EVOLUTIONARY, PHYSICAL, AND HISTORICAL CONTEXT OF INDIA'S BIODIVERSITY :

- 20-25 pages

1.1 Physical and Geographical Features

1.2 **Evolutionary and historical features of India's biodiversity** (including land/water use changes)

3.2.1 ***Geological evolution***

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3.3 Socio-economic features of India, relevant to biodiversity

3.3.1 ***Demographic features***

As the second most populous country in the world the majority of whose population continues to be directly dependent on bio-diverse natural resources for their livelihoods, India faces immense challenges in conserving its rich biodiversity while ensuring livelihood and ecological security.

The combined population of 28 states and 7 Union Territories of India on March 1, 2001 was 1027 million (102.7 crores). Although the decadal growth rate declined by 2.5 percent from 23.9 percent during 1981-91 to 21.3 percent during 1991-2001, the population of India increased by 181 million during the last decade. Further, there were wide variations in the population growth rates in different states. Whereas Andhra Pradesh recorded the sharpest decline of 10.3 percent in the decadal growth rate (from 24.2 percent during 1981-91 to 13.9 percent during 1991-2001), Kerala recorded the lowest growth rate of 9.4 percent followed by Tamil Nadu (11.2 percent). In contrast, Bihar's decadal growth rate increased from 23.4 percent to 28.4 percent. The overall population density of the country increased by 57 per sq. km. from 267 in 1991 to 324 per sq. km. in 2001 (Bose, 2001).

Although the overall sex ratio (females per thousand males) improved marginally from 927 in 1991 to 933 in 2001, the sex ratio of the child population in the 0 to 6 age group declined sharply from 945 in 1991 to 927 in 2001. This decline has been particularly sharp in Punjab, Haryana, Gujarat, Chandigarh and Delhi. In Punjab the child sex ratio declined by 82 points in just ten years from 875 to 793.

The demographically backward states (Bihar, Madhya Pradesh, Rajasthan and U.P.) were given the acronym of BIMARU states in the 1980s. In view of the alarming decline in (their) girl populations, Professor Ashish Bose has coined a new acronym – DEMARU (where D stands for daughters and 'MARU' stands for killing) states for Punjab, Haryana, Himachal Pradesh and Gujarat taking a decline by 50 points in the juvenile sex ratio as a statistical cut off point. (Bose, 2001).

3.3.2 ***Cultural/ethnic diversity***

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The most comprehensive documentation of India's cultural and ethnic diversity has been undertaken by the Anthropological Survey of India (ASI) through its series of publications collectively titled the Peoples of India. ASI's findings, based on data collected from 421 districts, are summarised below (as excerpted from Singh 1992 by Taneja, N.):

- The Indian nation consists of one of the most diverse people in the world. There are 4635 identifiable communities in the country, diverse in biological traits, dress, language, forms of worship, occupation, food habits and kinship patterns.

- Most Indian communities have a mixed ancestry, which includes the Proto-australoid, Paleo-mediterranean, Caucasian, Negroid and Mongoloid roots. The racial components that have gone into making the Indian peoples are the Aryan, Greek, Hun, Arab, Turk, African, Mongol, European. These have got so intertwined that none of them can be found in their pure form in India today.

- Genetic and morphological traits within some communities vary more than those between communities. Homogeneity is along the lines of region, not caste or religion. For example, Tamil Brahmins have little similarity of racial traits with Brahmins in the North - say, Kashmiri Pandits.

- There are few communities in India, which do not consider themselves as migrants or "outsiders". Every community recalls its migration in its folklore, history and collective memory. All accepted the regional ethos of the area in which they settled, and contributed to its local traditions.

- Language is an important source of diversity and unity. There are as many as 325 languages and 25 scripts in use, deriving from various linguistic families - the Indo-Aryan, Tibeto-Burman, Dravidian, Austro-Asiatic, Andamanese, Semitic, Indo-Iranian, Sino-Tibetan and Indo-European, apart from thousands of dialects. At least 65% of the communities are bi-lingual, most tribal communities are tri-lingual. The numerous mother tongues are important instruments of cultural expression and preservation of diversity. Language contact through biligualism is a major vehicle for social and cultural inter-action.

- The lives and livelihoods, occupations, dress, songs and settlement patterns of 85% of the different communities are rooted in local eco-systems, climate and occupations based on local natural resources. According to experts, "rootedness" in the eco-cultural zone is an outstanding characteristic of Indian communities, irrespective of their religious beliefs.

- Only 3% of the communities derive their names from religious sects, while 71.77% live within a single regional or linguistic boundary and are rooted in its ethos. Those in Kerala and Lakshadweep share a great number of traits, those in Kerala and Punjab do not.

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- 55% of the communities derive their names from the traditional occupations they pursue, for example, Bhuiyar (peasant), Alvan (salt maker), Churihar (bangle-maker), Lohar (blacksmith), Buna (weaver), Chitrakar (scroll-painter), and also gaddis, gujjars, julahas, dhobis, sapera, nai, etc. 14% have their names associated with their environment i.e. mountains, plains rivers etc. and another 14% to their places of origin, such as Gond, Alhuwalia, Kanpuria, Chamoli, Arandan, Shimong.

- Caste categories are also based on occupations, and cut across religion. Many surnames derive from occupations pursued, offices traditionally held, and original villages, cutting across community boundaries and region. Singh, Acharya, Patel, Naik, Prasad, Gupta, Sharma, Khan are examples.

- Popular cultural expression cuts across religion. 775 traits have been identified by experts - relating to ecology, settlement, identity, food habits, marriage patterns, social customs, social organisation, economy, occupation and impact of change and development, which reveal a sharing of cultural traits across religious categories. Clans bearing names of animals, plants or inanimate objects cut across religions, language and region.

- The cultural and ethnic traits of different communities are not static but have evolved and continue to change through interaction with their physical and social environment and with each other. (Taneja, N. based on Singh, K.S.,1992)

3.3.3 *Indigenous knowledge/ traditional knowledge*

According to one estimate, two thirds of the world's population could not survive without foods provided through indigenous knowledge of plants, animals, insects, microbes and farming systems (RAFI, 1994, quoted in MIDS, 2001). Up to 80 per cent of the world's population depends on traditional medicine for its primary health needs (WHO/IUCN/WWF, quoted in MIDS, 2001). In eleven States of India a half or more of surface irrigation comes from traditional sources (Sengupta, 1993, pp 14-16). For the poorest segments of the rural women and men of developing countries and for the indigenous people, traditional knowledge is indispensable for survival. (MIDS, 2001)

In certain commercial sectors too, traditional knowledge (TK) has considerable importance. For pharmaceuticals, the estimated market value of plant-based medicines sold in OECD countries in 1985 was US$ 43 billion (Principe,1989). Many of these were culled from TK. Of the 119 plant-based compounds used in medicine worldwide, 74 per cent had the same or related use as the medicinal plants from which they were derived (Farnsworth, Norman, 1988, pp. 83-97, quoted in MIDS, 2001). The interdisciplinary task force set up by GoI did an elaborate study of the USPTO's database for 90 medicinal plants reference, and found that 80 per cent of these references were on 7 medicinal plants of Indian origin. The Task Force also studied 762 patents in detail and was of the view that about 360 patents could be categorized as based on TK (GoI, 2001, quoted in MIDS, 2001).

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Due to being a country of mega biodiversity, India has also been bestowed with mega diversity of traditional/indigenous biodiversity knowledge. Over thousands of years, local women and men, be they shifting cultivators, hunter-gatherers, farmers, fishers, pastoralists, adivasis, healers or artisans, have accumulated a wealth of knowledge about local biodiversity through their day to day interactions with it. While deriving their subsistence and livelihoods from local biodiversity, people have nourished and protected it as a part of their spiritual and cultural heritage. TK and the spiritual value assigned to biodiversity is best reflected in the myriads of cultural and religious festivals of India's diverse communities. A significant aspect of Ganesh Pooja practiced from Kashmir to Kanyakumari, for example, is the requirement to offer the God 101 different kinds of leaves in Patra Pooja. The worshipper must not only find 101 different trees, plants and shrubs for these leaves but find them within a radius of one mile from his/her dwelling (Satheesh, 2000). Ensuring the conservation of such diversity requires being knowledgeable about it.

Similarly, a particular vegetable or leaf is a must for the countless festivals in the Deccan. This is a way of promoting knowledge about, and a continuous preservation of diversity through religious practices. Endlagatte Punnam in Telangana or Tene Habba in North Karnataka are festivals which celebrate biodiversity in agriculture. Banashankari Jatra near the famous Badami town is a fair around the celebrated temple of Banashankari, the Goddess of forest. For three days the entire town turns green with hundreds of varieties of leaves and flowers decorating the town and the temple (Satheesh, 2000).

The apocryphal story of Puri Jagannath that each day of the year, people made an offering of freshly harvested rice awakens one to a different understanding of agriculture. People had to have knowledge about, and ensure that there were enough varieties of rice on their lands such that at least some were ready for harvest on each day of the year ! Whether it was high summer, heavy monsoon or cold winter, there was a variety which matured and offered itself to the God ! (Satheesh, 2000)

Similarly there are 15 types of resource management practices that result in biodiversity conservation and contribute to landscape heterogeneity in arid ecosystems of Rajasthan. Environmental ethics of the Bisnoi community suggest compassion to wildlife, and forbid felling of *Prosopis cineraria* trees found in the region. Damage to crops by wildlife is tolerated. Indeed, people in a village contribute ~2500 kg of grains daily to feed migratory cranes during winters in the Thar desert. Bisnoi teachings proclaim: "If one has to lose one's head (life) for saving a tree, know that the bargain is inexpensive" (Pandey, 2001).

Despite modernization, the traditional ecological ethos continues to survive in many other local societies, although often in attenuated forms. Traditional resource use norms and associated cultural institutions prevailing in rural Bengal societies indicate that a large number of elements of local biodiversity, regardless of their use value, are still protected by local cultural practices. Some of these may not have any conservation effect, yet may symbolically reflect a collective appreciation of the intrinsic or existence value of life forms, and the love and respect for nature. Traditional conservation ethics are still capable of protecting much of the country's decimating biodiversity so long as local

September 17, 2001

To,

The Oriental Insurance Co.Ltd.
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Sub :- **Renewal & New Mediclaim Policy**

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Mr. Milind Wathare	- 1129
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Mrs. Gauri Patwardhan	- 1129
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	- 4516

And New Mediclaim Policy

Mr. Niraj Maid	- 1129
Ms. Kiran Patil	- 1129
Total	**- 2258**

Thanking you,

Yours faithfully,
For Integrated Decisions & Systems (India) Pvt. Ltd.

communities have even a minor share in the management of natural resources (Deb and Malhotra, 2001).

TK based local technology for harvesting rain water has produced 1.5 million village tanks, ponds and earthen embankments that harvest substantial rainwater in 660,000 villages in India (Pandey, 2001), and encourage growth of vegetation in the commons and agro ecosystems. If India were to simply build these tanks today it would take at least 131.25 billion euros—equivalent to the current cost of agri-environment agreements for 77 years in the European Union (Pandey, in press).

Even prior to the recently increased interest in traditional knowledge due to the CBD, TRIPS and the rapid development of biotechnology, the government of India has been promoting several programs that utilize traditional knowledge (Sengupta, 1995). For example, the Indian government had set up a whole department for promoting the Indian Systems of Medicine, constituted a Technology Mission on traditional cotton cultivation, adopted promotional measures for natural dyes etc. Out of all the Indian Systems of Medicine, for Ayurveda and Unani alone there are 250 hospitals, 15,000 dispensaries and 200 colleges with an annual turnover of 7500 graduates and 500 postgraduates (MIDS, 2001).

Outside of government, development activists had also initiated studies in TK with the main objective of redefining progress and development. The PPST had organised three Congresses of Traditional Science and Technologies in India, at the Indian institute of Technology, Mumbai in November-December, 1993, at the Anna University, Chennai in December 1995, and at the Gandhian Institute, Varanasi two years later. Apart from agricultural and biodiversity related matters, hundreds of papers, grouped under heads such as: architecture and building materials, bamboo, fisheries, food and nutrition, forestry, health care, metals and materials, navigational technologies, pottery, textiles, traditional industries, vermiculture, and water resources were presented at these congresses (MIDS, 2001).

In today's context TK is receiving increasing importance in many global fora. The Convention on Biological Diversity (CBD, 1992) was the first legally binding international instrument (Article 8(j) in particular) that explicitly refers to the protection of indigenous knowledge (IK). It requires that every Contracting Party should "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity and promote the wider application with the approval and involvement of the holder of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilisation of such knowledge, innovations and practices".

While the CBD approaches the issue of TK from the point of view of sustainability, TRIPS approaches it from the angle of trade. However, several national and global fora have drawn attention to the holistic nature of TK extending beyond the concerns of CBD or TRIPS. While trade concerns lead interest primarily to protection and benefit sharing

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with the TK holder indigenous and local people, developmental concerns lead to questions like recognition and use of modern avenues *by the* same people. Instead of specific aspects of IK being looked at in isolation, it needs to be recognised that IK is not just knowledge, but an integral part of diverse lifestyles and livelihood systems including the communities' access to and control over resources, use, cultures and property rights regimes (Kothari quoted in MIDS, 2001).

IK based practices are sustained through social mechanisms such as local institutions, leadership, regulatory rules and norms, and adaptations for the creation, transmission, and application of knowledge (Berkes et al., 2000; Pandey, 2001). Local knowledge systems have been found to contribute to sustainability in diverse fields such as natural resources, biodiversity conservation (Gadgil *et al.*, 1993), maintenance of ecosystems services and management of agroecosystems (Janzen, 1973 quoted in Pandey, D, 2001).

A major issue concerning traditional/indigenous knowledge is whether it requires validation by mainstream science before being granted legitimacy. While one school of thought considers this to be necessary, another school considers it to be falling in an incomparable domain. It needs to be kept in mind that de-legitimisation of traditional/indigenous knowledge began systematically during the colonial period in part to assert the superiority of western science as an instrument to promote colonial interests.

3.3.4 ***Economic profile (including occupational)***

According to the 1991 census, the overall work participation rate among the population (excluding J&K) was 37.46% with 51.55% of males and 22.25% of females recorded as being engaged in productive work. The distribution of main workers (working for at least 183 days a year) among the primary, secondary and tertiary sectors is given in the table below.

Percentage of Main Workers engaged in:			
	Persons	**Males**	**Females**
Primary Sector	67.5%	63.6%	81.2%
Secondary Sector	12.0%	13.1%	8.0%
Tertiary Sector	20.5%	23.3%	10.8%

Data Source: 1991 Census of India www.censusindia.net

According to the National Sample Survey (NSS) Organisation's survey in the year 1999-2000, the total employed workforce in both the organized and unorganised sectors of the economy was 397 million. Out of this, about 28 million were in the organised sector and the balance 369 million (93%) in the unorganised sector. A similar NSS survey in the year 1993-94 had shown the total employed workforce to be 335 million out of which around 27 million were in the organised sector and the balance 308 million (92%) in the unorganised sector. As evident from these estimates, there has been almost no increase in employment in the organised sector while the unorganised sector has expanded substantially over the 6 year period. (PC, 2001)

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Expectations that planned development will increase availability of secure employment in the organized sector have been belied by experience. The opening up of the economy under the programme of economic reforms has only exacerbated the problem with a clearly visible trend of contractualisation and casualisation of labour. The vast majority of the workforce remains in the unorganised sector and includes agricultural labour (there are 74.6 million landless agricultural labourers in the country), cultivators, small traders and hawkers, artisans and other self-employed persons (PC, 2001).

The livelihoods of the vast majority of the country's rural population primarily falling in the unorganized sector, are directly dependent on natural resources and elements of biodiversity in them. Biodiversity has multiple uses and users with potentially conflicting interests in them. Livelihood security for this segment of the population is critically linked to both ecological security and security of access and control over resources. Sustainable livelihoods require a sustainable resource base since land, water and biodiversity are the basis of rural livelihoods and the "means of production for the rural people" (Kocherry, 2001).

More than two-thirds of India's population is directly dependant on land for practicing a very wide diversity of agro and agro-pastoral livelihood systems for livelihood and food security. These include settled agriculture, shifting cultivation, a mix of the two, nomadic pastoralism, a combination of agriculture and pastoralism, etc. This percentage has remained almost unchanged in the last 80 years as employment generation in the secondary and tertiary sectors of the economy is unable to absorb even the additional urban labour force (Saxena, 2001). Yet, tenurial security over land for small and marginal farmers, particularly for farmers in so-called 'marginal' lands (mountains, marshlands, coasts, arid and semi-arid areas, etc.), and access to common lands for pastoral groups and shifting cultivators is declining rapidly with changing land policies in the context of globalization. Agricultural land ceiling laws are being amended to permit much larger land holdings by corporate farmers or companies and conversion of agricultural and common lands to non-agricultural uses for the benefit of industries is being made easier (Kothari, 2001(?)). There is large scale unofficial alienation of tribal lands and in many tribal areas, farmers lack legal titles to their cultivable lands despite cultivating it for generations due to the manner in which appropriation of the commons by the state took place (Saxena, 2001?; Das,V, EPW article; Sarin et al, 2002). All these factors are threatening agricultural livelihoods, agro-biodiversity and the indigenous knowledge systems which sustain them. (Kothari, 2001(?))

The oft-derided *jhum* or shifting cultivation systems incorporate maintenance of rich agro-biodiversity. Swidden farming by the Angamis in Nagaland, for example, involves the cultivation of 15 to 60 crop species, pest control through multi-cropping and spreading the availability of diverse foods (and the associated requirement of labour) over several months of the year. It has been called a 'female farming system' as sowing, manuring, weeding, seed selection and storage are all done by women while men do the tree cutting, clearing and burning of the jhum plot. (Raju & Sarin, 2001)

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The country's network of water bodies, intertwined with lakes, canals and rivers leading to the sea, also harbours rich biodiversity on which about 22 million fisher-people depend. About 12 million fisher people depend on marine fishing along India's 7000 km long coastline. Another 10 million derive their livelihoods from inland fishing in the country's 52 rivers, large number of wetlands and other water bodies. Fresh water culturing in family ponds has been a traditional practice in states like West Bengal and is now being promoted in other states. Another 5 million people depend on post harvest activities. 90% of them live in a subsistence economy. Fish is consumed by about 300 million people and is an essential component for their health and nutrition (Kocherry, 2001). Yet, be it aquatic conservation policies, or economic development for the global market, the livelihoods and priorities of these fisher people have tended to be overlooked. Mobilization of millions of fisherfolk by the National Fishworkers' Forum to protest against destructive commercial trawling and intensive aquaculture, has brought national attention to this neglected sector.

Poverty in rural India is generally considered to be linked with inadequate arable land or its low productivity. Collections from forests such as fuelwood and non-timber forest products (NTFPs) and their contribution to household subsistence and income in rural areas, especially for villagers living adjacent to forests, go largely unnoticed (Kumar et al, 2000). There are an estimated 100 million forest dwellers in the country living in and around forests and another 275 million for whom forests constitute an important source of livelihood (Bajaj, 2001). Gathering of fuelwood, fodder and NTFPs is an important subsistence and economic activity for poor women and about 60-70 percent of the gatherers are women (Gera, 2001)

Perhaps the most neglected livelihood groups in India are nomadic communities. Fully nomadic people move in seasonal cycles over a given territory, have no permanent dwellings and practice no agriculture. Semi-nomads have permanent dwellings and may engage in agriculture or other pursuits but migrate for a part of the year. India has both pastoral and non-pastoral nomads. (CSE, 1982, pp 118).

Over 200 castes are engaged in pastoral nomadism, numbering up to six per cent of the total Indian population. The pastoral nomads are animal herders and breeders who can be found in almost all parts of India, Kerala and the northeastern states being notable exceptions. India is unique in the world in terms of the diversity of animals associated with pastoral nomadism. There are examples of herders of camel (Rajasthan, Gujarat), donkeys (Maharashtra), yaks (Ladakh), pigs (Andhra Pradesh), sheep, goats, buffaloes, cows (in most parts of the country, especially in arid and semi-arid regions as well as in the western Himalayas), ducks (Southern India), etc. A few castes, especially shepherds, also engage in weaving. Their other products include milk, butter, ghee, eggs, meat, hides, manure, wool, etc. These nomads depend entirely on natural vegetation and not on planted pastures. (CSE, 1982, pp 118). Rights over the seasonal commons were regulated by customary law, and had evolved over centuries reflecting their inter-dependence with settled cultivators (Chakravarti-Kaul, 1996). Most of the pastoralists traditional pasture lands have been appropriated by the state either as state owned 'forests' or as revenue 'wastelands'. While the Forest Departments have often undertaken afforestation in such

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natural grasslands (Prosopis juliflora in Kutch, Pine, Acacia Catechu & Eucalyptus in HP and Uttaranchal), the Revenue Departments have allocated them for other development needs (for example irrigated agriculture with the Indira Gandhi canal in Rajasthan). Both types of interventions have not only seriously damaged their ecosystems and wildlife habitats (for example destruction of the habitat of the Great Indian Bustard due to tre plantations undertaken by the Forest Department – Dr A. Rahmani on TV) but also created a crisis of survival for the traditional livelihoods of the nomadic groups.

Hunters, trappers, fisher-folk, artisans, entertainers, dancers, singers, fortune-tellers, palmists and traditional doctors are some of the non-pastoral nomads. They comprise over 300 groups (in Maharashtra and Karnataka alone they number about 105 and 90 respectively) and constitute about one per cent of the total Indian population (CSE, 1982, pp 119).

3.3.5 *Current land use pattern*

India has a geographical area of 328.73 million hectares (m.ha). Due to land being an in-elastic resource, per capita availability of land in India is declining with the growth of population. It was 0.89ha/capita in 1950-51 which had declined to 0.33 ha/capita in 1999-2000 (PC, 2001a).

Land use and land management have undergone significant changes in the last 50 years although to date, no comprehensive land use policy taking ecosystems diversity and livelihood systems based on them has been developed. Changes in land use have been affected in accordance with changes in the government's development priorities during different periods. Thus in the initial post independence decades, the major priority was to bring more land under agriculture both for increasing food production and providing livelihood security to the landless through land distribution programmes. This period saw significant clearance of both forests and revenue wastelands for conversion to agriculture, resulting in major destruction of wild life habitats and biodiversity. From the early 1980, concern over forest destruction led to a reversal of priorities with the 1988 forest policy requiring that 33 percent of the country's total area should be brought under forest cover. While apparently concerned with environmental conservation, no detailed studies have been undertaken to justify the desirable area under forest cover, which land uses will be replaced through conversion to 'forests' and how ecosystem integrity and biodiversity conservation shall be integrated in the process. The emphasis continues to be on equating tree plantations with 'forest' cover, often leading to land use changes from natural pastures and grazing lands to locally less useful tree plantations.

At present, changes in land use are not recorded in a timely manner due to delays in verification and sanctioning of the changes. Consequently, there are significant discrepancies in the recorded versus actual land uses. (Iyengar, 2001). Obtaining an accurate picture of the current land use pattern is also difficult due to the nature, quality and reliability of data available from different sources.

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According to the nine-fold land classification, out of 304 million hectares of land in India for which records are available, roughly 40 million hectares are considered totally unfit for vegetation. This is either urban and under other non-agricultural uses such as roads and rivers, or is under permanent snow, rocks and deserts. The break-up of the remaining 264 million hectares of land fit for vegetation is as follows (Saxena, 2001):

	Million Hectares
Cultivated land[1]	142
Forest land	67
Fallows/culturable wastes/pastures/groves	55
Total area of culturable lands	264

Whereas the actual cultivated land in the above table may reflect actual use on the ground fairly closely, this is not necessarily the case with the other two major categories. Considerable amounts of legally designated 'forest lands', for example, are either under shifting or settled cultivation or are actually natural grasslands or alpine pastures which have legally been designated as state owned forests (INSERT KULU's STATISTICS). The third category of Fallows/culturable wastes, etc. is even more problematic as it is well known that large areas of government owned wastes are either under cultivation or other uses through encroachment or common pasture lands.

At the all India level, total uncultivable land inclusive of all categories constituted 44% in 1994-96. Of that 14% was barren and uncultivable, about 21% was forest and 9% pastures and cultivable waste. These records originate in the land use statistics generated by the agriculture department. Unfortunately, land use statistics and the records created from the remote sensing exercise are not tallied. (Iyengar, 2001)

Overlapping with the above categorization of land use are highly variable estimates of the extent of land considered 'waste' or degraded. The problem starts with the definition of wastelands. Three different definitions are used. One based on land productivity, second on ecological characteristics, and the third on both. None of the categories refer to their existing uses or the biodiversity they support.

According to estimates of the Ministry of Agriculture, 175 mha of the country's land area are wastelands. These include private lands under rainfed paddy cultivation considered prone to soil and wind erosion. As this estimate suffered from overlapping wasteland categories, in 1984, SPWD published the first comprehensive estimate of the different categories of wastelands outside forest areas. This figure came to a total of 93.69 mha. The SPWD classification was based on soil types and on ecological qualities such as salinity, alkalinity, water erosion, wind erosion, water-logging and so on instead of the productivity linked classification of the Ministry of Agriculture. Instead of economic criteria, SPWD's focus was on ecological instability, loss of topsoil and toxicity in the root zones. (Eswaran, 2001)

[1] Out of the net sown area of 142.82 m.ha., 87.68 m.ha. is rainfed. (MOA quoted in PC, 2001a).

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OFFICE SUPPLIES - SOFTWARE DEVELOPMENT	**38.00**
SOFTWARE DEVELOPMENT 38.00 Dr	
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BEING CASH PAID TO HOUSE OF FORMS FOR PURCHASE OF PF FORM 5/10, 12A, FORM 16 & FORM 10C REF C.M.NO.8699 /18.7.2001	
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To address the problem of different agencies using different definitions of wasteland, the Technical Group of the National Wasteland Development Board (NWDB) in its report of 1986 provided the following definition: 'Wastelands mean degraded lands which can be brought under vegetative cover with reasonable effort and which is currently lying as under-utilized, and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes.' This still does not refer to ecosystem integrity or natural biodiversity.

The March 2000 *Wastelands Atlas of India* prepared by the National Remote Sensing Agency for the Department of Land Resources defines wasteland as: 'Degraded land which can be brought under vegetative cover with reasonable effort, and which is currently under-utilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes. Wastelands can result from inherent/imposed disabilities such as by location, environment, chemical and physical properties of the soil or financial or management constraints.'

Within this broad definition the Atlas lists 13 categories of wastelands: gullied land and ravines; land with or without scrub, waterlogged and marshy land; land affected by salinity/alkalinity-coastal/inland; shifting cultivation area; underutilized degraded notified forest land; degraded pastures/grazing land; degraded land under plantation crop; sands – inland/coastal; mining/industrial wastelands; barren rocky/stony waste/sheet rock area; steep sloping area; snow covered and/or glacial area.

The Atlas shows about 63.85 mha of total wasteland area (including 14.06 mha of degraded notified forest lands), i.e., 20% of the geographical area covered in the exercise, excluding 12 mha of J&K. (Eswaran, 2001)

The 1995 report of the high level committee on wastelands development (the Mohan Dharia Committee) analysed the land use statistics available for 305 million ha out of the 329 mha land area of the country, and noted that there was much confusion regarding the extent of wastelands. In the committee's view confusion arose from differing definitions of wastelands used by various agencies; also because these agencies failed to distinguish between lands which had gone out of productive use because of extreme degradation and lands which were still in use although these too were degraded to some extent. The latter it preferred to describe as 'degraded lands'.

A major problem with all the above land use and land quality classifications is that none of them indicate the number of people dependent on these supposed waste lands, how their livelihoods are supported by them and whether the land is considered degraded or 'waste' even by them. Neither is there any clear information about the ecosystems in which these lands fall, the biodiversity and habitats they harbour or the specific causes leading to their degradation.

Due to relative inelasticity in the use of cultivated and forest lands, major interventions for changing land use during recent decades have been targeted at both government and privately owned wastelands. There have been two main policies for government owned

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MEALS & ENTERTAINMENT-SOFTWARE	**130.00**
SOFTWARE DEVELOPMENT 130.00 Dr	
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SUPPORT 76.00 Dr	
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BEING CASH PAID TO HANUMAN PROVISION STORES FOR PURCHASE OF SANCKS FOR TEA TIME FOR ALL SNACKS FOR SUPPORT MEETING AND PURCHASE OF LIQUID, VIM BAR, BULB FOR OFFICE	
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wastelands - the land distribution policy of the 1970s and the social forestry policy of the 1980s (Saxena, 2001).

Some 6 mha of wastelands under various programmes have been allotted to the poor over the last 20 years. Thus, substantial culturable waste land has been privatized as a conscious policy outcome, although such lands may still be lying uncultivated.(Saxena, 2001)

During its initial years, the NWDB's major reclamation strategy was tree plantation, a legacy from the 'social forestry' years following the 1976 Report of the National Commission on Agriculture. Possibly because of 'social forestry', wastelands development and the NWDB were placed in the Ministry of Environment and Forests (MoEF), and the states followed suit. (Saxena, 2001). There was no attempt to evoke the interest and participation of local communities when social forestry was taken up on common lands or to understand the role of existing land uses or local biodiversity in supporting the existing diversity of livelihood systems.

Most government interventions have been technocratic, largely on the assumption that its agencies were writing on a clean slate, ignoring how the land and water were already being used, by whom and for what purposes.

In villages with intensive irrigated cultivation, common lands have become of marginal importance for supporting livelihoods. In states like Punjab and Haryana, most common lands have been brought under cultivation (both through encroachment or an outcome of official policy) or converted to other land uses. (INSERT FIGURE FROM HARYANA BSAP)

For the landless and small and marginal farmers, however, specially in the semi-arid and arid regions of the country, the official wastelands are common lands which continue to be the source of diverse biomass products such as fuel, fodder, fibre, medicines and a variety of non-timber forest products for subsistence and income besides providing important ecosystem services. N.S. Jodha's seminal studies have highlighted the reduced availability of biomass from common lands to the poor over the decades due to their reduction and degradation (Eswaran, 2001). The critical role of common lands and their natural biodiversity in supporting local livelihoods needs to be taken into account while planning and implementing so called wasteland reclamation.

There are no definitive official estimates of common property resources (CPR) in India (Eswaran, 2001). Rights to CPRs may be based on private land ownership or customary usage or both. There is also a need to analyse the link between degradation of common lands and the erosion of community institutions which earlier managed them.

Research in the economic history of land management in India has indicated that at the time of Independence, the de facto administration of uncultivated public land lay with the village and/or community panchayats and the state administration barely interfered (Iyengar, 2001).

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After Independence and the merger of princely states, the revenue departments in all states took over these common lands, relegating the panchayat and community institutions to the background (Iyengar, 2001). This centralization of control over management converted most of these lands into open access, leading to further degradation of the uncultivated commons. (This should probably be moved to Ch V).

There is a clear need for developing a sound land use policy based on a reliable database on land use that can be easily updated. The system of collection and collation of data also needs to be reviewed as at present there is no way to access inter-category transfer of land in the current land use data collection. (Iyengar, 2001). More importantly, land use data needs to incorporate data about the existing users of the land, particularly of de facto common lands and the customary or legal rights to them as well as local biodiversity.

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BEING CASH PAID TO SONY COMMUNICATION VIDE BILL NO. 197 FOR REPAIRING SUPPORT MOBILE 98230 - 76982 FOR CHANGING NETWORK IC	
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No. : **CPPP/684** Dated : **17-Jul-2001**

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MEALS & ENTERTAINMENT-SUPPORT	**950.00**
SAMEER AMBHORE **950.00 Dr**	
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3. EVOLUTIONARY, PHYSICAL, AND HISTORICAL CONTEXT OF INDIA'S BIODIVERSITY:

3.1 Physical and geographical features

3.1.1 *Introduction*

India is the seventh largest country in the world with an area of 32,87,263 sq.km extending from 8° 4' to 37° 6' N and 68° 7' to 97° 25' E. The country extends for 3,214 km on the north to south axis and for 2,933 km east to west. It has a land frontier of 15,200 km and coastline including that of the islands amounting to 7516 km (Grover & Arora, 1996, Government of India, 2001). The country lies completely in the northern hemisphere and the Tropic of Cancer more or less divides the country into two equal halves. Even though parts of the country lie in what can be described as temperate latitudes, India is normally referred to as a Tropical country.

The physical features of a country greatly influence its climate and hence the natural vegetation. The physical features in conjunction with the natural vegetation form the habitat for wild biodiversity. India has a great variety of habitats largely due to its location and varied physical features and this results in its rich and varied biodiversity.

3.1.2 *Geological divisions of India* Note: Sections 3.1.2 to 3.1.5 have been written based on material presented by Wadia, 1983 and M.S. Mani 1974.

India is composed of three distinct units or earth features, which differ in their physical and geological characters. They are: a. The Peninsula, the Deccan plateau south of the Vindhyas. b. The Himalaya mountains also referred to as the Extra-Peninsula, which borders India to the north and east. c. The Indo-Gangetic Plains, which lies between the two former divisions and extends from the Indus valley in the west to the Brahmaputra valley in the east.

3.1.2.1 THE PENINSULA

The Peninsula varies a great deal from the other two divisions on a number of characters. The first is stratigraphic (connected with the geological history); since the dawn of geological history (Cambrian Period), the Peninsula has been a land area and has never been submerged by a sea, except locally and temporarily. The second difference is geotectonic (pertaining to the geological structure); the Peninsula is a segment of the earth's outer shell and is composed of ancient rock-beds that stand upon a firm and immovable foundation. This structure has remained unaltered for a very long period of time. Fracturing of the crust into blocks and their radial or vertical movements is the only significant structural disturbance experienced by the Peninsula. The third difference is the physiography (external or surface relief). The mountains in the Peninsula are mostly of the "relict" type. They are not mountains in the true sense of the term but portions of the old plateau that have experienced the weathering that has cut all the surrounding land. The rivers flowing through the Peninsula have flat, shallow valleys with a very low gradient. Much of the Peninsula is constituted by the Deccan plateau, extending from 12° to 21° N with a mean elevation of about 600 m. The plateau is highest in the south and west and slopes eastwards. Large areas in the south exceed 600 m in elevation and some even 900 m. The plateau is flanked by a narrow coastal strip on the west and by a much broader coastal region in the east.

The important mountain ranges of the Peninsula are the Aravallis, the Vindhyas, the Satpuras, the Western Ghats and the Eastern Ghats. Of these only the Aravallis are a true tectonic mountain range. These mountains were a prominent feature in the old Palaeozoic and Mesozoic

geography of India and had a much more extensive presence than the eroded remnants that are present today. They are one of the oldest mountain systems in the world. Mt. Abu at 1,721 m is the highest elevation in this range. They run southwest to northeast for 700 km from Gujarat to Delhi. The Vindhyan mountains and their eastern continuation, the Kaimur range are situated along the southern edge of the Central Indian highlands and range in elevation between 760 to 1,220 m. Horizontally bedded ancient sedimentary rocks are the major constituents of this range. The Satpura mountains run parallel and south of the Vindhyas. The Satpuras are located south of the Narmada valley and north of the Tapti valley and they stretch from Gaya and Rewa to Rajpipla hills in the west in Gujarat. Basalts and metamorphic rocks are the major constituents of this range. The Western Ghats are nearly a continuous and unbroken mountain range running from the extreme south of the sub-continent, northwards for about 1,600 km and parallel to the west coast. The Palghat Gap is the only major break in this range occurring north of the Anamalais and south of the Nilgiris. The mean elevation of this range is 900 m. The highest peak in the Peninsula, Anaimudi, rises to an elevation of 2,965 m. South of the Palghat Gap the range is composed of ancient and massive crystalline rocks while north of the Gap horizontally bedded lavas constitute the range. The Eastern Ghats are a broken and discontinuous set of hills extending roughly parallel to the east coast from northern Orissa to Tamil Nadu and then westwards where they fuse with the Western Ghats in the Nilgiris. The average elevation is around 600 m. These hills are ancient and very varying in their geological composition.

3.1.2.2 THE HIMALAYA

The Himalaya are true mountains or "tectonic" mountains. They originated due to the powerful lateral thrusts acting from the north (Tibetan region) towards the Peninsula, which resulted in a distinct uplift in the earth's crust. These mountains are a weak and flexible portion of the earth's surface and have undergone a lot of deformation. Numerous evidences of movement of the earth like rock-folds, faults and thrust-planes are present here. This is indicative of the enormous amount of compression and upheaval that this region has undergone in its fairly recent geological history.

The Himalaya was submerged by seas for the greater part of its history. It is covered by marine deposits characteristic of the geological periods, commencing with the Cambrian. The rivers in this region are rapid and torrential streams in an immature stage of river development. They are actively eroding their courses and have cut numerous deep gorges.

The Himalaya are not a single continuous range of mountains, but a series of more or less parallel ranges, intersected by enormous valleys and extensive plateaus. The overall width of these mountains varies from 160 to 400 km while it is about 2,500 km long. The individual ranges generally present a steep slope towards the plains and a more gently inclined slope away from the plains. The northern slopes support dense natural vegetation with snow-covered peaks in the higher elevations. The southern slopes being very steep accumulate very little snow and support sparse natural vegetation.

The Himalaya has an enormous influence on the meteorology of the Indian sub-continent. It affects both the air and water circulation patterns. Its snow-covered peaks have a moderating influence on the temperature and humidity of northern India. The Himalaya is a tall and continuous wall obstructing the flow of the moisture-bearing monsoon winds and this causes the precipitation of much of this moisture either as rain or snow. The numerous Himalayan glaciers are fed by this snowfall form the source of numerous rivers, which lower down also gather much of the monsoon rainfall.

The Himalaya is classified into three parallel zones:

a. The Great or Inner Himalaya, is the northern most of the ranges with an average elevation of 6,100 m and much of its upper reaches are under perpetual snow.
b. The Lesser or Middle Himalaya, lies in the middle and is lower in elevation (ranging from 3,600 to 4,600 m) with an average width of 80 km. The ridges of these ranges run in irregular directions and branch repeatedly
c. The Outer Himalya or Siwalik ranges, lie between the Plains and the Lesser Himalaya. They are a series of low hills with an average elevation of 900 to 1,500 m and range in width from 8 to 50 km. They are composed of narrow parallel ridges running northwest to southeast, separated by broad valleys called the "dun". They are of more recent origin than the rest of the Himalaya.

Both the Inner and Middle Himalaya are mostly composed of crystalline and metamorphic rocks with unfossiliferous sedimentary Purana and Mesozoic deposits. The Siwaliks are composed almost entirely of Tertiary and Upper Tertiary sedimentary river deposits. The Trans-Himalaya lies north of the main range and includes Zanskar and Ladakh ranges. The extensive plateau lying north of the Great Himalaya (Tibetan Zone) is composed of a series of highly fossiliferous marine sedimentary rocks, ranging in age from the earliest Palaeozoic to the Eocene age. Parts of the Ladakh region are composed of Tertiary rocks and deposits of Mesozoic sedimentary rocks.

Geographically, the Himalaya is divided into a) the Eastern or the Assam Himalaya, which is about 720 km long and lies between the Namcha Barva peak and the river Teesta in the west; b) the Central or the Nepal Himalaya, is about 900 km long and lies between river Teesta and river Kali in the west; c) The Kumaon or Western Himalaya, extends for about 320 km between river Kali and river Sutlej; and d) the Northwest or the Punjab Himalaya, lies west of river Sutlej and extends for 560 km.

3.1.2.3 THE INDO-GANGETIC PLAINS

The Plains are the alluvial deposits of the rivers of the Indo-Ganges system. These have been eroded from the Himalaya and deposited at its foothills. The silt covers a deep deposit of river-clays. These plains were originally a deep depression lying between the Peninsula and the Himalaya. The Plains are 250 to 450 km wide and extends for more than 3,000 km from the Arabian Sea to the Bay of Bengal. The Plains are very flat with a gentle seaward slope. The depth of the alluvium is estimated to be 1980 m and the alluvial filling is of unequal thickness.

The Plains are topographically homogenous for hundreds of square kilometers but for the ravines formed by gully erosion along river courses like that of the Chambal. Along the outer slopes of the Siwaliks, a steep gravel slope called the *bhabar* is often found. In this porous tract the surface waters of most of the rivers tends to disappear. These waters then seep out in the marshy *terai* areas further south.

3.1.2.4 THE RAJASTHAN AREA

The flat lands west of the Aravallis have a mixture of geological characters of the Peninsula and the Himalaya. The geo-tectonics of this area shows no post-Cambrian folding, which is typical for the Peninsula but it contains fossil deposits of marine organisms belonging to the Mesozoic and Cainozoic eras, which is typical of the Himalaya. This is the only part of the Peninsula, which has been submerged repeatedly by the sea. Prolonged and continued aridity has resulted in desert topography. A thick mantle of sands derived both from weathering of rocks as

well as blown in by the winds from the west cover this region. This is the Thar, a semi-desert area. This is essentially a pene-plain, covered by sand from which project sandstone inliers and bare hills of granites.

3.1.3 *Rivers and river valleys*

Rivers are the main channels of drainage and the chief agent of land erosion. Due to the differing topography, the river systems of the Peninsula and the Himalaya are very different. In the Peninsula the river systems are very ancient and their channels have approached the last stage of river development, namely base-levelling. The valleys are broad and shallow with a very low gradient. Water flowing through these valleys have very little momentum but for during the floods. During the non-flood season these rivers are precipitating their silt in parts of their basins, estuarine flats and similar areas and the stream flow is slow, shallow and meandering. The major Peninsular rivers have a pronounced east-flowing drainage system. The Western Ghats forms the main watershed for these rivers, for example Cauvery, Krishna and Godavari. The Peninsular rivers are entirely fed by the monsoon rains and are very seasonal in their flow and normally very to completely dry during the summer. The Peninsular rivers are often divided into two groups, a) the coastal rivers, are relatively small streams and number more than six hundred from Saurashtra to Cape Comorin. The drain the western side of the Western Ghats and flow across the narrow plains before flowing into the Arabian Sea; b) the inland rivers, include the west-flowing Narmada and Tapti and the east-flowing Mahanadi, Godavari, Krishna and Cauvery. The west-flowing inland rivers flow between mountain ridges, so that their catchments are narrow and elongated and they do not form deltas. In contrast the east-flowing inland rivers have a wide catchment area and also extensive deltas.

The drainage system in the Himalaya is of much more recent development. The rivers are still actively eroding and transporting materials and at the same time also depositing these materials as they flow through the plains to the seas. These rivers have contributed to the development of the vast Indo-Gangetic plains by the deposition of silt eroded from the mountains. There is evidence to suggest that many of these rivers are of greater antiquity than the Himalaya. During the upliftment of the Himalaya these rivers more or less stuck to their original channels but their flow-rate was accelerated due to the gradient. These rivers are not dependent on the monsoon rain but are fed by the melting snow of the Himalaya. The volume of water flowing through these rivers tends to fluctuate seasonally but they never dry up completely.

Several of the Himalayan rivers (Indus, Sutlej, Bhagirathi, Alaknanda, Kali, Gandak) drain the southern slopes of these mountains and also the northern Tibetan slopes. The watershed of these rivers lies a great distance north of the highest peaks of the Himalaya. Much of the initial drainage is in longitudinal valleys running parallel to the mountains and then these rivers take an acute bend and descend to the plains by cutting across the mountains. Most of these result in very deep gorges ranging in depth from 1,800 to 3,700 m.

3.1.4 *Lakes*

Lakes play only a very limited role in the drainage of India. The bigger lakes are found in Sikkim (Yamdok Cho and Chamtodong) and a few in Kashmir and Ladakh (Wular, Dal, Pangkong and Tsomoriri). Nainital, Bhimtal and similar small lakes are found in Kumaon Himalaya.

The lakes of northern Kashmir and Ladakh are undergoing a period of marked desiccation. There are distinct terraces, which are indicative of the retreating waters. This is due to the decreasing inflow of water to these lakes and also the increasing aridity of the entire region, caused in no small measure by the cutting off of the monsoon winds by the high Himalaya mountains. Waters of many of these lakes are also showing an increase in their salinity. This is due to the decreasing volume of water in these lakes and the lack of any outlet for drainage. All the salts brought in by the rivers are getting concentrated in these waters. These lakes show a fairly large range in their salinity.

The Peninsula has few small fresh water lakes. Rajasthan has four or five salt water lakes of which the Sambhar lake is most well known (the others include Didwana, Phalodi and Pachbadra). During the monsoon when it is full, it has an area of 233 sq.km with a depth of 1.2 m. For the rest of the year it is largely dry and the surface is encrusted with white saline silt.

The Chilka Lake located on the east coast in the state of Orissa, varies in area from 900 to 1,200 sq.km and its water varies widely in its salinity depending on the season. It is only a few metres deep in most of its spread. The lake is cut off from the sea by a long spit of sand which occasionally opens up.

3.1.5 *Coasts*

The coasts of India are comparatively regular and uniform with only a few inlets and creeks of any significant size. A part of the west coast (Malabar region) has a number of lakes, lagoons and backwaters. These shallow lagoons are inlets of the sea and lie parallel to the coastline. At some places along the coast, extensive mangrove swamps are found especially along tidal estuaries, salt marshes or river deltas. The western littoral region is remarkable for the relatively low number of rivers draining through it and that too small ones for the most. This is despite the favourable conditions that prevail for the formation of rivers. The coastal lands along the west coast are relatively narrow, as they are flanked by the Western Ghats for most of its length. At most places the mountains are only 40 to 55 km away from the Arabian Sea. The eastern littoral region is very different from the west. The lowland is much wider and and much of it is true coastal plain in its structure. In places it is formed of the deltas of major rivers like Mahanadi, Godavari, Krishna and Cauvery. The coastal lowlands are 100 to 130 km wide. The entire sea-board is surrounded by a narrow submarine ledge where is the sea is shallow (the continental shelf). This shelf is broader in the west when compared with the east coast. From these shelves the sea suddenly deepens out into the open seas.

3.2 **Evolutionary and historical features of India's biodiversity**

3.2.1 *Geological evolution* Note: This entire section is written based on Krishnan 1974.

3.2.1.1 THE PENINSULA

The ancient block of the Peninsula is composed of highly metamorphosed rocks, like gneisses and schists of the Archaen System. This ancient crystalline complex occupies much of the Peninsula and particularly the central and southern portions. The Peninsula has been a stable landmass since very ancient times, at least the Pre-Cambrian. At a later period, it was part of the Gondwana Continent. The Deccan area has remained a continental mass right through from that ancient time. During Jurassic times, marine conditions prevailed over large parts of present day Rajasthan and coastal areas of present day Tamil Nadu. Fossils bear witness to this. During Cretaceous times, basaltic lavas covered extensive areas of what is currently known as the

Deccan. The lava flow is currently estimated to cover 520,000 sq.km and can be recognized by the characteristic flat-topped hills.

The earliest changes, after the deposition of the earlier Peninsular sedimentaries, seem to be the folding of the Aravallis during the earlier Vindhyan Period. This was followed by the peneplanation of the Aravallis and a rejuvenation at the beginning of the Gondwana times. In the west, Kathiawar (Saurashtra) is largely Deccan lavas, with some marine Jurassic and Tertiary fringe, particularly in Kachchh. These two areas form a small dissected plateau and scarpland, linked to the Peninsula by alluvial plain of Gujarat, the subsidence of which has formed the salt-marshes and large mudflats of the Rann.

The Palghat Gap is the only really easy passage across the Western Ghats. It probably is tectonic in origin. The summit of the Gap is a broad tableland with an elevation of about 300 m. The Eastern Ghats on the other hand has numerous and much more pronounced discontinuities, some of which is about 160 km wide. In the north there are some dissected massifs of the older Peninsular rocks. Remnant portions of ancient mountains constitute the middle region (Nallamalai, Velikonda and Palkonda). The Shevroys and the Pachaimalai Hills form the southern portion.

The Deccan Lavas seem to have erupted from numerous fissures in the crust, during a period of tension. The lavas appear to be of the uppermost Cretaceous to the Lower Eocene in Kachchh, Kathiawar and Gujarat. The lava in most areas is of Eocene age. The Deccan Lavas erupted and spread over an uneven pre-existing land surface that was already in an advanced stage of maturity and their base is now found at various levels, both above and below the sea level. The lava has suffered gentle warping in certain places but they are mostly horizontal.

The coastal plains of the east are typical upland plains of marine erosion. The general lithology and the stratigraphy of the marine deposits on the east coast seem to indicate that since the latter part of the Palaeozoic Era, the general run of the coastline has never been very far from its present position.

3.2.1.2 THE HIMALAYA

The rise of the Himalaya mountains (also referred to as the extra-peninsula) to the north, west and east is the result of the intense squeezing out of the Tethyan geosyncline between Laurasia, advancing from the north, and the Indian Peninsular (Gondwana) Block from the south. The opposing land masses squeezed out the soft contents of the Tethyan geosyncline into the east-west Himalaya. Laurasia overrode the Peninsular Block and the latter also dived under Laurasia and led to the elevation of the Tibetan Plateau.

During the middle of the Tertiary times, the areas that are now Tibet and the Himalaya were covered by an extension of the Tethys Sea, in which deposition of immense sediments had continued for a long period of time. The Tethys Sea separated Eurasia from the southern Gondwana landmass. During this time but for the Aravallis no other high mountains existed in the Indian landmass. The sedimentation, accumulated from the Palaeozoic Era attained an enormous thickness of about 15,200 m and was accompanied by slow sinking of the sea bed. During a period of crust movements, the floor of the sea began to rise gradually and was thrown into a series of long and parallel wave-like folds. The crests of the waves were eroded by rain and weather and the rising land became much broken and irregular. A combination of concurrent uplift and erosion thus gave rise to the Himalaya.

The Himalaya is the result of a series of great orogenic movements separated by periods of relative quiescence. The deformation seems to have been initiated during the Upper Cretaceous

times and continued through the Middle Miocene, end of the Pliocene, Pleistocene and Sub-recent times. The Middle Miocene times represent perhaps the period of maximum uplift, when the great masses of granites were intruded into the axial region of the Main Himalaya. The succession of mountain ranges from the orogenic acitivity that transformed the Tethyan geosyncline is thus marked by three major phases; a) The elevation of the central axis of the ancient crystalline and sedimentary rocks during the Oligocene times. The Nummultic limestones were deposited in a series of basins, especially in Ladakh. b) The Miocene movement that folded the Murree sediments of the Potwar basin. c) The post-Pliocene phase that affected Mio-Pleistocene Siwalik sediments and which apparently has not yet ceased.

The influence of the Gondwana Block on the alignment of the Himalaya is very marked. The ranges of the Himalaya are wrapped around this block in loops. The strike of the rock systems parallels that of the planes of thrusting onto the Penisular Foreland. The Great Himalaya represents the original axis of the uplift of the Tethyan geosyncline, bending sharply southwards at each end, into Baluchistan and into Assam-Arakan Ranges, where the pressure of the Gondwana Block suddenly ceases.

3.2.1.3 AGE OF ROCKS

The Indian Peninsula has rocks of Pre-Cambrian ages over more than half of its area, the rest being covered by rocks of Mesozoic and Tertiary ages. Volcanic flows of the Deccan Trap covering a large part of central and western India, the Gondwana formations of central and east-central India, and the Tertiaries forming a narrow fringe along the coast, constitute the latter group.

The Pre-Cambrians include crystalline gneisses and schists and sedimentary rocks underlain with gneisses. The oldest Pre-Cambrian rocks, forming the Archaean divisions, of more than 2,400 million years, are restricted to limited exposures in Kerala, Karnataka, Jharkhand and the Aravalli belt of Rajasthan. Radiometric dating has revealed the existence of some gneisses and schists in southern Kerala and southern Karnataka, showing ages of 3,000 to 3,200 million years. The Older Metamorphic series of the southern part of Singhbhum district are also of this age. Zircons, isolated from some of the gneisses near Jaipur in Rajasthan, have indicated ages around 3,600 million years. It is also likely that the Eastern Ghats of Orissa and Vishakapatnam contain rocks 2,500 to 3,000 million years old.

The Western Ghats are constituted by Charnockites, gneisses and schists. Most of the gneisses are very old, around 2,500 million years or older. The Charnockites have been dated to be about 2,500 to 2,800 million years old. There are also younger intrusives with ages of about 2,000 to 2,100, 1,000 and 450 to 600 million years.

Various rocks from the Aravallis have been dated as follows; Bundelkhand granite 2,550 million years, banded gneisses complex 2,300 to 2,400 million years and post-Aravalli granites 2,100 to 1,900 million years. The Aravallis were subjected to folding at about 1,900 million years.

The Vindhyans are divided into two major groups. The Lower Vindhyans, are well exposed in the Son Valley with an estimated age of 1,400 to 1,100 million years. The Upper Vindhyans are dominantly sandstone formations with subordinate shale beds. They form a plateau-like region, with well marked sandstone scarps, the Vindhya Mountains. The Upper Vindhyas are dated 1,000 to 600 million years.

Pre-Cambrian rocks are exposed at several places along the sub-Himalyan zone. There are also Pre-Cambrian rocks in the Central Himalaya. Some of the peaks like Nanda Devi and Nandakot are composed of Pre-Cambrian gneisses and schists.

3.2.2 *Prehistoric flora and fauna*

3.2.2.1 INTRODUCTION

As sediments are deposited, the remains of plants and animals may be entombed in them. These remains along with other evidence of the presence of plants and animals like tracks are called fossils. In a succession of undisturbed sedimentary beds, the upper beds have been deposited later than the lower ones. In general the lower beds will contain fossils of simpler and more primitive life forms. The most primitive fossil organisms are of simplest form and occur in the oldest rocks. Only hard parts of plants and animals get fossilized (Dey, 1968).

Fossils are a key to the past history of the earth. They help to explain the progress of life through geological ages and the distribution of past land and sea. Fossils are also indicators of the environment of ancient sedimentary rocks in which they are found (Dey, 1968).

The areas known as Gondwana land are the repositories of sediments containing fossils of plants and animals. They lie along the valleys of Son, Damodar, Narmada, Mahanadi and Godavari and are located in the present day states of Madhya Pradesh, Jharkhand, Orissa, Andhra Pradesh and Chattisgarh. These fossils date from the Carboniferous and Permian periods of the Palaeozoic to the Cretaceous period of the Mesozoic (Bharucha, 1983).

3.2.2.2 PALAEOBOTANY

The Mesozoic flora of India mainly consisted of Cycads and conifers with a few ferns. The flora was meagre in the beginning of the Triassic but gradually increased in the Jurassic before dwindling again in the Cretaceous, when it was restricted to few ferns and conifers (Prasad, 1999).

In the Tertiary period, the Mesozoic flora almost completely went extinct and new types evolved. Cycads and conifers flourished but in lower numbers. Monocotyledons like palms and *Sabal* became dominant in the early part of this period (Prasad, 1999).

The Eocene flora of India has been mainly discovered in the Intertrappean beds. Many of these fossils are fragmentary and the information is far from complete. Algal and fungal remains have been collected near Rajamundary. A few charophytes have been recorded near Rajamundary and Madhya Pradesh. Ferns including a water fern have been collected from these Intertrappean beds. Gymnospermous wood and fruits of conifers and palms have also been collected. In Assam, algae belonging to Corallinaceae and Dasycladaceae have been recorded from limestones of Eocene age. Angiospermous flowers and fruits are also known from the Intertrappean beds and this includes *Sahnianthus panjai* the first known flower. Fruits include that of a palm *Palmocarpon* and a Musa, *Musa cardiosperma.* Numerous leaf impressions of angiosperms, gymnosperms, pollen grains and fungal spores have been collected from Barmar sandstone in Rajasthan. A fossil of *Mesua ferra* leaf (Family Guttiferae) and many algae have also been recorded from this region (Prasad, 1999).

The Miocene flora of India has several mega-spores and micro-spores and wood from the Siwalik formations, Cuddalore sandstones of southern India and Assam. This includes a palm *Palmoxylon wadia* from the Siwaliks (Prasad 1999).

A variety of forms belonging to the Pleistocene flora have been collected from the Karewa formation of Kashmir and these include dicotyledons, monocotyledons, ferns, pines and diatoms.

The common dicots include oak, willow, birch and maple. Many of these forms are still flourishing in these areas. In Assam, Pleistocene deposits have included many species of dicotyledons including species belonging to *Quercus* and allied genera (Prasad, 1999).

In the Gondwanaland after glaciation, warm and humid climate prevailed up to the end of the Permian giving rise to very luxuriant vegetation. The Lower Gondwana flora is referred to as Glossopteris flora due to the characteristic distribution of *Glossopteris* with its numerous species in the Lower Gondwana period. The Gondwana formations in India have been broadly divided into an Upper and Lower division with several stages in each. The lowest of the Gondwana formations known as the Talcher stage of Upper Carboniferous age occurs in numerous places. Equisetales and Cordaitales are important Talcher stage fossils (Prasad, 1999).

The beds overlying the Talcher are known as Damudas and it consists of lower Karharbari and Barakar stages, the middle unfossiliferous Barren measures and the top Raniganj stage (Prasad, 1999). Cycads and conifers dominate the Upper Gondwana or Rajmahal flora and important representatives include *Ptilophyllum acutifolium*, *Otozamita bengalensis* and *Taeniopteris spatulata* (Bharucha, 1983).

3.2.2.3 PALAEOZOOLOGY

With the opening of the Palaeozoic era, good and extensive fossil records become available. The Lower Palaeozoic is characterized by the abundance of trilobites, graptolites and brachiopods. No vertebrate animal is found until in the uppermost part of the Ordovician. The scorpions, the first air-breathing animals, appeared in the Silurian. The uplift of the land and the retreat of the sea towards the close of the Palaeozoic caused the extinction of the trilobites. Some forms of trilobites evolved into the ancestors of present-day crabs and lobsters. The eurypterids and the water scorpions probably migrated to inland lakes and started living in freshwater. Later they were forced to evolve into forms like land scorpions, spiders and flying insects, as the lakes started to dry up (Dey, 1968).

In the Newer Palaeozoic, graptolites are absent; the trilobites decreased in number and finally went extinct. Corals, crinoids and cephalopods became more numerous while brachiopods reached their climax. Some worm-like animals in the sea began to develop a spinal cord and in turn evolved into fishes and other vertebrate animals. The first vertebrate animal evolved in the Devonian period, which is also referred to as the age of fishes. Marine fossiliferous Palaeozoic rocks are found in Kashmir and the Himalaya. The presence of brachiopod-like forms in most of the Vindhyans places it in Lower Palaeozoic and possibly even in Cambrian. Cambrian to Devonian rocks containing recognizable fossils are not found in the Peninsula (Dey, 1968).

In Kashmir, the Cambrian is represented by slates, sandy rocks and quartzites containing badly preserved fossils. In the Spiti Valley of Western Himalaya, an extensive fauna containing *Redlichia* occurs and it contains no species definitely recognizable in any other part of the world except southern Iran. Marine Ordovician beds overlie the Cambrian with strong basal conglomerates in Spiti and other Himalayan areas and contains a typical Upper Ordovician brachiopod fauna extending into Spiti, Kumaon and Kashmir (Dey, 1968).

In the Upper Carboniferous, when the climate grew warmer and the glaciers melted and the sea level rose higher, the Tethys returned to the Himalayan region and sedimentation started again from the Upper Carboniferous to the early Tertiary. Brachiopod fauna including *Productus* and *Spirifer* flourished along the southern shore of the Tethys (Dey, 1968).

Brachyops laticeps, the first Labyrinthodont amphibian discovered in India was found in the fossil beds of Mangli, Maharashtra and this corresponded to the Raniganj stage.

Gondwanasaurus bijoriensis is another amphibian collected from the Raniganj stage in Madhya Pradesh. These animals were nearly 2.5 m long and heavily built (Dey, 1968).

Prior to the end of the Palaeozoic era, the reptiles were already well established. During the Mesozoic they spread all over the world, on land, in the air and the sea. They maintained their dominance till the end of this era and the Mesozoic is called the Age of the reptiles. The Mesozoic era is divided into three periods, the Triassic, the Jurassic and the Cretaceous. Marine Triassic fossils are found extensively in the Himalaya from Kashmir to Kumaon. Cephalopods are abundant in these deposits. The most complete section of this deposit is exposed in the Spiti-Kumaon belt. Spiti has remarkable species richness in ammonite fauna. Massive limestone deposits in Spiti, Garhwal and Kumaon belonging to the Jurassic period have a rich set of fossils of *Belemnites*. A fossil belonging to the Lower Triassic of the freshwater reptile *Lystrosaurus* was found in the Panchet beds of the Raniganj coalfield in West Bengal. The Middle Gondwana of the Mahadeva Hills of the Satpura range has fossils of crustaceans, fish, amphibia and reptiles. The most complete development of the Upper Gondwana is in the Satpura and Godavari regions. Numerous fossils of reptiles, fish and crustacea have been found from here. A species of reptile belonging to the long-necked *Plesiosaurus* has been found in the Umia beds in Kachchh (Dey, 1968).

The Cretaceous was a period of extensive invasion of the sea on the continental margins and low-lying interior plains. The Cretaceous is also one of the most widely distributed systems in India and is represented by a variety of rocks, deposited in the land, sea, estuary and lakes. In Spiti, deposits belonging to Upper Jurassic and Lower Cretaceous have fossils of lamellibranchs and ammonites. The Middle and Upper Cretaceous, especially in the Pondicherry-Tiruchirapalli sector are mainly shore deposits. In the central parts of the Peninsula occur estuarine and lacustrine deposits called Lametas. The Lameta beds from Jabalpur and Chanda districts have yielded some remains of dinosaurs. The Pondicherry-Tiruchirapalli sector of the east coast is of great palaeontological interest as it contains more than 1,000 fossils of polyzoa, crinoids, echinoids, corals, brachiopods, lamellibranches, gastropods, ammonites, fishes and dinosaurs. The fishes are represented by 17 species. The dinosaurs are well represented but their remains are too fragmented for reconstruction. No Cretaceous mammals have been found in India. In the Deccan, during the periods of quiescence that intervened successive volcanic outbursts, lakes were probably formed during the blockage of rivers by lava streams. In these lakes, fishes, frogs, small crustaceans and several other creatures thrived. In the marshy areas, dinosaurs thrived and tortoises on the shorelines. A succession of lava flows followed by lake formation and then sedimentation led to the formation of inter-bedded sediments the Intertrappeans. The most common shell of the intertrappean beds is *Physa prinsepii*, a species of freshwater snail (Dey, 1968).

The Earth has acquired its present features including all physical features, climatic zones, and distribution of plants and animals in the Cainozoic era during a relatively short geological time of about 60 million years. This era is divided into two periods, the Tertiary and the Quartenary. The Tertiary in turn is divided into five epochs, Palaeocene, Eocene, Oligocene, Miocene and Pliocene. The Tertiary has been called the Age of mammals, because of the great abundance of the fossil remains of mammals in the deposits of this period. During Palaeocene, crocodiles and turtles were common in lakes and rivers. Fishes were largely the bony fishes and the majority resembled present day fishes. Very primitive mammals resembling reptiles in many characteristics were found in this epoch. New and progressive forms that will go onto be the

ancestors of modern families, evolved during the early Eocene. Certain carnivores and ungulates developed characters similar to modern forms (Dey, 1968).

The thick terrestrial sediments derived from erosion of the rising Himalaya is referred to as the Siwalik system of India. This is famous for fossils of extinct species of elephants, rhinoceroses, horses, giraffes, pigs, deer, antelopes, bovids, camels, apes and many more species. The majority of the Siwalik formations are unfossiliferous but in certain areas some formations are richly fossiliferous. The fossil records span from Middle Miocene to Lower Pleistocene and indicates a wide range of environment, from humid forest condition to aridity. Ancestral forms of elephants, *Trilophodon* and *Dinotherium* first appear in the Lower Siwaliks. Other ancestral forms the *Mastodon* and *Stegodon* join these in the Middle Siwaliks but did not survive the Upper Miocene. The *Mastodon* and *Stegodon* resemble modern elephants but have different teeth patterns, lower skull and exceptionally large tusks. In the Lower Siwaliks, small pig-like animals called *Anthracotheres* occur. They soon became extinct and were replaced by *Merycopotamus*, possible ancestor of the hippopotamus. The hippopotamus, which became abundant in the Upper Siwalik appeared in the Middle Siwalik when giraffe-like animals were also found (Dey, 1968).

During the Pliocene epoch, the mammalian fauna became more diverse than the present day. The earlier forms of true elephants were the Stegodons. *Stegodon ganesa* from the lower horizons of the Upper Siwalik had enormous tusks of about three metres. The lowest stage of the Upper Siwalik contains some of the genera founding the Middle Siwalik. These include *Hipparion*, *Merycopotamus* and *Hippopotamus*. *Stegodon* is more numerous than *Mastodon*. The *Hipparion* was a three-toed horse living in the grassy plains. Large giraffes were found including the *Sivatherium*, the largest known ruminant. Buffaloes, new types of antelopes and other ruminants are also seen in the lowest stage, above which the first true elephant *Elephas planifrons* appeared along with other forms which included *Stegodon*, *Equus*, *Rhinoceros*, and *Merycopotamus*. A giant tortoise, *Colossochelys atlas*, measuring over six metres in length has been found in the Upper Siwalik beds (Dey, 1968).

The marine faunas of the Pleistocene show little difference from those currently exisiting. Extinct forms are very rare. Like Pliocene, the early Pleistocene was a time for the giant mammals. The mammoths evolved and spread very rapidly and then died out leaving the African and Asian elephants as the only survivors. In the Boulder Conglomerate, the highest horizon of the Siwalik system and referable to Lower Pleistocene, modern ox, camel and horse make their first appearance, while *Stegodon ganesa* (the last of the *Stegodon*), *Rhinoceros*, *Hippopotamus*, *Sivatherium*, *Hyaena*, and *Felis* remain as survivors from previous fauna. A fauna consisting of *Elephas antiquus* and *Equus namadicus* with numerous extinct including species of *Rhinoceros*, *Hippopotamus*, *Cervus*, *Bos* and *Sus* have been found in the Middle Pleistocene alluvium of the Narmada Valley. The anthropoid apes are represented in such numbers and variety in India that the original centre of distribution of the group could not be far away from northern India. From the entire Siwaliks, over 80 specimens have been classified under four genera, *Sivapithecus*, *Sugrivapithecus*, *Bramapithecus* and *Ramapithecus* (Dey, 1968).

The modern fauna when compared with the fossil evidence available from the Siwaliks is very depauperate. The modern fauna is in general smaller in size and also has much fewer species. There were a hundred ungulate species in the Siwaliks compared to 18 present day species, the carnivores were also more numerous. One elephant species represents 16 related species, which are extinct. Bovids have diminished from eight to two species. This decrease has largely been caused by the violent climatic fluctuations experienced in this epoch (Dey, 1968).

3.2.3 ***Human settlements***

3.2.4 ***History of land use as well as people-resource use relations***

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