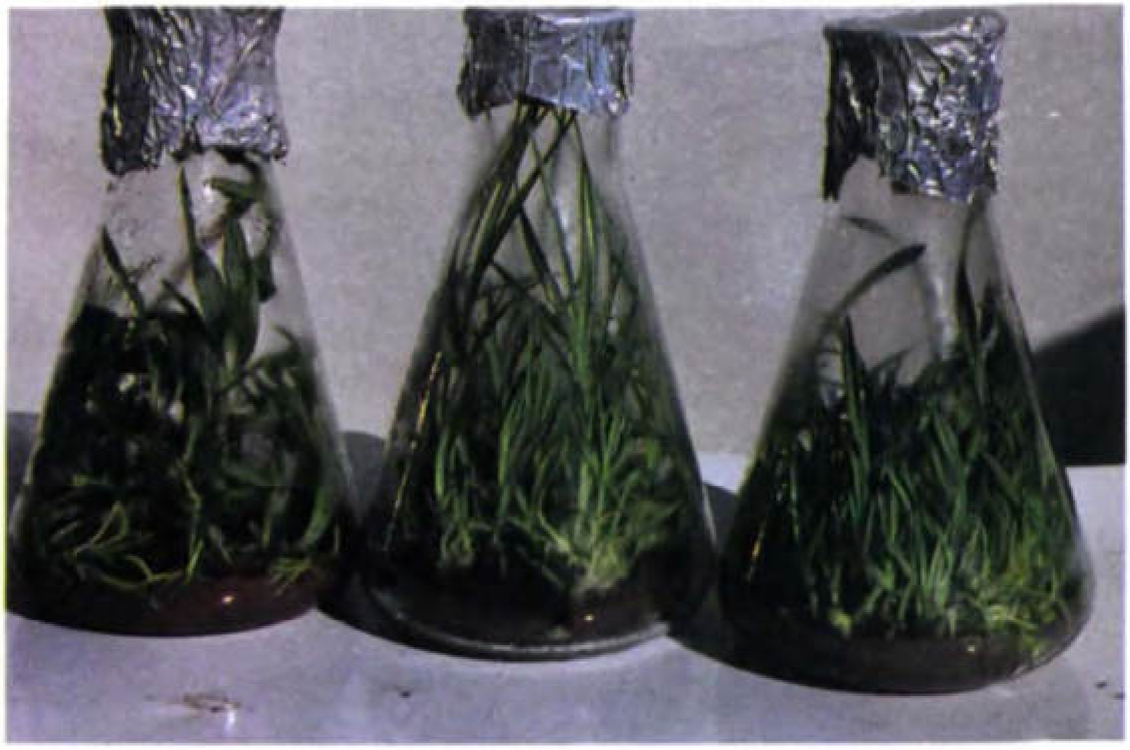
A view of Tissue culture Laboratory, BSI, Shillong.

A view of Tissue culture Laboratory, BSI, Shillong.

The same in closer view.

Nepenthes khasiana - *in vitro* raised plants.

Lilium mackliniae - weaned plantlets.



L to R : Culture of *Dendrobium nobile, Arundina graminifolia* and *Cymbidium tracyanum.*

Successfully transferred lab to land *Dendrobium primulinum* in flower.

HERBARIUM

N.P. Singh
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In recent years the conservation of biodiversity has become the catchword of biologists and conservationists. The publication of "Conserving the World's Biological Diversity" by World Resource Institute (WRI) (McNeely *et al.*, 1990), World Wide Fund for Nature (WWF), International Union for Conservation of Nature and Natural Resources (IUCN) and World Bank has highlighted it as the most important and burning issue for the survival of human race on this planet.

Human activities in the last quarter of the 20th century have reduced the biological diversity at a rate that may be unprecedented in the history of life on earth. It is impossible to assess with our limited knowledge, the consequence of the disappearence of the species for the stability of Earth's environment or the economic value lost because of extinctions. The best available estimates indicate that if the current trends continue, some 15-20% of the estimated 30 million species of plants and animals may become extinct by 2000 AD (Wolf, 1987). Human activity is greatly accelerateing the extinction rates. More species of the earth's flora and fauna may disappear in the next few decades than were lost in the mass extinction that wiped out whole taxonomic groups of animals, including the dinosaurs 65 millions year ago (Wolf, 1987). The conservation of plants that provide us food, fodder, fibre, shelter, medicines etc., which are part of our daily life, is one of the most important issues for humankind today.

The "World Commission on Environment and Development" (WCED), constituted by the General Assembly of the United Nations in 1986 endorsed the urgent need for conserving the world's rich biodiversity and special emphasis was laid on the tropical areas. The deterioration of the earth's environment and its life support system prompted the United Nations to host a "Conference on Environment and Development (UNCED)" in Rio de Janerio, Brazil in June, 1992. In the Rio Conference, also known as the "Earth Summit" the participating nations discussed the issue of world environment and development. The most important issue resolved in this conference was the "Convention on Biological Diversity (CBD)" which, while recognising the sovereignty of the Nation States on their biological resources, enjoins upon them to ensure the conservation of biological diversity, the sustainable utilization of biological resources, fair and equitable sharing of benefits arising out of the utilization of the biological resources, access to biological resources and transfer of technology and devise mechanisms to conserve biological diversity at the national level.

In independent India, the need to conserve biodiversity was identified as a priority even in the early years of planning and development and the conservation principles were included in the first Five Year Plan as early as in 1950. The Govt. of India enunciated the National Forest Policy in 1952 with the aim of conserving a third of the forest cover in the country. Environmental protection and the conservation of natural resources in the context of poverty alleviation emerged as key national priorities in India in the wake of the Stockholm Conference on Human Environment in 1972.

India's rich phyto-diversity

The Indian region is one of the most diverse biogeographic regions of the world, embracing a wide range of topography from perpetually snow covered high Himalayan ranges to Plains at sea level, low lying swamps, mangroves and wetlands; from tropical evergreen rain forests to fertile alluvial plains, hot deserts and high altitude cold deserts. As many as 12 biogeographic regions, representing 3 basic biomes and 2 natural realms, as identified by Udvardy (1975), are recognised in India. There are almost rainless areas to the world's highest areas. Cherrapunji and Mawsynram in Meghalaya are the wettest places on the earth. Dras in Ladakh is the coldest inhabited place on earth. The climate ranges from tropical in Indo-Gangetic plains and peninsular regions to sub-tropical in higher hilly regions of southern India and Himalaya, and temperate and arctic in the Himalayan regions. With a geographical area of about 329 million hectares i.e. 32,87,263 sq. km and over 7500 km of coast line, India is the 7th largest country in the world and 2nd largest in Asia. A great variety of climatic and altitudinal variations, coupled with varied ecological habitats have contributed immensely to the rich vegetational wealth and varied flora.

Concept and development of Herbarium

Since the dawn of civilization man has been dependent on the plants for all his basic needs such as food, fodder, fiber, clothing, shelter, medicines etc. The thought of sharing his knowledge and experience about the use of plants with his fellow beings might have prompted him to preserve such useful plants for future reference. This must have been the beginning of the development of the herbarium practices. The concept of preserving plant specimens in dried form, as is practiced in modern herbaria, is about 450 years old. Arbor (1938) discussed about 'Herbals' and their origin. The present concept and development of Herbarium is due to efforts of botanists for more than four centuries. Although one can not say with certainty as to who discovered this method of preserving plants, the oldest preserved herbarium specimen is kept in Rome, collected by a naturalist Gharardo Cibo, a pupil of Luca Ghini in the year 1532. The first Herbarium of the world was established in 1545 in the University of Padova, Italy. The simple, yet revolutionary technique of preserving plants by drying them under moderate pressure between sheets of paper and mounting them on stiff paper or cards marked the beginning of the modern herbarium (Mortan, 1981).

Although the specimens in a Herbarium are each unique and in some ways resemble the books of a library, in a wider context they are a set of samples. They are samples of populations; samples of a vegetational cover; and samples of the taxa to which they belong. There is a definite connection between the specimen and the living flora of which it was once a part. Even a single specimen has a great deal of information content about the taxon of which it is a sample.

What is Herbarium

Herbarium is not merely a collection of dried plants but it is a great filing system for information about plants, both primary in the form of actual specimens and secondary in the form of published informations, pictures and recorded notes (Fosberg & Sachet, 1965).

It is a store house of plant specimens collected from far and wide, dried, pressed and mounted on appropriate sheet and arranged according to some known system of classification (Jain & Rao, 1977). An ideal herbarium sheet possesses a good specimen with correct botanical as well as local names, if any, alongwith its family, its exact place of collection, information on habitat, habit, phenological data, frequency, distribution, flower and fruiting time, colour, its uses, economic and/ or ethnobotanical informations, and other important notes.

Salient features of some Indian Herbaria

1. ***Central National Herbarium, Howrah, W.B. (CAL) :*** The Central National Herbarium, situated in the Indian Botanic Garden, Sibpore, Howrah (W. B.), being the repository of not only the Indian but a sizable samples of the world flora, provides an essential aid in the pursuit of taxonomic researches in India, both fundamental and applied. The classificatory sequential arrangements of hundreds of genera and thousands of species, a huge assemblage of the 'Types' of many of the Indian taxa and preservation of duplicate set of the famous Wallichian sheets, amongst many other classical collections made during the 19th century, impart a prestigious position to this Herbarium. The historical collections include those of Roxburg, Wallich, Griffith, Wight, J.D. Hooker, T. Thomson, Royle, C.B. Clarke, G. King, Prain, Kurz, W.W. Smith, etc. The Central National Herbarium (C.N.H) has a chequarred past, extending over the last two hundred years.

Since the reorganisation of the Botanical Survey of India in 1956 more than 2,50,000 plant specimens were added to this herbarium, by the scientists of Botanical Survey of India, from different parts of the country. And at present it houses *ca* 1,500,000 specimens of Angiosperms, Gymnosperms and Pteridophytes. Apart from that it also houses *ca* 3000 specimens of lichens, *ca* 7000 specimens of bryophytes and *ca* 15,000 specimens of fungi. Besides, there are *ca* 10,000 type specimens and *ca* 20,000 photo negatives of type specimens

2. ***Herbarium, Industrial Section, Indian Museum (BSIS) :*** Situated in Calcutta, this herbarium was established in 1887 but subsequently was merged with Botanical Survey of India in 1911.

There are at present *ca* 50,000 herbarium specimens and 15,000 museum exhibits.

3. ***The Madras Herbarium (MH)*** : The Madras Herbarium, now known as the herbarium of the Botanical Survey of India, Southern Circle, Coimbatore has to its credit about 150 years of fine service.

Initiated around the year 1853 as 'Madras Museum Herbarium' by Huge Clegharn with his own collections alongwith those of Dr. Drew and Sir W. Elliot, it was subsequently merged with 'Madras Herbarium' established by M.A. Lawson in 1874. While R. H. Beddome not only contributed to Madras Museum Herbarium but also donated his private herbarium comprising *ca* 6000 specimens. A.G. Bourne made substantial contributions to the latter. It was during Bourne's tenure as Superintendent of Madras Museum during 1897-98 that both these herbaria were merged under the name 'Madras Herbarium'

The herbarium was transferred to the Government Botanist in 1898-99 when C.A. Barber took up the appointment alongwith that of Director, Botanical Survey of South India. Subsequently in 1905 the herbarium was transferred to Coimbatore. Untill 1908 the herbarium had nearly 40,000 specimens. Dr. Barber added over 20,000 specimens to this. From 1912 to 1923 K. Rangachariar was incharge of the herbarium, who also considerably augmented herbarium holdings.

With the setting up of the Southern Circle of Botanical Survey of India at Coimbatore in 1955, the herbarium with 95, 106 specimens, representing the Flora of the old Madras Presidency (including Mysore, Coorg, Cochin and Travancore) and specimens from north India, Myanmar, Sri Lanka, Malaya, Europe, Africa, Australia, U.S.A., etc., was transferred to this Circle. More than 88,000 specimens from Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, part of Madhya Pradesh and the Andaman were added to this herbarium at a later date by the scientists of the department. There are about 800 'Type' and many authentic specimens. At present nearly 233,000 specimens are housed in this herbarium.

4. ***The Blatter Herbarium (BLAT)*** : The herbarium is situated in St. Xavier's College at Bombay. The precise date of foundation of this herbarium is uncertain. According to Santapau (1954) it was

founded some time between 1906 -1907 after Blatter received a consignment of specimens from C.E.C. Fischer from the Coimbatore Herbarium. In the beginning the herbarium was known as St. Xavier's College Natural History Museum but was later renamed as 'Blatter Herbarium' in 1941 when Fr. H. Santapau took charge of the herbarium.

After Blatter's demise in 1934, McCann was assistant Curator and then Curator of the Natural History section of the Museum. Soon after independence he migrated to New Zealand along with *ca* 20,000 specimens, given to him by Blatter. Later he returned these specimens to the Blatter herbarium in 1972. The herbarium houses about 2,00,000 specimens representing the collections, besides others, of L.J. Sedgwick, R. D. Aucland, J.C. Lisboa, M. L. Banerjee, B.G. Mundkar, H. Santapau, etc.

5. ***The Dehra Dun Herbarium (DD)*** : It is the herbarium of the Forest Research Institute & College, Dehra Dun (now Indian Council of Forestry Research and Education) and is composed of the Forest School Herbarium, started by J.S. Gamble in 1890. The erstwhile Saharanpur herbarium was merged with it in 1908. The oldest specimens collected by George Govan dates back to about 1816 are also available in the herbarium.

Dr. George Govan was appointed the first Superintendent of the Saharanpur Botanic Garden in 1816. He collected plants mainly in the adjacent Sirmoor State, now in Himachal Pradesh. Dr. J.F. Royle succeeded Dr. George Govan in 1823. He collected plants in the adjacent Himalayas. Dr. Huge Falconer succeeded Royle in 1831 and sent his collectors to Kashmir and Ladakh. Dr. William Jameson succeeded Dr. Falconer in 1842. After Jameson's retirement in 1876, the post of Superintendent went outside the medical service and J.F. Duthie was appointed as his successor. During Duthie's time Gamble was vigorously building up the Forest School Herbarium at Dehra Dun.

Immense amount of labour was put in, mainly by Duthie and Gamble, for bringing together a good representation of the Flora of North-Western region of the Indian sub-continent. A good collection of trees and shrubs by U.N. Kanjilal and his associates and several private herbaria made by forest officers, viz. Smythes, Gustav Mann and J.C. McDonell were presented to the school. A number of Australian specimens were also received, on exchange basis.

The Dehra Dun herbarium now contains more than 300,000 specimens which include collections of J.E.T. Aitchison, N.L. Bor, D. Brandis, J.F. Duthie, J.S. Gamble, G. Govan, Gustav Mann, H. H. Haines, W. Jameson, U.N. Kalljilal, P.C. Kanjilal, A.E. Lowrie, H.F. Mooney, A.E. Osmaston, R.N. Parker, C.E. Parkinson, Stocks, Keshavanand, M.B. Raizada, J.F. Royle, K.C.Sahni, R.R. Stewart and many others from not only N.W. Himalayan region but other parts of the country as well. The collections include *ca* 1200 'Type' specimens.

6. Herbarium of Botanical Survey of India at Pune (BSI): Western Circle of Botanical Survey of India came into being on 12th December, 1955 at Pune with the transfer of the herbarium of the Western Zone or the old Botanical Survey of India under the then Government of Bombay. This old herbarium was started in 1880 by the Government of Bombay under Theodore Cooke of the Science College. G.M. Woodrow succeeded Cooke in 1896. There were about 5000 sheets by 1899. However, the entire collection was destroyed by fire in May 1902. It was re-established with the duplicate set generously presented by T. Cooke. This formed the nucleus of the Poona Herbarium. Gammie succeeded Woodrow and made large collections not only within the state but from as far as Kashmir to Assam in the Himalayas. W.A. Talbot's collections of North Kanara were purchased and added to the herbarium in 1910. Lastly the Maharaja of Kuchh presented the collections of Jaykrishna Indrajit Thakkar from Gujarat in 1929.

Besides Cooke and Woodrow a number of other workers also contributed to this herbarium. Notable among them are Kanitkar in 1891, Ranade in 1909, Bhide in 1898, Patwardhan in 1908, Paranjpe in 1909, Shavda in 1909, Burns in 1916, Narayana in 1922, and Godbole in 1929. Ryan's collections of 1908, mostly from Sind, were also added. At present more than 1,50,000 specimens are housed in this herbarium, which include about 465 'types'.

7. The Herbarium of the National Botanical Research Institute, Lucknow (LWG) : Established relatively recently with the efforts of late Prof. K. N. Kaul, with his collections mainly from Delhi, Mussoorie and Kashmir, the herbarium at the National Botanical Research Institute, Lucknow, presently houses *ca* 1,20,000 specimens, which include, besides Gymnosperms and Angiosperms, the lower groups like Fungi, Lichens, Bryophytes, Pteridophytes as well as some carpological collections. Specimens of grasses and other herbaceous elements were transferred from Government Agriculture College, Kanpur. Norman Gill's collection from Kumaon were also acquired. Besides, D.D. Awasthi, R.C. Bharadwaj, K.P. Biswas, B.K. Nayar, H.O. Saxena, J.G. Srivastava, H. Yadav, etc., have also made important contributions towards the development of this herbarium.

8. ***The Rapinat Herbarium (RHT) :*** The credit of having this prestigious herbarium goes to St. Joseph's College, Tiruchirapalli. The herbarium, organized in 1967, is named after Alfred Rapinat (1892-1959) whose collections formed the nucleus of the herbarium. At present there are more than 87,000 specimens in the herbarium. Fr. K.M. Mathew, as incharge of the herbarium, has significantly contributed towards the development of this herbarium.

9. ***The Herbarium of Central Circle, Botanical Survey of India, Allahabad (BSA) :*** The herbarium was established in 1962 with the establishment of this Circle. There are more than 75,000 specimens, which have accumulated through the sustained efforts of the scientists of the department.

10. ***The Herbarium of Northern Circle, Botanical Survey of India, Dehra Dun (BSD) :*** This herbarium came into being with the setting up of this Circle in 1956. At present it houses more than 1,01,750 specimens which include 65 'Type' specimens, collected by the scientists of the department from north-western U.P., Delhi, Jammu & Kashmir, Himachal Pradesh, Punjab, etc. Besides, *ca* 1,500 specimens of fungi, belonging mostly to Aphyllophorales and few bryophytes are also available for study and reference. Apart from that, the herbarium also houses a sizeable number of Japanese and Russian specimens acquired on exchange basis.

11. ***The Herbarium of Andaman & Nicobar Circle, Botanical Survey of India, Port Blair (PBL) :*** With the establishment of this Circle in 1972, this herbarium was also started. There are more than 30,000 specimens, collected by the scientists of the department

from Andaman & Nicobar Islands. These include 30 'Type' specimens of the newly described taxa.

12. ***The Herbarium of Eastern Circle, Botanical Survey of India, Shillong (ASSAM) :*** Established in the year 1956 with the transfer of *ca* 40,000 specimens, from the erstwhile Assam Forest Herbarium it has since been, enriched and increased manifolds through the concerted efforts of the scientists of the department. At presont it accomoda *ca* 2,25,000 specimens of Angiosperms, Gymnosperms and Pteridophytes which include some historical collections of Gustav Mann, P.C. Kanjilal. U.N. Kanjilal, N.L. Bor etc. Apart from that with *ca* 15,000 specimens of lichens and 11,000 specimens of bryophytes (mostly liverworts), the ASSAM herbarium has the distinction of having one of the largest collections of these groups in India. The herbarium also has *ca* 460 'Type' specimens.

13. ***The Herbarium of Sikkim Himalayan Circle, Botanical Survey of India, Gangtok (BSHC) :*** The herbarium was established in the year 1979. There are about 10,000 specimens representing collections from Sikkim state.

14. ***The Herbarium of Arunachal Pradesh Circle, Botanical Survey of India, New Itanagar (ARUN) :*** The herbarium was established in the year 1979. The herbarium holding at present represents more than 10,000 specimens.

15. ***The Herbarium of Arid Zone Circle, Botanical Survey of India, Jodhpur (BSJO) :*** The herbarium was established in the year 1972. It houses more than 17000 herbarium specimens.

Cryptogamic Collections/Herbaria

Barring few, most of the Indian herbaria are poorly represented by cryptogamic collections. This is because of inadequate studies carried out so far, on cryptogamic flora. In order to comply with the C.B.D. objectives, it is essential to have complete knowledge on cryptogams which comprise over 27,000 species in India. For proper and systematic knowledge of these plants, existing herbaria have to be enriched by new collections and new herbaria need to be established to meet the challenges in future. The institute like Botanical Survey of India can play a significant role in this direction.

Role of Herbarium in conservation of plant-diversity

Scientists have two great sources of information. One is, of course, scientific literature. This is the record of observations and conclusions of workers. Because it is recorded information it must be regarded as a secondary source. It is subject to a considerable increment of error because it has been written down by the human hand. The same increment may also occur in the raw data recorded from experiments or field observations. Another primary source is the actual objects of study. In biology it is an organism.

Several scientists have discussed at length the importance of herbaria and their role in conservation, disseminating scientific informations and plant researches (Ayensu, 1981; Beaman *et al.*, 1965; Biswas, 1944; Brenan, 1968; Cronquist, 1966, 1968; De Wolf, 1968; Dumond, 1973; Ghosh, 1948; Hernandez Cardona, 1983; Heywood, 1968; Jain, 1969, 1987; Jain and Sastry, 1982; Mukherjee, 1959; Murti and Singh, 1994; Panigrahi, 1977; Rau, 1964; Santapau, 1954; Shetler, 1969; Subramanyam and Sreemadhavan, 1970).

The important functions of a Herbarium are as follows :

1. ***Influx of material :*** The plant specimens are accumulated through field survey and collections, gifts from different institutions/ persons, through exchange between institutions and in exchange of identitification services rendered to others.

2. ***Preservation of historical materials :*** Many historical collections of renouned botanists and 'type' specimens are housed in Herbaria, which are available for study to future scientists.

3. ***Stimulation to research :*** The continual flow of new specimens, queries and requests for informations stimulate the search for new informations and clarification of old ones. In the course of attempting to identify specimens and answer inquiries, gaps in our knowledge are encountered such as defects in the classification, misinterpretations of facts, undescribed species of plants, unsatisfactory keys for identification

etc. The specimens provide basic materials for the research in the field of anatomy, palynology, chemo-taxonomy, embryology, cytology, ecology, phytogeography, economic botany, ethnobotany, etc.

4. ***Preservation of data on vegetation :*** Due to 'various anthropogenic activities the earth's biological diversity is being destroyed with tragic rapidity. The ever increasing human populaiton has accelerated the species extinction rate. Thus one of the most important tasks for the Herbarium is the preservation of data on the original vegetation. The only documented records of much value are the labels and notes accompanying the herbarium specimens.

5. ***Meeting place for botanists :*** Another very real, though perhaps unintended, function of a herbarium is to provide a meeting place for botanists. They are attracted by the collection of the plant specimens and thus brought into contact with one another. This provides opportunity for exchange of ideas and for mutual benefit from experiance.

6. ***Supply of informations to taxonomists and non taxonomists:*** Many useful informations on economic and ethnobotanical aspects, rarity, ecology, population, vernacular names, etc. are recorded on herbarium sheets and other field notes. These are used by taxonomists as well as non taxonomists.

7. ***Teaching botany :*** It is difficult for a student to gain a useful knowledge of plants without extensive collection and identification of his collection. This is impossible without a reference to a herbarium for determination by comparison.

8. ***Help in assessing air quality :*** Herbarium collections of certain plant groups like lichens and bryophytes serve as "Environmental specimen bank" and may help in monitoring pollution trends in a given area over a period of time.

9. ***Help in conservation of plant-diversity :*** The basic objectives of the Convention on Biological Diversity (CBD) include the conservation of biological resources, their sustainable utilization and equitable sharing of benefits arising from utilization of such resources. In order to achieve these objectives it is imperative to know what components

of biodiversity we have. In what quantity these components are available? Where are they all distributed? And what for and how are they utilised by people. For conservation of a species, proper information about its occurrence, habitat, phenology, abundance, ecology and distribution are essential and Herbarium can effectively feed back on these lines.

Herbarium provides valuable informations on such species which are under threat due to various factors such as habitat destruction, over exploitation, developmental activities, tourism, reproductive and/ or biological imparities, etc. Herbarium provides inputs to record changes in a specific or a set of parameters of biodiversity, which in turn provides necessary informations for formulating policies and programmes for effective management and conservation of biological diversity.

Herbaria form the important tool for identification of rare and endemic plants. Analysis of herbarium specimens provides useful clues to the status of a species. Based on such studies of herbarium specimens, a number of areas have been identified/declared as "fragile ecosystem", "Hot Spots", "Wildlife Sanctuaries", "National Parks" and "Biosphere Reserves".

Herbaria provide useful informations on traditional use of plants in ethnic communities to the urban society. They also provide informations on rarity of a particular species. For example, a scrutiny of *Berberis* specimens in various Indian Herbaria revealed that about 50% species are not or poorly collected during the past several decadees. Some of the species have not been collected after their "Type" collections. Usually, if a species is not represented by more collections in a Herbarium, it is presumed to be a rare species. Certain ephemeral species such as species of *Gentiana, Primula, Saxifraga,* etc. complete their life cycle in a short span of time and such species are likely to be missed by field botanists, thus poorly represented in the collections of a Herbarium. Also the species might have been originally described on a stray collection from a spot not visited by botanists frequently. Hence, Poor representation of a species in a Herbarium may not necessarily conclude a species to be rare or endangered; but such analysis could be considered as better than no data at all. Balakrishnan and Rao (1983) recorded several such species from Andaman & Nicobar islands, which are represented by "Type" collections only (Table-I).

Table I
Some rare species from Andaman and Nicobar Islands represented by "Type" collections (Balakrishnan & Rao, 1983).

Botanical name	Family	Locality
Hypoestis andamanensis	Acanthaceae	M. Andaman
Strobilanthes andamanensis	Acanthaceae	Andaman
Crinum pusillum	Amaryllidaceae	Nicobar
Mangifera andamanica	Anacardiaceae	S. Andaman
Artabotrys nicobarianus	Annonaceae	Gt. Nicobar
Orophaea salicifolia	Annonaceae	M. Andaman
O. torulosa	Annonaceae	M. Andaman
Popowia parvifolia	Annonaceae	Nicobar
Uvaria hamiltonii var. *kurzii*	Annonaceae	Andaman
U. nicobarica	Annonaceae	Gt. Nicobar.
Aglaonema nicobaricum	Araceae	Nicobar
Amorphophallus carnosus	Araceae	Andaman
A. longistylus	Araceae	S. Andaman
A. oncophyllus	Araceae	S. Andaman
Calamus dilaceratus	Arecaceae	Andaman
C. nicobaricus	Arecaceae	Nicobar
Corypha macropoda	Arecaceae	S. Andaman
Bombax insigne var. *polystemon*	Bombacaceae	Narcondum Is.
Hippocratea andamanica	Celastraceae	S. Andaman
H. nicobarica	Celastraceae	Nicobar
Garcinia cadelliana	Clusiaceae	S. Andaman
G. calycina	Clusiaceae	Kamorta Is.
G. kingii	Clusiaceae	Andaman
Mesua manii	Clusiaceae	S. Andaman

Botanical name	Family	Locality
Connarus nicobaricus	Connaraceae	Gt. Nicobar
Cyperus kurzii	Cyperaceae	Andaman
Dioscorea rogersii	Dioscoreaceae	Andaman
D. vexans	Dioscoreaceae	Andaman
Antidesma andamanicum	Euphorbiaceae	S. Andaman
Bridelia kurzii	Euphorbiaceae	Kamorta Is.
Drypetes leiocarpa	Euphorbiaceae	S. Andaman
Excocaria rectinerveis	Euphorbiaceae	Katchal Is.
Sphyranthera lutescens	Euphorbiaceae	M. Andaman
Neolitsea andamanica	Lauraceae	Andaman
N. nicobarica	Lauraceae	Nicobar
Strychnos narcondamensis	Loganiaceae	Narcondam Is
Ginolla andamanica	Loranthaceae	S. Andaman
Phrynium cadellianum	Marantaceae	Andaman
Aglaia fusca	Meliaceae	Andaman
Stephania andamanica	Menispermaceae	S. Andaman
Tinospora andamanica	Menispermaceae	Andaman
Ficus andamanica	Moraceae	S. Andaman
Ardisia andamanica var. *effusa*	Myrsinaceae	S. Andaman
Embelia microcalyx	Myrsinaceae	Katchal Is.
Syzygium andamanicum	Myrtaceae	Andaman
Olax imbricata var. *membranifolia*	Olacaceae	Katchal Is.
Jasminum andamanicum	Oleaceae	Andaman
J. unifoliolatum	Oleaceae	N. Andaman
Malleola andamanicum	Orchidaceae	Andaman
Phalaenopsis speciosa	Orchidaceae	Andaman
Taeniophyllum andamanicum	Orchidaceae	Andaman
Zeuxine rolfiana	Orchidaceae	Andaman

Botanical name	Family	Locality
Hedyotis andamanica	Rubiaceae	Andaman
Ixora andamanica	Rubiaceae	Andaman
I. hymenophylla	Rubiaceae	Andaman
I. capituliflora	Rubiaceae	Andaman
I. longibracteata	Rubiaceae	Andaman
I. tenuifolia	Rubiaceae	Nicobar
Nauclea gageana	Rubiaceae	Nicobar
Prismatomeris andamanica	Rubiaceae	Andaman
Psychotria andamanica	Rubiaceae	Andaman
P. tylophora	Rubiaceae	Katchal Is.
Pubistylis andamanensis	Rubiaceae	S. Andaman
Henslowia erythrocarpa	Santalaceae	Kamorta Is.
Mimusops andamanensis	Sapotaceae	Andaman
Tetrastigma andamanicum	Vitaceae	Andaman
Boesenbergia albolutea	Zingiberaceae	Andaman
Kaempferia siphonanth	Zingiberaceae	N. Andaman

Jain and Sastry (1984), on the basis of herbarium collections, reported the following species known from "Type" collections only.

Goniothalamus wynaadensis (Annonaceae). Tamil Nadu Nilgiri, Devala and Cherambady hills, Wynaad. Endemic.

Miliusa nilagirica (Annonaceae). Tamil Nadu, Nilgiri Hills, Wynaad, Coimbatore, Anamalai Hills. Endemic. Known only from type locality and Anamalai Hills.

Phaeanthus malabaricus (Annonaceae). Kerala, Wynaad and Tambracherry Ghat. Endemic.

Chaerophyllum cachemiricum (Apiaceae). Kashmir, H.P. Endemic.

Ferula thomsonii (Apiaceae). Kashmir (Banihal) Endemic. Not collected after 1848.

Heracleum jacquemontii (Apiaceae). J. & K.

Peucedanum thomsoni (Apiaceae). Kashmir (Banihal and Kishtwar) Endemic.

Corypha taliera and **C. umbraculifera** (Arecaceae). Both are not seen in wild, only under cultivation in IBG, Howrah. No recent collections.

Impatiens reidii (Balsaminaceae). Kumaon, Endemic.

Poeciloneuron pauciflorum (Clusiaceae). Kerala, Western Ghats.

Rhododendron concinnoides (Ericaceae). Arunachal Pradesh. Endemic.

R. subansiriense (Ericaceae). Arunachal Pradesh. Endemic.

R. wattii (Ericaceae). Manipur. Endemic.

Derris kanjilalii (Fabaceae). Pilibhit (U.P.). Endemic.

Hypericum japonicum var. ***major*** (Hypericaceae). Tamil Nadu, Nilgiri. Endemic. Not collected again from type or other localities; possibly extinct.

Archineottia microglottis (Orchidaceae). Garhwal. Endemic. Collected after a gap of about 80 years after type collection.

Aphyllorchis gollani (Orchidaceae). Tehri Garhwal. Endemic.

Calanthe pachystalix (Orchidaceae). Simla, Mussoorie.

Pleione lagenaria (Orchidaceae). Khasi Hills. Collected by Thomas Lobb in 1849 from Khasi Hills, since then not collected, not known even in cultivation.

Clematis theobromina (Ranunculaceae). Tamil Nadu. Coonoor, Kara Kundha Nilgiri. Endemic. Collected after about 90 years after type collection.

Euonymus angulatus (Celastraceae). Coorg, Nilgiri, Bolampatty Hills, Coimbatore. Endemic. After Beddome's collection in 1869 again collected after 100 years from Silent valley.

Machenzia caudata (Acanthaceae). S. Canara, Coorg, Wynaad. After Beddome's collection in 1867 again collected in 1973 only from Palghat.

Gentiana saginoides (Gentianaceae). Kumaon.

G. tetrasepala (Gentianaceae). Kumaon, Ralam Valley.

Herbarium specimens also throw light on the occurrence of certain groups of genera, species and even families in a particular region or phytogeographic zones. Orchids are more abundant in north east India and Western Ghats which are more humid and hot. Ranunculaceae, Brassicaceae, Gentinaceae, Asteracese, Caryophyllaceae are more abundant in temperate regions. Mukherjee (1983), while working on the taxonomy of Indian umbellifers, concluded that of the 55 genera and 186 species of Umbellifers in India, 150 species under 45 genera were Himalayan and 70 species under 23 genera were recorded from Eastern Himalaya. He recorded the following 25 species as either very rare or represented by "Type" collections only.

Acronema nervosa Only from the type, collected in 1911 from Sikkim.

A. pseudotenera Only from the type, collected in 1892 from Sikkim.

A. johrianum Only from the type, collected from Nepal in 1965.

A. hookeri var. **graminifolia** Only from the types, collected in 1844 from Sikkim.

A. wollfiiana Only from the types, collected from Sikkim between 1870 and 1888.

Angelica nubigena from types and one last collection by Cav. in 1909.

Trachydium affine Only from types, collected in 1911 from Sikkim.

Pimpinella wallichii Only from types, collected in 1870 from Sikkim.

Peucedanum sikkimensis Only from types, collected between 1870 and 1875.

Pternopetalum radiatum Only from the types, last collected in 1892 from Sikkim.

Chaerophyllum cachemiricum Only from type, collected in 1874 from Dalhousie.

Heracleum jacquemontii Only type in Paris, no specimen in India.

Meeboldia selinoides -Type collected in Nainital in 1905, no specimen in India.

Pycnocycla glauca Last collected from Ranchi in 1918.

Carum villosum Only from type, no specimen in India, last and only collection in 1918.

Ligusticum albo-alatum -Type and the other collection in 1940 from Sarguja, M.P.

Bunium nothum Only from the type (not in India) and the other collected in 1883 from Nilgiri.

Schulzia benthamii - Probably collected before 1849 from Canara,no specimen in India.

Zosimia absinthifolia only collection from Bombay Presidency in 1845.

Heracleum pinda - probably only the type

Polyzygous tuberosus Only two specimens, one of Dalzell and the other by Stocks-in flowers, immature fruits

Chaerophyllum reflexum var orientalis - Only from the type, collected in 1885 from Naga hills.

Pimpinella flaccida - Only from the type, not in India, last collected from Kohima in 1895.

Pimpinella evoluta - Only from the type.

Heracleum burmanicum - Last collection 1895 by C.B. Clarke.

On the basis of study of herbarium specimens only some possibly extinct plants are listed below (Table II).

Table II
List of Indian plants possibly/presumed extinct.

Family	Botanical name	Known range of occurrence
Acanthaceae	*Neuracanthus neesianus*	N. Arcot dist., Tamil Nadu
	Dicliptera abuensis	Rajasthan
Adiantaceae	*Adiantum soboliferum*	Assam, Nagaland, S. India: Myanmar& Malaya
Apiaceac	*Unium nothum*	Nilgiri hills; Sri Lanka.
	Carum villosum	Sandstone hills of Ramnagar
	Ligusticum albo-alatum	Netarhat plateau, Samripat, Sarguja, Ranchi, Bihar
	Pimpinella evoluta	Naga hills, Nagaland.
	P. pulneyensis	Kodaikanal sholas
Aquifoliaceae	*Ilex gardneriana*	Nilgiri hills.
Asclepiadaceae	*Ceropegia fantastica*	Sulgeri, N. Kanara dist., Karnataka
	C. arnottiana	Khasi hills in Meghalaya
	C. lucida	Khasi hills in Meghalaya; Cachar in Assam; Riyang river Sikkim.
	C. maculata (= *C. parviflora*)	Tamil Nadu Kerala, Sri Lanka
	Oilainthus deccanensis	Chatursringhi hills, Pune, Maharashtra.
Aspidaceae	*Lastreopsis wattii*	Manipur
Asteraceae	*Vernonia recurva*	Annamalai hills, Tamil Nadu.
Balsaminaceae	*Impatiens anaimudica*	Anaimudi slopes, Idukki dist., Kerala
	I. johnii	Kalar valley, Idukki dist, Kerala.
	I. macrocarpa.	Idukki dist., Kerala

policies and programmes for effective conservation of plant diversity. They help in identifying areas with rich phytodiversity for *ex situ* conservation. They provide the necessary baseline data on distribution, abundance and/or rarity, habitat types, ecology, etc. of palnt species.

In order to provide further knowledge to readers, some of the valuable informations about national and international herbaria are appended below (Table III-VI).

Fifteen countries, viz. U.S.A. (22.1%), France (7.4%), U.S.S.R. (6.6%), England, U.K. (5.7%), Sweden (4.5%), Federal Republic of Germany (4%), Switzerland (3.9%), People's Republic of China (3.7%), Italy (3.3%), Czechoslovakia (2.8%), Austria (2.7%), Japan (2.6%), Canada (2.5%), Australia (1.9%) and the Netherlands (1.7%) currently hold 75% of the total specimens in the world (Holmgren *et al.,* 1990).

India has 48 herbaria with total specimens of about 3,585,628. U.S.A. has largest number of herbaria 628, with a total numebr of specimens of 60,421, 964.

The five oldest herbaria in the world are following (Holmgren *et al.,* 1990).

Name	Acronym	No. of sheets (approx)	Year of founding
Naturkun de museum Kassel, Federal Republic of Germany	KASSEL	30,000	1569
Universitat di Bologna, Bologna, Italy	BOLO	1,30,000	1570
Universitat Basel, Basel, Switzerland	BAH	2,20,000	1588
University of Oxford, Oxford, England, U.K.	OXF	3,75,000	1621
Laboratoire de Phanerogamie, Museum National d'Histoire Naturelle, Paris, France	P	7,000,000	1635

Family	Botanical name	Known range of occurrence
	Vanda wightii	Nilgiris hills, Tamil Nadu
	Zeuxine pulchera	Sikkim
	Calanthe whiteana	Sikkim
Arecaceae	*Corypha taliera*	India
Poaceae	*Deyeuxia simlensis*	Simla, Himachal Pradesh
	Eragrostis rottleri	E. Coast of Tranquebar, S. India
	E. mauiensis	Tamil Nadu
	Eriochrysis rangacharii	Paikara in Nilgiri district, Tamil Nadu.
Rubiaceae	*Hedyotis hirsutissima*	Nilgiri dist., Tamil Nadu.
	Opercularia ocolytantha	Karnataka, Kerala
	Ophiorrhiza barnesii	Travancore, Kerala.
	O. brunonis	Hills of Kerala, Tamil Nadu and Karnataka
	O. caudata	Kerala
	O. pykarensis	Nilgiri hills
	O. radicans	Kerala; Sri Lanka
	Pavetta oblanceolata	Kerala
	P. wightii	Nilgiri hills, Coonoor, Tamil Nadu.
	Psychotria tylophora	Nicobar Islands.
	Wendlandia angustifolia	Courtallum and Tirunelvelli, Tamil Nadu
Sapotaceae	*Madhuca bourdillonii*	Quilon dist., Kerala
	Madhuca insignis	Mangalore, Karnataka.
Sterculiaceae	*Sterculia khasiana*	Khasi Hills, Meghalaya
Zingiberaceae	*Hedychium marginatum*	Nagaland.

Thus, the foregoing account amply highlights the role of Herbarium in conservation of plants. Herbarium specimens and the recorded field notes provide important informations and guidelines for formulating policies and programmes for effective conservation of plant diversity. They help in identifying areas with rich phytodiversity for *ex situ* conservation. They provide the necessary baseline data on distribution, abundance and/or rarity, habitat types, ecology, etc. of palnt species.

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Universitat Basel, Basel, Switzerland	BAH	2,20,000	1588
University of Oxford, Oxford, England, U.K.	OXF	3,75,000	1621
Laboratoire de Phanerogamie, Museum National d'Histoire Naturelle, Paris, France	P	7,000,000	1635

Table III
Herbaria of Botanical Survey of India

Name	Acronym	No. of sheets (approx)	Year of founding
Central National Herbarium, Horwah	CAL	15,00,000	1793
Eastern Circle, B.S.I., Shillong	ASSAM	2,25,000	1956
Western Circle, B.S.I., Pune	BSI	1,50,000	1880
Northern Circle B.S.I., Dehradun	BSD	1,01,750	1956
Southern Circle, B.S.I., Coimbatore	MH	2,33,000	1853
Central Circle, B.S.I., Allahabad	BSA	70,000	1962
Arid Zone Circle, B.S.I., Jodhpur	BSJO	17,300	1972
Sikkim Himalayan Circle, B.S.I., Gangtok	BSHC	10,000	1979
Arunachal Pradesh Circle, B.S.I., Itanagar	ARUN	10,000	1979
Andaman & Nicobar Circle, B.S.I., Port Blair	PBL	30,000	1972
Industrial Section, Indian Museum, BSI, Calcutta	BSIS	52675	1887

Table IV

Important Indian Herbaria (excluding B.S.I.)

Name	Acronym	No. of sheets (approx)	Year of founding
Forest Research Institute & College Herbarium, Dehradun	DD	3,30,000	1890
National Botanical Research Institute, Lucknow	LWG	1,20,000	1948
Central Drug Research Institute, Lucknow	CDRI	40,000	1951
Institute of Genetics and Tree Breeding, Coimbatore	FRC	36,382	1962
National Herbarium of Cultivated Plants, N.B.P.G.R., I.A.R.I., New Delhi	IARI	6,000	1983
Herbarium, Division of Mycology and Plant Pathology, I.A.R.I., New Delhi	HCIO	41,000	1905
Marine Algae Herbarium, Central Salt and Marine Chemicals Research Institute, Bhavnagar, Gujarat	BHAV	3,000	1961
Mycology and Plant Pathology Herbarium, Maharashtra Association for Cultivation of Science Research Institute, Pune	AMH	27,000	1968

Table V
Important University Herbaria in India

Name	Acronym	No. of sheets (approx)	Year of founding
Centre for Taxonomic Studies, St. Joseph's College, Bangalore	JCB	50,000	1964
Botany Department, Punjab University, Chandigarh	PAN	28,620	1947
Botany Department, Rajasthan University, Jaipur	RUBL	20,000	1963
Botany Department, Kolkatta University, Kolcutta	CUH	25,000	1921
Rapinat Herbarium, St. Joseph's College, Tiruchirapalli	RHT	87,000	1967
Botany Department, Presidency College, Madras	PCM	1,00,000	1901
Botany Department, Delhi University, Delhi	DUH	19,000	1947
Botany Department, Punjabi University, Patiala	PUN	40,000	1967
Botany Department, Kashmir University, Sringar	KASH	55,300	1972
Botany Department, Garhwal University, Srinagar, Uttaranchal	GUH	10,000	1978
Botany Department, St. Xavier's College, Bombay (Blatter Herbarium)	BLAT	2,00,000	1906
Botany Department, Lucknow University Lucknow	LWU	35,000	1925
Botany Department, Banaras Hindu University, Varanasi	BAN	25,000	1918

Table VI
Important Herbaria of the world (after Holmgren *et al.* 1990)

Name	Acronym	No. of sheets (approx)	Year of founding
Royal Botanic Gardens, Kew, U.K.	K	7,000,000	1841
V.L. Komorov Botanical Institute, Leningrad, U.S.S.R.	LE	5,770,000	1823
Museum National d'Historis Naturale Laboratoire de Phanerogamma Paris, France	P, PC	8,877,300	1635
Rijksherbarium, Leiden, Netherlands	L	3,000,000	1829
Conservatoire et Jardin Botaniques, Geneve, Switzerland	G	5,000,000	1824
U.S. National Herbarium, Washington, U.S.A.	US, USNC	4,368,000	1848
Swedish Museum Natural History, Stockholm, Sweden	S	5,600,000	1739
New York Botanical Garden, New York, U.S.A.	NY	5,300,000	1891
The Natural History Museum, London, U.K.	BM	5,200,000	1753
Botanical Museum, Upsala Univeristy, Sweden	UPS	2,500,000	1875
Botanical Museum, Lund, Sweden	LD	2,400,000	1770
Natural History Museum, Chicago, U.S.A.	F	2,415,000	1893
Royal Botanic Gardens, Edinburgh, U.K.	E	2,000,000	1839
Grey Herbarium, Cambridge, U.S.A.	GH	4,607,000	1864
Arnold Arboretum, Massachussetts, U.S.A.	A	1,230,000	1872

The countries with most of the oldest harbaria are Italy (12), France (7), England, U.K. (5) and Sweden (4) (Holmgren *et al.*, 1990).

The number of herbaria founded in different periods are as follows (Holmgren *et al.*, 1990).

Period (Year founded between)		Number of herbaria
1569	1599	3
1600	1699	3
1700	1749	4
1800	1809	10
1900	1909	87
1950	1959	217
1960	1969	306
1970	1979	229
1980	1988	80

The six biggest herbaria of the world are as follows (Holmgren *et al.*, 1990).

Name	Acronym	No. of sheets (approx)	Year of founding
Museum National d'Histoire Naturelle, Paris, France	P, PC	8,877,300	1635
Royal Botanic Gardens, Kew, U.K.	K	7,000,000	1841
Komorov Botanical Institute, Leningrad, U.S.S.R.	LE	5,770,000	1823
Swedish Museum of Natural History, Stockholm, Sweden	S	5,600,000	1739
New York Botanical Garden, New York, U.S.A.	NY	5,300,000	1891
The Natural History Museum, London U.K.	BM	5,200,000	1753

There are 2,852,695 "Types" in the different herbaria of the world, excluding Herbarium, Conservatoire et Jardin Botaniques de la Ville de Geneve, Switzerland (G), Herbier, Laboratoire de Cryptogamie, Museum National d'Histoire Naturelle, Paris, France (PC), Herbier, Institut de Botanique, Montpellier, France (MPU) and Herbier, Departement de Biologie Vegetale, Universite de Lyon, France (LY).

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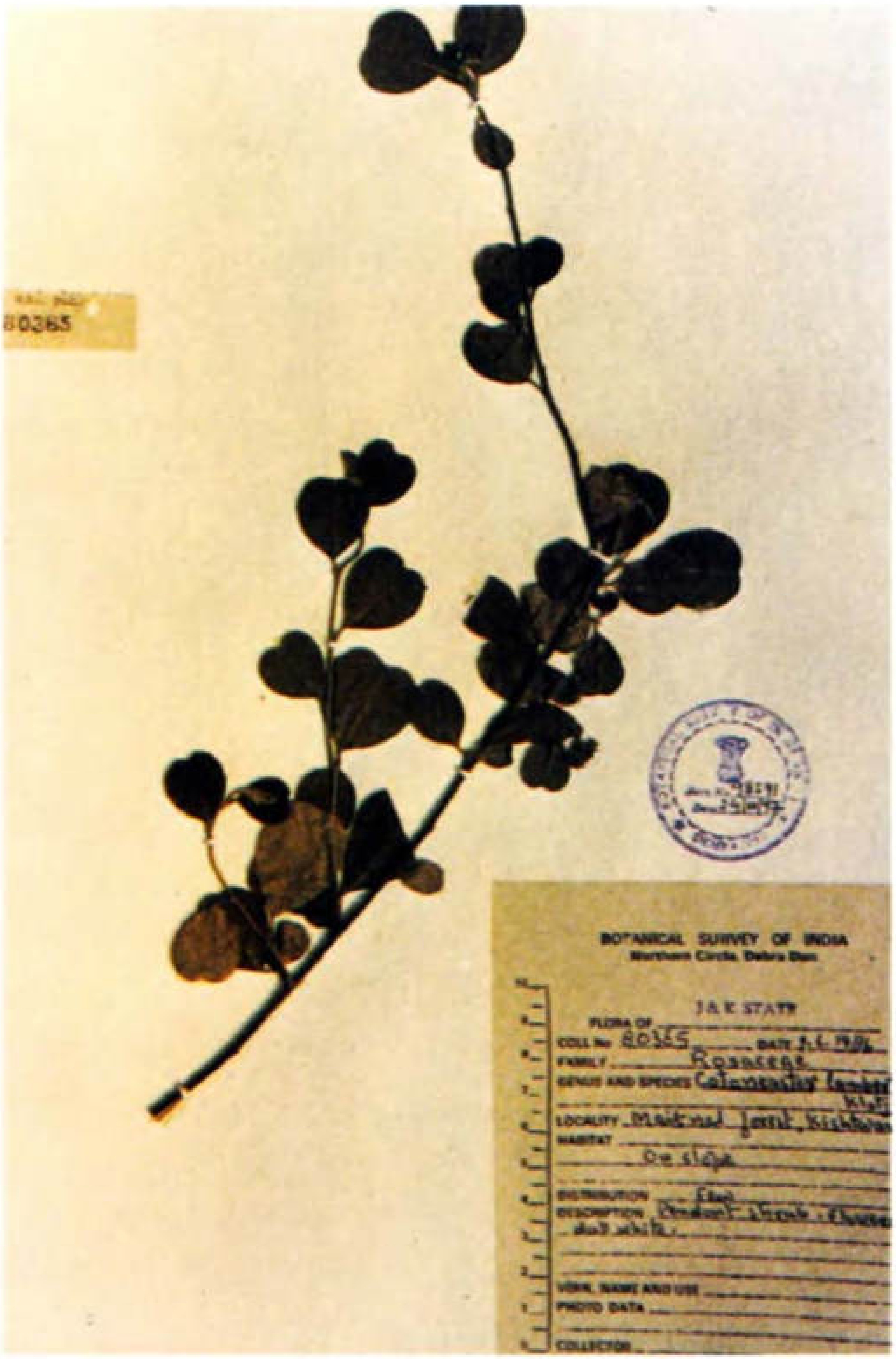
Herbarium of Botanical Survey of India at Dehradun.

View of herbarium of B.S.I. at Dehradun showing type and medicinal plant section.

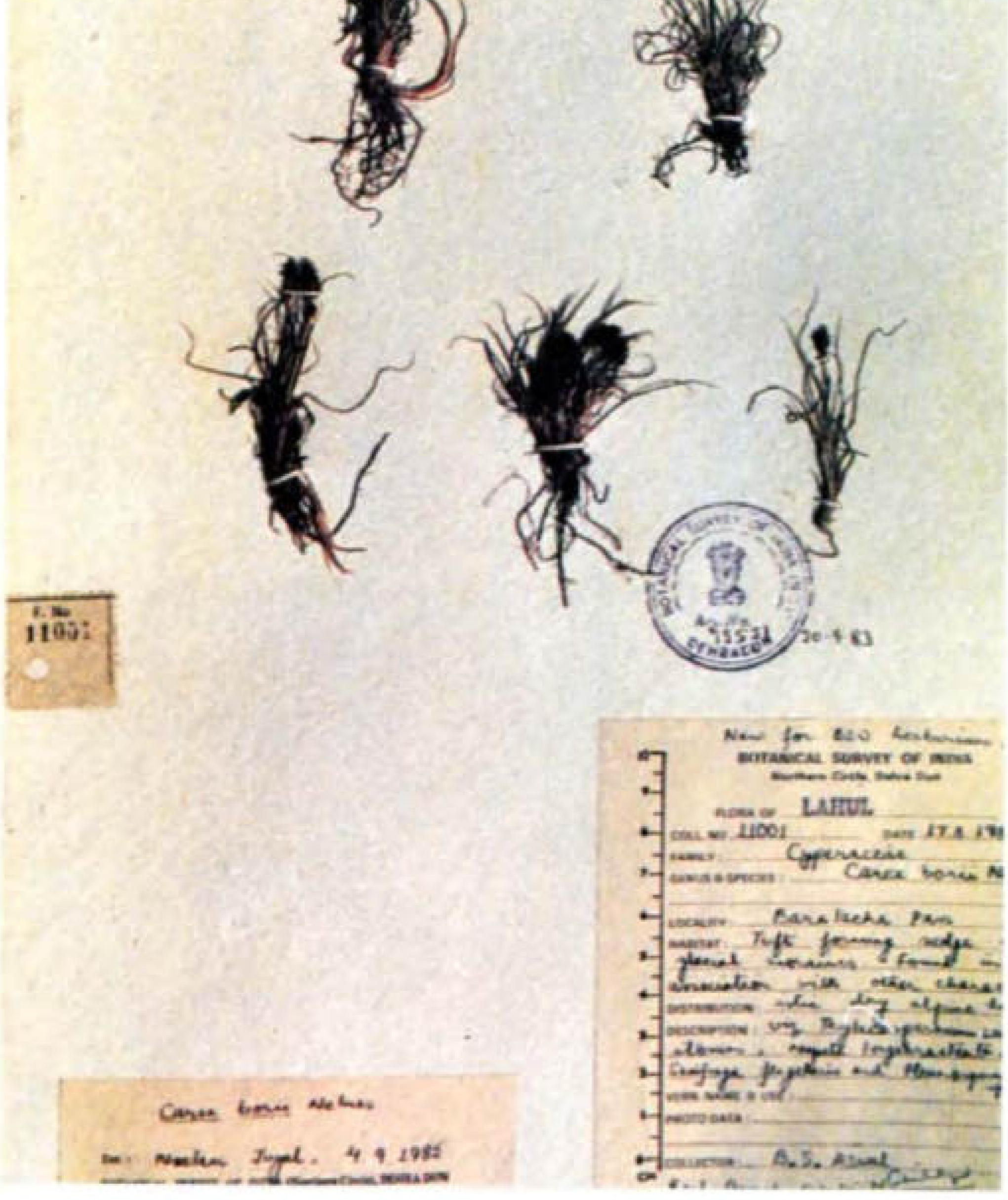
Isotype of *Lactuca lahulensis*

Trachycarpus takil **- collected more than 100 years after the type collection.**



Cotoneaster lambertii - collected after type collection.

Anemone narcissifolia **- an endemic species.**



Carex borii - an endemic species.

Waldhemia vestita **- a rare species.**

Oxytropis duthieana - a rare species.