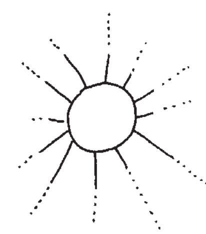
Chapter 3

Evolutionary, Physical and Historical Context of India's Biodiversity

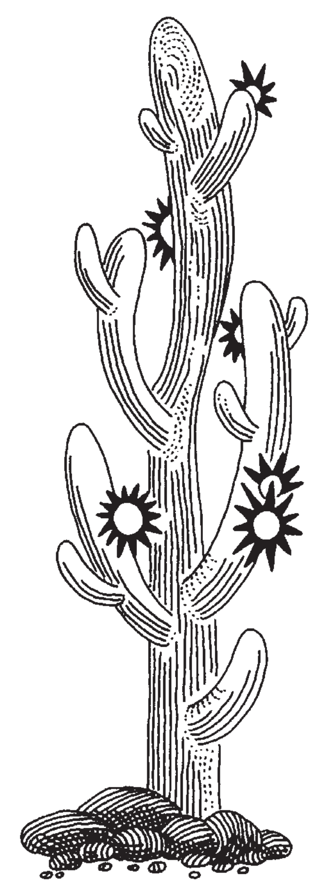
3.1 Physical and Geographical Features

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. Its territory extends for 3,214 km north to south and for 2,933 km east to west. It has a land frontier of 15,200 km and a coastline, including that of the islands, amounting to 7516 km (Grover and Arora 1996; GoI 2001). The countries bordering India are the People's Republic of China to the north and north-east, Myanmar and Bangladesh to the north-east and east, Nepal and Bhutan to the north, Pakistan to the west and Afghanistan to the north-west. The southern peninsula extends into the tropical waters of the Indian Ocean with the Bay of Bengal lying to the east and the Arabian Sea to the west. Sri Lanka, in the Indian Ocean, also borders India. 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 predominantly a tropical country (see *Map 3.1*).

3.1.2 Geological Evolution



Some 225 million years ago, in the Palaeozoic era, all the present-day continents were part of one landmass called Pangaea. By about 180 million years ago, in the late Triassic and early Jurassic periods, this super mass started breaking, creating Laurasia (Angara) in the north, and Gondwanaland in the south, with the Tethys Sea in the middle. Gondwanaland then split in the Jurassic period, with South America and Africa drifting to the west, India breaking off from Antarctica, and the southern hemisphere landmasses slowly coming into their present-day positions. By about 45 million years ago, India had begun thrusting into Eurasia, creating the buckling and folding which produced the mighty Himalayan chain. This northwards push of the Indian landmass is continuing even today (Krishnan 1982).

3.1.3 Geological Divisions of India

(Note: *Sections 3.1.3.1* to *3.1.3.8* have been written based on material presented by Wadia (1983) and Mani (1974), except where otherwise indicated.)

India is composed of three major units or earth features, which differ in their physical and geological characters. They are:

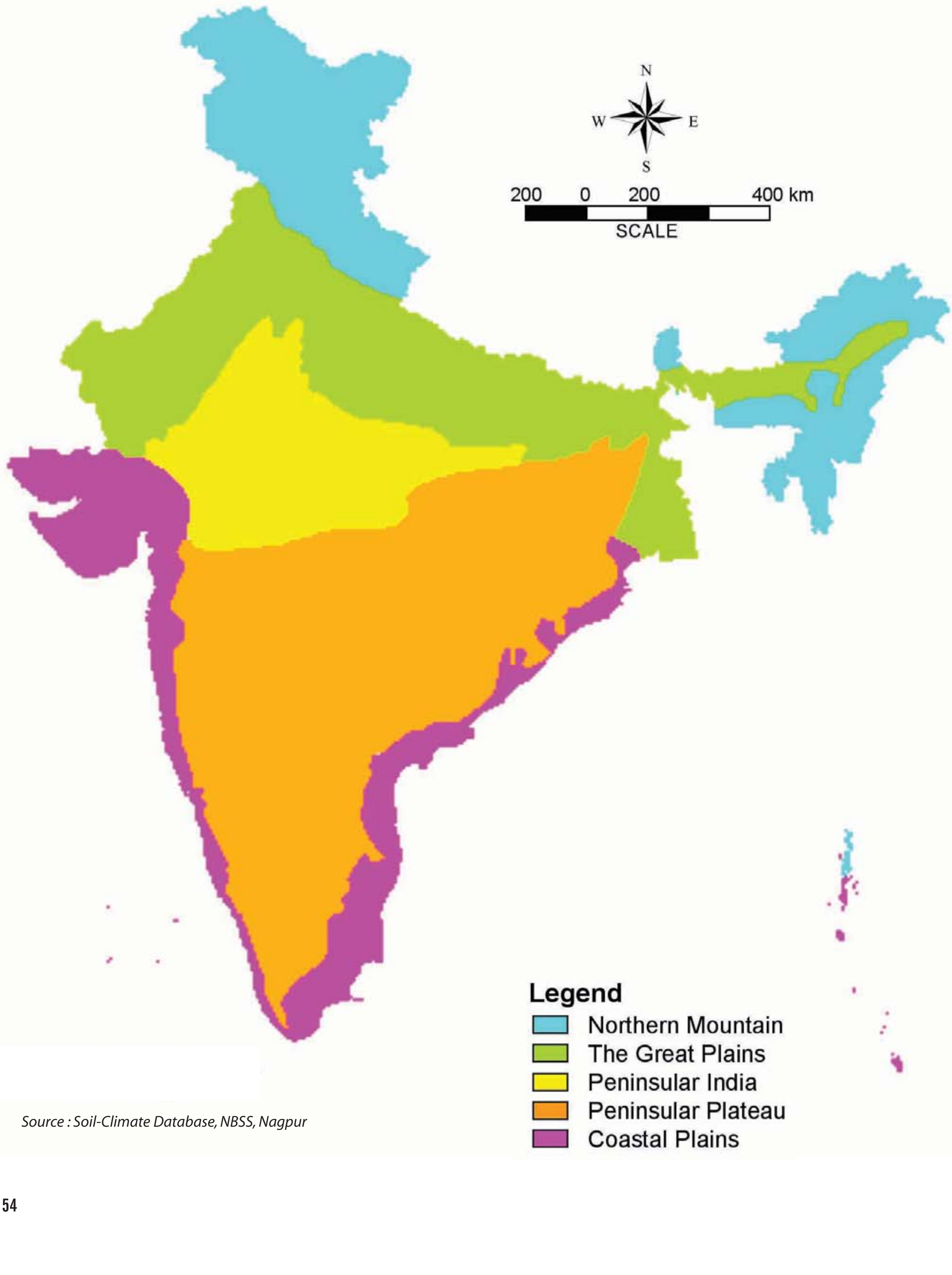
a. The Peninsula, i.e., the Deccan plateau south of the Vindhyas;
b. The Himalaya mountains, also referred to as the Extra-Peninsula, which borders India to the north and east; and;
c. The Indo-Gangetic Plains, lying between the other two divisions and extends from the Indus valley in the west to the Brahmaputra valley in the east.

Five other distinct but smaller divisions can be distinguished: the deserts of Rajasthan, the islands in the Indian ocean and the Arabian sea, the long coastal stretch, the rivers, and the major lakes (see *Map 3.2*).

3.1.3.1 The Peninsula

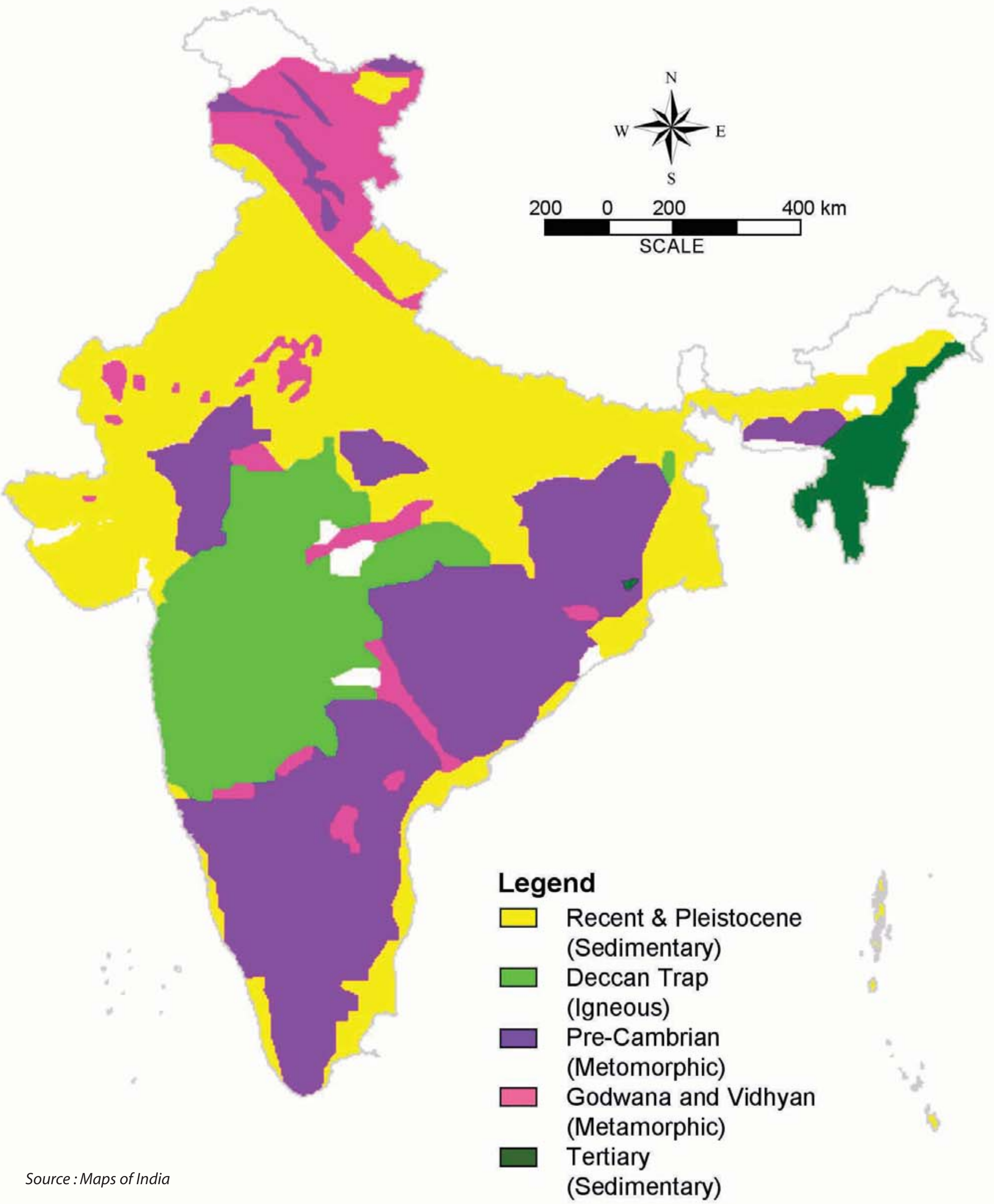
The Peninsula differs a great deal from the other geological divisions on a number of characters. The first differ-

Map 3.1 Physiographic Regions of India



Source : Soil-Climate Database, NBSS, Nagpur

Map 3.2 Geological Divisions of India



Source : Maps of India

Table 3.1 Geological Time Scale

(Figures outside the brackets show the total duration of the Group or System in millions of years, while those within brackets indicate how many million years ago before the present the period/era started.)

Group	System	Geological Formations in India	Chief Fossils
Quarternary	Recent (.01) Pleistocene 1(1)	Recent Alluvia, Sand dunes, Soils Older Alluvia, Karewas of Kashmir, and Pleistocene river terraces etc.	Living animals Humans appear. Many mammals die off during glacial periods.
Tertiary or Cainozoic	Pliocene 7(8) Mio-Pliocene	Shiwalik, Irrawady and Manchhar Systems; Cuddalore, Warkilli and Rajamahendri Sandstones. Formation of Western Ghat scarp and its retreat.	Mammals, mollusca and flowering plants dominant. Division largely based on proportion of living to extinct species of mollusca and the presence of mammal species.
	Miocene 17(25) Oligo-Miocene	Murree and Pegu Systems; Mari and Gaj Series.	
	Oligocene 13(38)	Ranikot-Laki-Kirthar-Chharat Series; Eocene of Burma. Creation of Western Ghats and Western Ghat scarp facing the sea.	
	Eocene 27(65)		
	Late Eocene – Upper Cretaceous	Deccan Trap and Inter-trappeans.	
Secondary or Mesozoic	Cretaceous 75(140)	Cretaceous of Trichinopoly, Assam and Narmada valley; Giumal and Chikkim Series; Umia beds.	Giant reptiles and ammonites disappear at the end. Flowering plants become numerous.
	Jurassic 60(200)	Kioto Limestone and Spiti Shales; Kota-Rajmahal and Jabalpur Series.	Ammonites abundant. First birds, flowering plants and sea urchins.
	Triassic 40(240)	Lilang System including Kioto Limestone; Mahadeva and Panchet Series.	Ammonites, reptiles and amphibia abundant. Arid climate.
Primary or Palaeozoic	Permian 50(290)	Kuling System; Damuda System.	Trilobites disappear at the end.
	Carboniferous 60(350)	Lipak and Po Series; Talchir Series.	Many non-flowering plants; first reptiles appear.
	Devonian 60(410)	Muth Quartzite	Abundance of Corals, Brachiopoda; first amphibians and lung-fishes.
	Silurian 35(544)	Silurian of Burma and Himalayas	Graptolites disappear at the end; first fishes; probably first land plants.
	Ordovician 60(505)	Ordovician of Burma and Himalayas	Abundance of Trilobites, and Graptolites.
	Cambrian 100(605)	Haimanta System; Garbyang Series	Abundance of Trilobites.
Pre-Cambrian or Proterozoic	Pre-Cambrian (2500)	Cuddapah and Vindhyan Systems; Dogra and Shimla Slates; Martoli Series.	Soft-bodied animals and plants.
Archaean or Azoic	Archaean (3600)	Dharwar and Aravalli Systems; Salkhala, Jutogh and Daling Series, various gneisses, etc.	Lifeless.

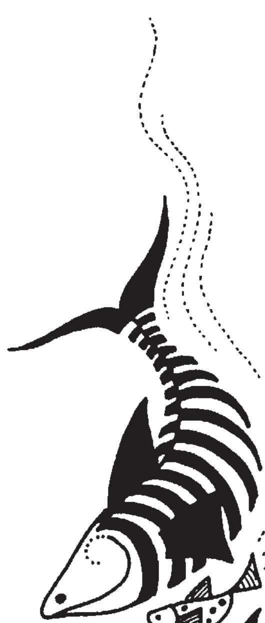
(Adapted from Krishnan 1982, and Radhakrishnan 1993) ence is stratigraphic – the Peninsular Region during the early part of geological history (Pre-Cambrian, 600 million years ago) was a land area and had never been submerged by the sea. The second difference is geotectonic (pertaining to the geological 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. 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. Two hundred million years ago it was part of the Gondwana Continent, called 'Gondwanaland' (*see Table 3.1*). The oldest surface that can be identified in India belongs to that remote period. It has been possible to recognize this surface as the oldest surviving surface in all continental fragments (Radhakrishnan 1993).

The Peninsula has been a stable landmass, at least since the Pre-Cambrian period. The oldest Pre-Cambrian rocks, forming the Archaean divisions (of more than 2,400 million years ago) are restricted to limited exposures in Kerala, Karnataka, Jharkhand and the Aravalli belt of Rajasthan.

The ancient block of the Peninsula is composed of highly metamorphosed rocks like charnockites, gneisses and schists of the Archaen System. This ancient crystalline complex occupies much of the Peninsula and particularly the central and southern portions. Much of the Peninsula is constituted by the Deccan plateau, extending from 12˚ to 21˚ N. The Deccan traps represent one of the largest accumulation of continental lava flows covering an area of over a million square kilometers with an average present-day exposed thickness of over 1000m. Earlier it was thought that the trap activity was spread over many million years, but recent geochronological and paleomagnetic researches seem to indicate the possibility of a shorter duration of volacanic activity around 65 millions years ago (Radhakrishnan 1991). Deccan volcanism, with its burst of tremendous volcanic activity, arose all of a sudden at the close of the Cretaceous and the dawn of the Tertiary, and, coupled with the extinction of nearly 90% of the flora and fauna, is a major geological event with global importance (*ibid*).

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 a much broader coastal region in the east.

The inherent geological setting of the Deccan traps inhibits large-scale storage and availability of copious groundwater supplies, except in parts of the valleys of the Deccan rivers (Mahanadi, Krishna, Kaveri, Godavari, etc.). Furthermore, the topographical conditions and consolidated geological formations encourage surface runoff away from the region. In consonance, the soils are also more suitable for dryland farming, pasturing and forestry. Most of the valuable coal and economic geological deposits occur in this region, as also a lot of biodiversity hotspots (S. Sinha, personal communication 2003).



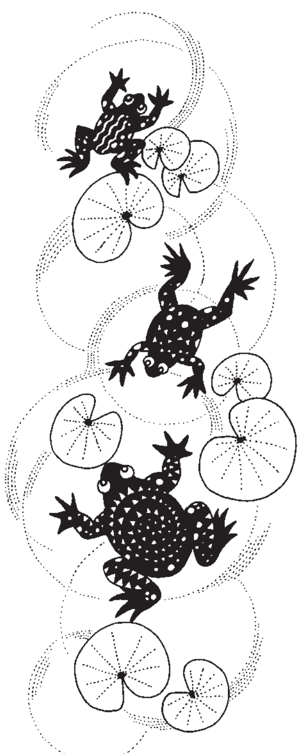
The important mountain ranges of the Peninsula are the Vindhyas, the Satpuras, the Western Ghats and the Eastern Ghats. These mountains were a prominent feature in the old Palaeozoic and Mesozoic periods of India and had a much more extensive presence than the eroded remnants that are present today. The earliest change, after the deposition of the earlier Peninsular sedimentaries, seems to be the folding of the Aravallis during the earlier Vindhyan Period. They are one of the oldest mountain systems in the world. These hill ranges and the flatter plateau areas between them are characterised by a wide diversity of forests and grasslands, from very sparse dry forests to very moist rainforests.

3.1.3.2 The Himalayas

The Himalayas are true mountains or 'tectonic' mountains. 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 advancing from the south. These mountains are a weak and flexible portion of the earth's surface and have undergone a lot of deformation. 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 and has continued through the Middle Miocene, the end of the Pliocene, and the Pleistocene, until the present time.

The Himalayas were submerged by seas for the greater part of their history. The sedimentation accumulated from the Palaeozoic Era attained an enormous thickness of about 15,200 m, and was accompanied by slow sinking of the seabed. 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 Himalayas 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 this region varies from 160 to 400 km, while it is about 2,500 km long. 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 altitude, temperature, and rainfall gradient of this region supports a very high diversity of forest, grassland and aquatic ecosystems, including India's only temperate habitats.



The Himalaya has an enormous influence on the meteorology of the Indian sub-continent. 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 fed by this snowfall form the source of several rivers, which lower down also gather much of the monsoon rainfall.

The Himalayan region is classified into three parallel zones:

a. The Great or Inner Himalaya is the northernmost of the ranges, with an average elevation of 6,100 m and much of its upper reaches 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.
c. The Outer Himalaya (or Shiwalik 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 '*doon*'. They are of more recent origin than the rest of the Himalaya.

3.1.3.3 The Indo-Gangetic Plains

The Indo-Gangetic plains stretch along the southern fringe of the Himalayas. The Plains are the alluvial deposits of the rivers of the Indo-Ganges system. These deposits owe their origin and fertility to erosion of nutrient-rich material from the mountains and its deposition in the basin through the river system under the overall influence of monsoonal dynamics. These plains were originally a deep depression lying between the Peninsula and the Himalayas. The region is 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 Shiwaliks, a steep gravel slope called the *bhabar* is often found. In this porous tract the surface waters of most of the rivers tend to disappear. These waters then seep out in the marshy *terai* areas further south. The Gangetic plains are home to a diversity of dry and moist vegetation types (mostly deciduous) and an extensive network of wetlands.

3.1.3.4 The Rajasthan Area

In Rajasthan, the Aravallis are a true tectonic mountain range. The Aravallis form a division between the sands of the 'Thar' desert and the central highlands to the east. They mark the present-day frontier between the western Asiatic desert region and the true Peninsula of the sub-continent. 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-

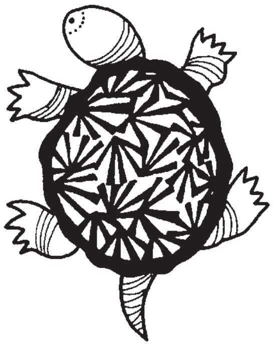
Cambrian folding, which is typical for the Peninsula, but it contains fossil deposits of marine organisms belonging to the Mesozoic and Cainozoiceras, which is typical of the Himalaya. This is the only part of the Peninsula which has been submerged repeatedly by the sea. Prolonged and continued aridity 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 the Thar region.

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 about 1,900 million years ago.) This region is India's driest, characterised by deserts and semi-arid ecosystems, including dry deciduous and scrub forests.

3.1.3.5 The Islands

Besides the continental landmass, the Indian territory also includes coastal and offshore islands. The former consists of a large number of small islands – the largest ones not exceeding 100 ha in size – lying mainly in the Gulf of Mannar and the Gulf of Kachchh, though several small islands are to be found off the coasts elsewhere as well. These islands are generally low-lying, with elevations of not more than 100 m or so, and support scrubby vegetation on the exposed and coral reefs on the sub-littoral regions. Most of the islands of the Gulf of Kachchh also support extensive mangrove patches. Some of the islands in the Gulf of Mannar also have mangroves, but not in abundance.

The offshore islands fall into two categories. In the first are the low-lying coral atolls of the Lakshadweep archipelago (9-12˚ N, 72-74˚ E) in the Arabian Sea. These islands are in fact the emerged parts of the coral atolls growing on extinct submarine volcanoes of the Chagos-Laccadives Ridge. The elevation of the islands is generally less than 2 m and the area not exceeding a few sq km. The island vegetation is almost exclusively coconut, besides a few species of sand dune flora and leguminous and ornamental plants imported from the mainland. The aquatic realm is remarkable for the prolific reefs and the diversity of marine life.



In the second category are the Andaman and Nicobar islands (6-14˚ N, 92-94˚ E), which are the emerged part of a mountain chain that lies on a ridge extending southward from the Irrawaddy delta area of Myanmar. There are approximately 572 islands in the chain, some of which are volcanic. The islands occupy an area of 8293 sq km. All the islands are high islands, with dense forests inland and dense mangrove swamps on the coast. All islands have fringing coral reefs with a great amount of biodiversity.

3.1.3.6 Rivers and River Valleys

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 has very little momentum except during the floods. During the non-flood season these rivers precipitate their silt in parts of their basins, estuarine flats and similar areas, and the stream flow is slow, shallow and meandering. The Western Ghats forms the main watershed for these rivers. The Peninsular rivers are entirely fed by the monsoon rains and are very seasonal in their flow, being normally very dry during the summer. These rivers are often divided into two groups: a) the coastal rivers, relatively small streams, numbering more than six hundred from Saurashtra to Cape Comorin. They drain the western side of the Western Ghats and cut across the narrow plains before flowing into the Arabian Sea; and, b) the inland rivers, including the west-flowing Narmada and Tapti and the east-flowing Mahanadi, Godavari, Krishna and Cauvery.

The drainage system in the Himalaya is of much more recent development. The rivers are still actively eroding, transporting and 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. This results in very deep gorges ranging in depth from 1,800 to 3,700 m.

The Brahmaputra originates in Tibet, east of Kailas-Mansarovar. From Assam the Brahmaputra flows into Bangladesh, where it is joined by the Ganga. Further south numerous distributaries are formed, which then constitute the vast Sundarbans mangrove delta prior to flowing into the Bay of Bengal (Verghese 1990).

3.1.3.7 Lakes

India's bigger freshwater 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 the Kumaon Himalaya.

The Loktak lake, in the northeastern state of Manipur, is the largest of the *phats* – shallow marshes found in the central valley of the state – drained by the Manipur river. This lake is characterized by *phoomdi*, floating islands of decaying vegetation.

The lakes of northern Kashmir and Ladakh are undergoing a period of marked drying- up. 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 blocking 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.

The Peninsula has a few small freshwater lakes. Rajasthan has four or five saltwater lakes of which the Sambhar lake is most well known (the others include Didwana, Phalodi and Pachbadra). The Chilika and Pulicat lakes are located on the east coast. The Chilika Lake, in the state of Orissa, varies in area from 900 to 1,200 sq km and its salinity varies widely depending on the season. It is only a few metres deep across most of its spread. The lake is cut off from the sea by a long spit of sand which occasionally opens up. Spreading across the coastal states of Andhra Pradesh and Tamil Nadu, Pulicat lake is the second largest lagoon in India after Chilika lake. Its area varies from 250 to 460 sq km. Due to deltaic deposits, the lake is extensively shallow (Mathew 1991).

3.1.3.8 Coasts

India has a long coastline stretching along nine states and two archipelagoes (Ramakrishna and Venkataraman 2001). The coastline is 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 (small ones for the most part) draining through it. 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 their length. At most places the mountains are only 40 to 55 km away from the Arabian Sea.

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. The eastern littoral region is very different from the west. The lowland is much wider and much of it is true coastal plain in its structure. In places it is formed of the deltas of major rivers like the Mahanadi, Godavari, Krishna and Kaveri. The coastal lowlands are 100 to 130 km wide. The entire seaboard is surrounded by a narrow submarine ledge where the sea is shallow (the continental shelf). This shelf is broader along the west coast than the east coast. From these shelves the sea suddenly deepens out into the open seas.

Besides the above-mentioned geological and physical divisions, an analysis of the Indian terrain in terms of the abiotic framework – that provides the diverse niches and habitats of biodiversity (both natural and agricultural) – would include factors like terrain, drainage, climatic factors and hydrologic cycle (*see Chapter 4*). The natural diversity and agro-biodiversity are influenced, and to a great extent determined, by the combination of these factors.

3.2 Evolutionary History of India

3.2.1 Palaeobotany and Palaeozoology

(This section is based largely on Prasad (1999) and Dey (1968).)

Fossil remains of plants and animals entombed in sediments are a key to the history of the earth. They help to explain the progress of life through geological ages, and the distribution of land and sea in the past. Fossils can also help us understand the environment of those times. It would be useful to look briefly at the fossil record of India with respect to the development of flora and fauna.

India was part of the southern hemisphere before it broke off from Gondwanaland. As with the rest of the southern hemisphere, India was also dominated by *Glossopteris* flora, characterised by a small number of species and scarcity of woody plants.[1] Apart from the seed-fern genera *Glossopteris* and *Gangamopteris*, other plants believed to have existed in India (then a part of the southern hemisphere) at the time included lycopods, horsetails, ferns, and gymnosperms. Then followed the *Dicroidium* flora, reaching its peak towards the end of the Triassic period (240 million years ago).

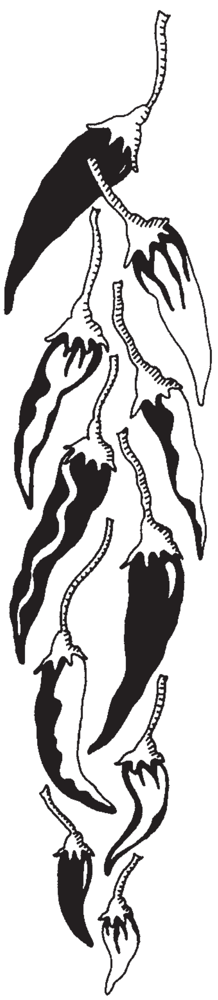
Immediately thereafter, by the middle Mesozoic era, the vegetation changed to *Ptillophyllum*-dominated flora, with associates like *Thinnfeldia*, and advanced ferns and gymnosperms. During the Jurassic period (200 million years ago), conifers were at their height, but they subsequently suffered a major setback during the Cretaceous period (140 million years ago). Interestingly, in this period, while other countries have shown a prominent presence of angiosperms, India displays virtually no record of angiosperms. Only in the Tertiary period (less than 65 million years ago), did angiosperms start dominating the Indian flora (and have done so till today). 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 and an increase in the number of angiosperms. 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 along with the dicotyledons became dominant in the early part of this period.

Fossils of the Eocene flora of India are fragmentary and the information is far from complete. There are algal and fungal remains, a few charophytes, ferns (including a water fern *Azolla*), gymnospermous wood and fruits of conifers and palms, angiospermous flowers and fruits including *Sahnianthus panjae* (the first known flower). Fruits include that of a palm *Palmocarpons Arceoidocarpon*, *Nypa*, *Hyphaeneocarpon* and a banana, *Musa cardiosperma*. The Miocene flora of India has several mega-spores and micro-spores and wood from the Shiwalik formations, and Cuddalore sandstones of southern India and Assam. This includes a palm *Palmoxylon wadiai* from the Shiwaliks.

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.

The fossil record also shows us the animal life that existed in India. The Palaeozoic era, between 600-290 million years ago (*see Table 3.1*) is characterized by the abundance of trilobites, graptolites and brachiopods. Marine fossiliferous Palaeozoic rocks are found in Kashmir and the Himalaya. The presence of brachiopod-like forms in most of the Vindhyas places it in the Lower Palaeozoic and possibly even in the Cambrian. Cambrian to Devonian rocks containing recognizable fossils are not found in the Peninsula.

In the Upper Carboniferous (around 300 million years ago), 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.



Marine fossils of cephalopods and ammonite fauna from the Mesozoic era are found extensively in the Himalaya from Kashmir to Kumaon. Massive limestone deposits in Spiti, Garhwal and Kumaon belonging to the Jurassic period have a rich set of fossils of *Belemnites*. A fossil of the freshwater reptile *Lystrosaurus* was found in the Panchet beds in West Bengal. The Middle Gondwana of the Mahadeva Hills of the Satpura range has fossils of crustaceans, fish, amphibians and reptiles. A species of reptile belonging to the long-necked *Plesiosaurus* has been found in the Umia beds in Kachchh.

The Cretaceous is 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 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. 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.

This fauna had begun to die out due to a period of intense dryness, during the Triassic-Jurassic periods, as also due to lava flows in the Deccan during the Cretaceous period. What did survive, however, were insects and other invertebrates that escaped the wrath of the lava by hiding in forested and marshy valleys in the Deccan. These took over the entire Peninsula in the Quaternary period (less than 2.5 million years ago), by which time the river systems as they are known today had been established.

Considerable faunal interchange between Africa and Eurasia took place some time during the early Miocene Epoch (about 20 million years ago), and subsequently between Africa and western India. Lorises and old world monkeys, porcupines, apes, rhinoceroses, elephants, pangolin and other animals migrated to India and diversified in the Shiwalik hills area (as proven by fossils found in these hills). Ancestral forms of elephants, *Trilophodon* and *Dinotherium* first appear in the Lower Shiwaliks. Other ancestral forms the *Mastodon* and *Stegodon* joined these in the Middle Shiwaliks, but did not survive the Upper Miocene. In the Lower Shiwaliks, small pig-like animals called *Anthracotheres* occured. They soon became extinct and were replaced by *Merycopotamus*, possible ancestor of the hippopotamus.

During the Pliocene epoch, the mammalian fauna became more diverse. It included *Hipparion*, *Merycopotamus* and *Hippopotamus*. 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 Shiwalik beds.

Close association has also been found between the fauna of the Peninsula (and Sri Lanka) with that of South-east Asia. Migration between these regions took place during the Pliocene Epoch, while during the Miocene Epoch the Bay of Bengal cut off such migration. In this period, humid tropical conditions occurred in the southern Himalayas, all the way from Baluchistan to China. Animal dispersal was entirely on this route. Subsequently, during the Pleistocene Epoch (less than 1.8 million years ago), Himalayan glaciers appear to have descended to levels much lower than they are now, creating conditions for the migration of fauna and flora into the Peninsula.

Like the 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 Shiwalik system and referable to the Lower Pleistocene, modern ox, camel and horse made their first appearance, while *Stegodon ganesa* (the last of the *Stegodons*), *Rhinoceros*, *Hippopotamus*, *Sivatherium*, *Hyaena*, and *Felis* remained as survivors from previous fauna. A fauna consisting of *Elephas antiquus* and *Equus namadicus* with numerous now-extinct species, including species of *Rhinoceros*, *Hippopotamus*, *Cervus*, *Bos* and *Sus* have been found in the Middle Pleistocene alluvium of the Narmada Valley. From the entire Shiwaliks, over 80 specimens of anthropoid apes have been found and classified under four genera: *Sivapithecus*, *Sugrivapithecus*, *Bramapithecus* and *Ramapithecus*. The Pleistocene marine fauna show little difference from those currently existing. Extinct forms are very rare.

3.2.2 Human Settlements and the Domestication of Biodiversity

3.2.2.1 History of Human Settlements

Although the early stages in the evolution of human from apes began in the Miocene period around 20 million years ago, proto-humans make an appearance only in the Pliocene period around 5 million years ago. Their cultural evolution, reflected mainly in their ability to manufacture and use tools, dates back to around 2 million years ago, during the Pleistocene period. The stages of development that followed in the prehistoric period are divided into the Paleolithic, Mesolithic and the Neolithic periods. The Paleolithic period or Old Stone Age is further divided into the Lower, Middle and Upper Phases.

The Lower Paleolithic phase is characterised by stone tool assemblages consisting of crude yet simple flakes and cores. The tool size, quality and variety improve in the succeeding Middle and Upper Paleolithic Phases, with the use of fine-grained siliceous rocks. By the Mesolithic phase we have complex and composite tools made out of micro-blades and flakes, which were fitted into grooves in bone, wood and reed shafts, and joined together by natural adhesive like gum and resin. These stages provide evidence of a nomadic, hunting-gathering way of life.

In India tools belonging to the Lower Paleolithic have been found in the Shiwalik beds (300,000-400,000 BP) (Mohapatra 1976), and in the regions of central India and the southern part of the Eastern Ghats. The deposits on the Narmada river are dated to 200,000 BP. A hominid cranium from these levels, at Hatnora in Madhya Pradesh, represents an advanced stage of *Homo erectus* or early stage of *Homo sapiens* (Kennedy and Chiment 1991). An exciting discovery of stone tools from the Shiwalik hills at Riwat, near Rawalpindi in Pakistan, has been dated to two million years on the basis of magnetic polarity stratigraphy (Rendell *et. al.*, 1987). This discovery made in 1985 has not yet been corroborated by more findings from other sites and for the present it stands in spatial and temporal isolation.

Apart from the abundance of riverine settlements on the Chambal, Son, Mahanadi, Narmada, Godavari and Krishna rivers and their tributaries, the spread of Paleolithic sites in India suggest that humans occupied a variety of micro-habitats. Examples include the semi-arid regions of western Rajasthan, along lakes and pools in the wide flood plains of shallow streams and stable sand dunes (Misra 1987), the rock shelters of Bhimbetka in the Vindhya hills of Central India, near Bhopal in Madhya Pradesh (Wakankar 1975), and open air settlements away from river banks (Jacobson 1985). The climate during this period was essentially semi-arid, but fluctuated several times, which resulted in significant climatic and environmental changes (Misra 1987). The faunal remains from the gravel beds of the Narmada consist of wild boar (*Sus namadicus*), cattle (*Bos namadicus*), elephant (*Elephas hysudricus* and *Stegodon insignis-ganesa*), horse (*Equus namadicus*) and hippopotamus (*Hexaprotodon namadi-*

cus). These suggest the existence of both forest and open grassland environments and the availability of water round the year.

Compared to sites of the Lower Paleolithic, Middle and Upper Paleolithic sites are relatively sparse. The reason could be the climatic conditions during the upper Pleistocene, a period of intense cold and glaciation in the northern latitudes. Areas bordering glaciated regions experienced high aridity. In north-west India extensive formation of sand sheets and sand dunes took place and the drainage became totally defunct due to the westward shift of the river courses. During the terminal Pleistocene, southwesterly monsoons became weak and the sea level decreased by scores of meters (Baskaran *et. al.*, 1986; Fontugene and Duplessy 1986; Kale and Rajguru 1987). The discovery of ostrich eggshells at over 40 Upper Paleolithic sites in Rajasthan, Madhya Pradesh and Maharashtra also suggests arid climatic conditions (Kumar *et. al.*, 1988). Middle and Upper Paleolithic sites are found in western Rajasthan, Central India, Chhota Nagpur plateau, Deccan plateau and the Eastern Ghats (Misra 1989). The earliest evidence of art, in the form of engravings on ostrich eggshells (Sali 1989) and of ephemeral structural remains which resembles a rectangular rubble platform (Kenoyer *et. al.*, 1983), also comes from this stone age phase. Together, the Middle and Upper Paleolithic phase dates between 1,50,000-10,000 BP.

The Mesolithic phase in India shows evidence of significant cultural evolution. It is marked by a spurt in human population as the tremendous increase in the number of settlements indicates. This was mainly due to the increase in rainfall during the Holocene Period (10,000 BP onwards), the evidence for which is provided by the pollen data from the salt lakes of western Rajasthan (Singh *et. al.*, 1974), deep weathering of sand dunes in Rajasthan and Gujarat (Misra 1978) and presence of wind-blown clay deposits in Central Indian rock shelters (Allchin *et. al.*, 1978).

It also marks the movement of people into regions so far unoccupied, e.g. the Ganga plains (Sharma *et. al.*, 1980), the deltaic region of West Bengal (Lal 1958), and Kerala in the west coast (Rajendran 1983). Although hunting, fowling, fishing and wild plant food gathering continued to be the subsistence pattern, artifacts such as grinding stones from this phase suggests some form of food processing. There is a surge of artistic activity in the form of rock paintings at the rock shelters in the Vindhyan sandstone hills of Central India (Neumayer 1983, Mathpal 1985). The depiction of bows, arrows, spears, daggers, sickles etc. in these paintings suggests enhanced efficiency in hunting, collection and processing of wild plant foods. The first evidence of intentional disposal of the dead also comes from this period (Lukacs *et. al.*, 1982, Kennedy *et. al.*, 1992), suggesting spiritual beliefs.

Although the Mesolithic is followed by the Neolithic, certain regions, particularly the regions around the Indus river, developed into centers of trade and agrarian activity. This was combined with the knowledge and extensive use of copper; hence the period is also known as the Chalcolithic phase in Indian prehistory. In the rest of India, particularly the Deccan, the Mesolithic evolved into the Neolithic, wherein the kind of faunal remains, stone tools and the crude pottery found indicate the existence of small-scale agrarian activity and animal husbandry along with the hunting-gathering subsistence pattern. These settlements flourished around the fourth to second millennium BCE and are confined to the Kashmir valley, the northern Vindhyas, middle and eastern Ganga valley, North-East India and the Deccan.

Substantive architectural remains in the form of simple wattle and daub huts in circular and rectangular shapes begin to appear in this phase. Some of the remains suggest a certain degree of settlement planning. The Neolithic sites of Kashmir suggest underground dwellings, with hearths and steps cut into the walls (Kaw 1989). The Neolithic phase in these areas continued to 1500 BCE.

Similarly the Megalithic phase co-existed with the Neolithic almost all over India. The Megalithic phase is represented mainly by the different kinds of burials, consisting of huge blocks of stone used to mark the graves. At several places in the northern Vindhyas, Vidarbha and South India, there are large Megalithic fields consisting of several hundred burial monuments. This phase continued into the Early Historic period (600 BCE); similar burial practices continue even today among some tribal groups (Moorti 1994).

During the Mesolithic phase, the nomads in the regions extending from the east coast of the Mediterranean up to the eastern edge of the Baluchistan plateaus were experimenting with the breeding of selected wild animals and cultivation of selected wild grasses. The first animals to be domesticated were dog, cattle, sheep and goat, and the first plants to be cultivated were wheat and barley (Weber 1991; Kenoyer 1998). The assured food supply generated by agriculture led to sedentarization of human settlements and establishment of villages. Extraction and smelting of copper also began around 7000 BCE in West Asia. The technique of producing bronze, a stronger metal than copper, revolutionized transport and pottery production.

The site of Mehrgarh, on the eastern edge of the Baluchistan Plateau overlooking the Indus plain, has pushed the antiquity of settled village life in the subcontinent to the seventh millennium BCE (Jarrige 1986). The dispersion of population led to the occupation of regions around the Indus River Valley. Mohenjo-daro and Harappa were among the first few sites to be excavated. However, excavations carried out in the last fifty years have unearthed numerous regional cultures, which seem to have also evolved simultaneously among the hills separating the narrow valleys of Baluchistan, in Saurashtra (Gujarat), in the Ghaggar-Hakra riverbeds of Rajasthan, and in Northern Pakistan. This is suggestive of considerable spatial and temporal diversity in key areas like town planning, architecture, ceramics, crafts and disposal of the dead. Collectively called the Indus Valley Civilization, the settlements are dated to between 3600 and 1800 BCE and spread over an area of more than one million sq km (Possehl and Raval 1989). The settlements vary in size from a few square meters to over a hundred hectares. The larger settlements provide excellent evidence of technology, economy, material culture and social organization. There is evidence from several sites not only of specialized industrial production of a variety of items, but also of coastal trade with the Persian Gulf countries (Ratnagar 1981; Lal 1997; Kenoyer 1998) and inland trade with contemporary hunting-gathering communities (Misra 1976; Possehl and Kennedy 1979).

The later phase of the Indus Civilization is marked by the collapse of its urban character into small semi-urban and rural settlements, located mainly in the upper reaches of the Ghaggar tributaries in Rajasthan, the Ganga-Yamuna doab in Uttar Pradesh and Gujarat. Further spread and interaction with local cultures gave rise to many more cultural zones during the first millennium BCE. Each cultural zone is characterized by its ceramic types, namely the Ochre Coloured Pottery (OCP) culture in the Ganga-Yamuna Doab; the Ahar culture in the Mewar region of Rajasthan; the Kayatha and the Malwa cultures in the Malwa region of western Madhya Pradesh; and the Savalda and Jorwe cultures in western Maharashtra. Subsistence continued to be a mix of both agrarian and pastoral activity along with hunting-gathering. The introduction of iron in the first millennium BCE led to large scale clearing of dense forests of the sub-humid plains of the Ganga valley and brought about effective human colonization of this vast fertile region. This region soon emerged as the seat of power from among the 16 *Mahajanapadas* (territorial states) during the 6th century BCE and laid the foundation for Indian history.

3.2.2.2 Evolution of Domesticated Species

(Note: The section is based on Zeuner 1963; Vishnu-Mittre 1977; Chang 1989; Thomas 1989; Rao and Murti 1990.)

Crops

India is known as a site for the earliest domestication of several crop and livestock species. In the case of crops, available records date back to the Neolithic (4500-4000 BCE) and Harappan (4600-3750 BCE) cultures, both characterized by incipient farming. Neolithic culture sites have been located in the north, east and south of India, while the Harappan sites are all located in the western region of the subcontinent, including Pakistan.

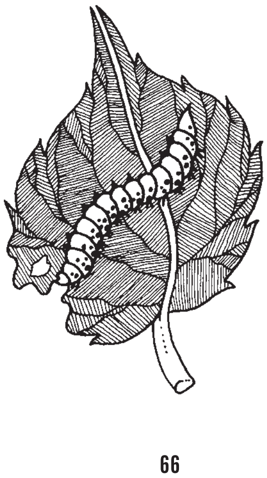
At the northernmost (and earliest) Neolithic site of Burzahom in the Kashmir valley, only seeds of wild forage plants, such as *Lithospermum arvense*, *Medicago polymorpha* , *Lotus corniculatus* and *Ipomoea* species were found. However, from the eastern Neolithic sites, such as Chirand, Singhbhum and Oriyup in Bihar, rice (*Oryza sativa*) has been found. In fact at Chirand, wheat (*Triticum sphaerococcum*), 6-rowed barley (*Chordeum vulgare*), both naked and hulled, rice of the *Oryza sativa* and *O. rufipogon* types, pea (*Pisum sativum*), lentil (*Lens esculenta*) and grass pea (*Lathyrus sativus*) have also been found. Wild rice (*Oryza perennis*) was found at the site of Baidipur in Orissa. At the southern neolithic sites of Hallur, *ragi* (*Eleusine coracana*) was found, and the wild bean (*Macrotyloma uniflorum*) was recovered at Tekkalakota. The Neolithic plant economy appears to have been largely of the subsistence type. The occurrence of highly advanced cultivars is believed to have been due to contacts with advanced contemporary cultures.

The agricultural economy of the Harappan culture on the Indus plains was based on the cultivation of wheat and barley. Harappan crops were primarily wheat, barley, sorghum (*Sorghum bicolor*), *Pisum sativum*, *Brassica*, *Sesamum* and dates. The Harappan short wheat (*Triticum sphaerococcum*), is considered to have originated in the western part of the subcontinent. Its evolution from *T. aestivum* or *T. compactum* was probably a result of natural adaptation to aridity of the climate, rather than any intervention by the Harappans. Chickpeas (*Cicer arietinum*) also formed a part of the Harappan diet. The Harappan settlements in the semi-arid regions of Gujarat have yielded millets like *jowar* (*Sorghum bicolor*), *bajra* (*Pennisetum typhoideum*), *ragi* (*Eleusine coracana*), little millet (*Panicum miliare*) and Italian millet (*Setaria italica*). Wild relatives of rice like *Setaria italica*, *Eleusine coracana*, and species of several wild herbaceous plants such as *Scirpus lateriflorus* and *Atriplex stocksii* were found at the Harappan site of Surkotada in Kachchh. At this site, wild plants accounted for a very high percentage (93%) of the seeds recovered. Apart from food crops, remnants of cotton (*Gossypium arboreum*) cloth and bast fibres were found at the Harappan site of Mohenjodaro.

The post-Harappan period saw a number of cultures spread over the country. This period extended up to about 3000 BP. In the east, rice is known from Mahisdal in Birbhum (Bengal) and from Chirand and Kausambhi in the Ganga-Yamuna Doab. At Atranjikhera in Uttar Pradesh, rice, barley, chickpeas, *Lathyrus* species, and a fibre-yielding plant of the Urticaceae family, *Boehmeria* sp., were recovered. At Ahar in Rajasthan, rice, sorghum and pearl millet (*Pennisetum americanum*) have been found. At Noh near Bharatpur in Rajasthan, rice, horse gram (*Macrotyloma uniflorum*) and the green gram bean (*Vigna radiata*) were recovered. Wheat was found at Kayatha in Madhya Pradesh, while at Navdatoli-Maheshwar in the same state, crops included wheat, rice, green pea (*Pisum sativum*, *Lathyrus sativus*), black gram (*Vigna mungo*, *V. radiata*), lentil (*Lens esculenta*), wild jujube (*Zizyphus nummularia*), linseed (*Linum usitatisimum*), and gooseberry (*Phyllanthus emblica*). From the Deccan sites in Maharashtra, flax fibre was found at Chandoli, silk at Nevasa, wheat at Songaon, and barley (*Hordeum vulgare*), lentil, black gram, green gram and melon seeds were found at Inamgaon. Rice appears to have been the most popular cereal in the Chalcolithic period. While it appears to have been used exclusively in eastern India, it was eaten in conjunction with other cereals in northwest and central India.

Coming to the Early Historic Period (about 1600-1700 BP), rice (*Oryza* spp.) was found in eastern and central Indian sites such as Sonepur, Rajgir and Pataliputra in Bihar, Rajghat and Hastinapur in Uttar Pradesh, Nagda, Ujjain and Garkhalia in Madhya Pradesh, and Kunnatur in Madras. *Vigna radiata* was found at Noh in Rajasthan; rice, *Pisum sativum*, *Lathyrus sativus*, *Zizyphus nummularia* and *Z. sphaericus* from Kaundinyapur (Maharashtra); and sorghum and chickpea (*Cicer arietinum*) from Bhatkuli in Maharashtra. Wheat, rice, barley, *Paspalum scrobiculatum*, *Macrotyloma uniflorum*, *Pisum* spp., lentil, black gram, *Lathyrus sativus*, castor (*Ricinus communis*), and *Zizyphus nummularia* were recovered from Ter in Maharashtra.

There is some controversy over the first known cultivation of rice. The Asian cultigens of rice have evolved from an annual progenitor over a wide belt ranging from the southern foothills of the Himalayas, across Upper Myanmar, northern Thailand and Laos, to north Vietnam and south-west and south China. Rice grain has been found embedded in earthen pots, and rice husk in cow dung, at Koldihwa and Mahagara, Uttar Pradesh, sites dating to about 7000 years BP.[2] Other crops such as sorghum (*Sorghum vulgare*), *ragi* (*Eleusine coracana*), pearl millet (*Pennisetum americanum*), *Macrotyloma uniflorum*, *Paspalum scrobiculatum*, *Phaseolus spp*., *Brassica*, *Sesamum*, *Buchanania* and date palm (*Phoenix dactylifera*) were first cultivated or consumed in the Indian subcontinent. No earlier records of these crops have been found elsewhere. There are also records of tea (*Thea sinensis*) being cultivated at least 4000 years ago in north-east India.



Animals

Domestication of animals in India goes back as far as 7000 years BP, judging from evidence from Mesolithic sites at Bagor in district Bhilwara in Rajasthan and Adamgarh near Hoshangabad in Madhya Pradesh. At Bagor, sheep/goat were identified as the principal domestic animals, while at Adamgarh, zebu cow (*Bos indicus*), buffalo

(*Bubalus bubalis*), sheep (*Ovis aries*), goat (*Capra hircus*), pig (*Sus domesticus*) and ass (*Equus asinus*) were all identified as domestic animals. Evidence for an agro-pastroal economy comes from faunal remains from the Neolithic sites of Peninsular India, which include zebu, buffalo, sheep, goat, pig (*Sus scrofa cristatus*), dog (*Canis familiaris*) and fowl (*Gallus spp*.) (Thomas 1974).

Box 3.1 First Domestication of Indian Animals

Millennium (BCE)	Domesticated Animals
12	
	Dog (10,000 – 12,000 BCE)
10	
9	
8	Pig (8,000 BCE)
	Sheep and Goat (7,000 – 8,000 BCE)
7	Cattle (7,000 BCE)
6	
5	
4	Donkey and Poultry (4,000 BCE)
	Horse (3,500 BCE)
3	Buffalo, Dromedary and Bactrian Camel (3,000 BCE)
	Silkworm (2,500 BCE)
2	Honeybee (2,000 BCE)
	Cat (1,000 -1,600 BCE)
1	Himalayan Musk Deer, Asian Elephant

Source: Adapted from IIPA 1996

The humped Indian cow, the zebu (*Bos indicus*), was the predominant domestic animal in the early cultures of India. Zebus appear to have descended from the wild cattle *Bos namadicus* (Zeuner 1963). *B. namadicus*, along with the European *B. primigenius*, are in turn possible descendants of *Bos acutifrons*, found in the Indian Shiwalik hill range around the Pliocene Epoch (5 to 2.5 million years ago). From all prehistoric levels and even up to some of the early historic cultural periods, zebus were killed for meat and were a major source of subsistence. Next in order of preference in the food economy from among domestic animals were sheep, goat, pig and buffalo. The dog (*Canis familiaris*) is associated with most prehistoric cultures.

Cattle were probably also used for heavy traction or draught purposes and for running irrigation devices. The use of cattle for threshing harvested crops is also a possibility. Terracotta wheeled carts found from Harappan sites indicate that cattle were used for draught purposes. The horse (*Equus caballus*), was introduced late into the early cultures of India, in an already domesticated form. Although fragmented remains of *Equus caballus* have been noted at the Harappan levels in Gujarat (Meadow and Patel 1996), it was during the Iron Age (3000-2400 BP) that horse-breeding became prevalent. Horse ornaments and equipment recovered from the Megalithic (3000-2100 BP) sites in the Vidarbha region of Maharashtra suggest the use of this animal for riding. Megalithic stone circles in the Vidarbha region have brought to light partial burials of horses in the form of skulls and lower extremities of limb bones.

It was from these early beginnings that Indian civilizations developed one of the world's most diverse and intricate agricultural and animal husbandry systems, one which aptly mirrored the region's great natural biological diversity. Indeed, several species from this region spread to and greatly influenced the agricultural development of ancient Egyptian, Assyrian, Sumerian, and Hittite civilizations (Mehra and Arora 1982). Indian crops were also taken to South-East Asia by Buddhists, and exchange took place with regions in Africa. In more recent times, around the 8-10th century A.D., Arabs took *Citrus* spp., cotton, jute, rice, and sugarcane to the Mediterranean region.

3.2.3 History of Land and Resource Use

(This section is largely based on Gadgil and Guha 1992, Chakravarti 1998, Flint 1998 and Rangachari and Mukherji 2000, except where otherwise indicated.)[3]

Agrarian activity proliferated with the emergence of the vast Mauryan Empire during the 3rd century BCE. Prior to this, both during the Indus civilization as well as during the Chalcolithic phases in Indian history (*see Section 3.2.3.1*), we see mostly small-scale irrigation structures. Domestic wells were commonplace at Harappan sites, except at large Harappan settlements like Dholavira (3500-1700 BCE) in Kachchh, where the settlers seem to have masterminded a unique system of water management.[4] At the Chalcolithic settlement of Inamgoan, there is evidence to suggest that the farmers used to divert the flood water of an adjacent river through a stream (Dhavalikar *et. al.*, 1988).

Early historical, archaeological and literary evidence from 600 BCE onwards, (e.g. Kautilya's *Arthashastra* 321 BCE, Megasthenes' *Indika*, Visakhadatta's *Mudrarakshasa*, and the inscriptions of Ashoka) indicates that a large share of the resources of the Mauryan empire came from the agrarian sector. The independent forest department, the duties of the superintendents, offences and the corresponding penalties are elaborately mentioned in the *Arthashastra*. That agriculture was the mainstay of the economy is evident from Megasthenes' statement that the cultivators were the most numerous communities in the Maurya period (Majumdar 1960). Kautilya's *Arthashastra* even discusses the political management of agrarian life (Kangle 1965). The programme of creating new settlements (*janapadanivesa*) as described in the *Arthashastra* indicates how deserted zones were brought under cultivation. This was done by populating the area with people from abroad or by shifting inhabitants from an overpopulated zone within the empire. While some of the land thus allotted went to priests and royal officers who were exempted from taxes, most of the arable land was distributed among tax-paying cultivators. These were mainly landless peasants from the Shudra community. This programme was closely integrated with irrigation projects of the state, because agrarian resources were considered a major source of wealth (*janapadasampat*) (Kangle 1965).

The spread of agrarian activity also resulted in large-scale forest clearance all over the subcontinent. In the process, hunter-gatherer communities were compelled to move into adjoining hilly tracts or take to agriculture and/or associated occupations and get assimilated into the steadily expanding caste-based rural and urban society. Clearance of forest was significant not just for the emergence of rural settlements but also to provide for large gardens near urban centres. (For example, the use of the suffix *vana* attached to the pleasure garden called *Jetavana* in the ancient town of Sravasti may imply the previous existence of a large forest tract.)

Irrigation resulted in the growth of rice agriculture both in the Ganga plains and peninsular India. Rapid increase in the use of the plough and demographic growth were associated developments, which in turn led to the spread of monarchial state systems and urban centres all over the subcontinent.

The Post-Mauryan period saw the cultivation of various types of cash crops, like cotton in the black soil of the Deccan, pepper in the far south, coconut on the Konkan coast and sugarcane in the Ganga valley. The *Manusamhita* emphasizes individual efforts to clear uncultivable areas and convert them into arable plots. There is hardly any reference to politico-administrative measures in this direction. The management of hydraulic projects – particularly local level and small-scale ones – was largely in the hands of individuals or groups of persons, though state interest and initiatives in large-scale irrigation works did not entirely stop (for example, the Tamil Sangam literature of this period speaks of the initiative taken by the Chola King Karikala in draining out the floodwaters along the Kaveri Delta). Of the local-level hydraulic projects, wells and tanks figured most frequently.

During the Gupta and Post-Gupta Period (4th-12th Centuries CE), uncultivated fallow tracts were regularly donated to members of priestly communities and to religious establishments and complexes such as Buddhist *viharas* and brahminical *mathas*. Epigraphic evidence repeatedly refers to donations of wells and tanks to individuals and religious establishments, such as Buddhist *sanghas*. While this tradition paved the way for the creation of settlements of priestly communities, it also led to the expansion of agriculture in hitherto uncultivated land (Sharma 1965). This also led to large-scale felling of forests.

Two new types of irrigation works, the water wheel or *araghatta* and the step-well or *vav*, became predominant around this time in the semi-arid states of Gujarat and Rajasthan (Jain 1990). This led to further growth and diversification of crops.

In south India tanks played a very important role in local-level irrigation projects (Chattopadhyaya 1973). Karnataka has over 44,000 man-made tanks constructed over centuries, beginning with the Vijayanagara dynasty (Karnataka *State BSAP*). Tanks were also the backbone of irrigation in medieval Tamil Nadu (Pallava and Chola period); these were managed by village assemblies (Dikshitar 1946). It has been suggested that the storage tanks of the Badaga tribe in the Nilgiri region might have been the forerunners of the complex tank irrigation techniques of South India (Allchin and Allchin 1968).

Extension of cultivation at the expense of forests, savannah or swamp was a common phenomenon throughout history. However, although agrarian expansion in the Indian subcontinent began during the Indus valley civilisation, the immensity and wealth of the surviving Indian forests in the 7th century CE was impressive, as has been very well recorded by Huen T'sang, the Chinese traveller to India. In fact, till four centuries ago the area under the plough was only 25% of the land area. In other words, forests, scrub, savannah and wetlands covered three-fourths of the landscape (Trivedi 1998).

The situation continued without much change during the late medieval and Mughal Period (1526-1700 CE). The proliferation of local-level irrigation projects over major parts of India is one of the principal features of the socio-economic and environmental history of medieval India. The old Yamuna canal constructed during the rule of Firoze Shah Tughlaq in the 14th century CE is a remarkable example of canal irrigation. The Muslim period is credited for selection and hybridisation of a wide variety of fruits. Contact with the west led to the introduction of several plants. However, this still remained an era of more forests than cultivated land (Moreland 1920).

A critical feature of land and water use up to this point in Indian history was the predominance of regimes of common property resources (CPRs). Large tracts of forests, pastures or grazing lands, freshwater bodies, coastal and marine areas and to some extent agricultural lands (especially *jhum* lands) were under CPRs, controlled and managed by village institutions. Many of these would have been technically owned by rulers, but this was largely nominal. CPR management systems were often highly sophisticated, involving complex customary rules and institutions based on deep ecological knowledge and cultural values, oriented towards conservation and judicious use of resources. Many of today's biodiversity-rich tracts owe their existence to such CPR systems (*see also Sections 3.3.2 and 3.3.3*).

The British colonial rulers' involvement in land – and water-use systems began with renovation and maintenance of the existing irrigation systems. New constructions were taken up from around the mid-nineteenth century, first under the military engineers and then under the newly constituted civil body, the Public Works Department (PWD) (Sengupta 1991). It was also during the colonial period that the scale and sweep of forest exploitation shot up dramatically. Forests were destroyed not just for revenue, but also to set up the railways (Nair 1985). The most accessible stands, located close to the coast or the riverbanks were the first to be cleared. Forests were cleared to develop plantations, and to take up commercial cultivation or animal husbandry (Pouchepadass 1995).

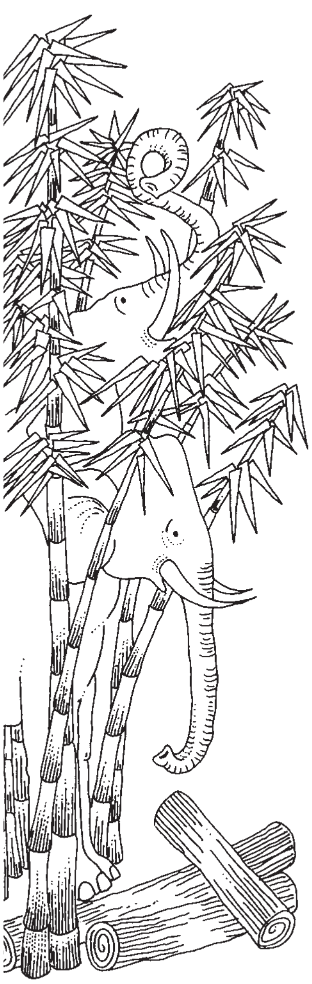
Among the various government policies, the 'permanent settlement' system, with its incentive to increase the rent rolls of *zamindars*, became an engine of deforestation in eastern India. Nature became an object to be 'mastered, exploited, transferred and commoditised, a means of speculation, a merchandise' (Pouchepadass 1995). Common property resources were turned into private or state property.

Along with the industrial revolution this intervention led to further exploitation of natural resources, such as wood for paper and fuel for transport. The commodification of objects such as wood had profound implications for resource use. From 1778-1860, the demand for timber for British merchant ships alone increased fourfold. In 1806, some forest area in the Malabar region was set aside to supply teak to the Royal Navy shipyards. In the 50 years following 1860, railways expanded almost 50 times – from 1,349 to 51,658 km (*ibid*). The anxiety to ensure a steady supply of timber for the railways (the first track was laid in 1853) led to the Forest Acts of 1865 and 1878; as a result of these the British in effect annexed large areas of land, and the land area of British India further increased by a fifth (Saberwal *et. al.*, 2001). The ecological effects of the destruction were most vividly seen in the districts of North Arcot and Chingleput of the Madras Presidency, where the ravage of deforestation led to alternating cycles of floods and drought. This also led to the demand in 1860s for a department to deal with forest conservation.

From 1869-1925, the forests, which were in states under the control of the princes, were also drawn into the orbit of colonial capitalist expansion. Tree felling exceeded sustainable limits in many cases (Gadgil and Guha 1992). Large-scale slaughter of wild animals (Elliott 1973) and the conversion, by British business houses, of large expanses of woodland into tea, coffee and rubber plantations were the other features of forest degradation during the colonial period.

In the course of a hundred years, between 1880 and 1980, about 42 million hectares of land was converted to 'fields' and the magnitude of forest loss (38 million hectares) indicates that much of this agricultural expansion took place at the expense of India's forest (Flint 1998). Tea plantations in the hills of Assam and Bengal in the 1850s and the expansion of rice cultivation along the Brahmaputra plains led to the extermination of animals like the rhino and wild buffalo over most of their range.

The domination of the economy by the colonial government also meant the penetration of the market into the subsistence economy and, with this intrusion, break-up of cohesive local communities. The state's takeover of forests and their subsequent use for commercial purposes were inevitably accompanied by the diminution of customary rights (Rangachari and Mukherjee 2000). The most serious consequence of colonial forestry policies and practices was the decline in traditional forest conservation and management systems. Simultaneously, sweeping changes in land ownership and management policies (e.g. regarding land tax), undermined the common property regimes that communities traditionally managed them under (*see also Section 4.2.3*). Traditional community restraints on resource exploitation slowly weakened. Traditional systems like *jhum* or shifting cultivation were viewed by colonial administrators as primitive and unremunerative forms of land-use. Settled agriculture and the forest-based subsistence activities of tribals were adversely affected by forest reservation.



By the mid-1800s, communities across the country were resisting colonial intrusion on their lands, forests and water systems. There were many small and big struggles by the tribals for their right to livelihood. Peasant rebellions against the British and against Indian feudal princes began in the late 18th century. This opposition was particularly manifest in tribal areas. Among the earliest uprisings was that of the Ho community in Chhota Nagpur (1820-1821), protesting the dislocation of their livelihoods by colonial rulers and moneylenders and *zamindars* supported by the British. There were also protests and rebellions against colonial laws such as the Forest Act of 1878 (S. Kothari 1993). These protests did not abate after a wide range of legislations on forest and forest use were consolidated in the Indian Forest Act of 1927 and some protective legislation granting specific rights to forest-dwellers was promulgated.[5]

The Bhils revolted in 1846 while the Koya tribals revolted in 1862, 1879 and 1880. The rebellions in Bastar in 1876 and the Rampa rebellion in the Godavari district were other major instances of forest *satyagrahas* against the Indian Forest Department.[6] In Jharkhand, the recorded history of resistance movements defending land and forests dates back to the early 1600s. The well-documented ones among them are the Tika Manjhi revolt of 1780, the Kol revolt of 1831, the Santhal Hul revolt of 1855 and the Birsa revolt of 1900.[7] The Santhal rebellion was of particular importance as it involved communities spread over the entire Santhal region, stretching from Bihar to Orissa, and was in direct opposition to colonial policies that disrupted their complex systems of cultural and economic life. In other parts of the country, widespread participation of peasants and tribals in the nationalist movement was visible by the 1930s, culminating in the Telangana and Tebhaga peasant struggles in 1946. In the post-Independence period, socialist and communist leaders led major struggles of farmers and tribals in different parts of the country. Notable among these were movements led by Godavari Parulekar in Maharashtra and Ram Manohar Lohia in Uttar Pradesh.

The interaction of colonialism, technological development, and resource reallocation from subsistence-use to central governments or external markets has generated land-use conflicts between the Indian agricultural and forestry sectors throughout the nineteenth and twentieth centuries (Flint 1998). While adherents of the newly emerging colonial science of forestry had begun to blame the agrarian and forest practices of forest-dwellers for the decline in forest cover, tribals and peasants continued to wage remarkable struggles based on their own moral economy.[8]

Box 3.2 Rulers and Wildlife in India: A Brief History

State-led conservation to save vanishing species is relatively recent, but the strategic value of certain animals and the value of specific landscapes was recognised from a very early period. The prehistoric rock paintings of hunter-gatherers, excavated faunal data and the artifacts of the Indus valley and later Chalcolithic period settlers (*see Section 3.2.2.1*) have documented the presence of a wide variety of aquatic and terrestrial animals in India. The literary evidence available from the 3rd century BCE onwards, including the early Sanskrit texts such as the pharmacopoeias of Susruta and Charaka, the Smritis and the Tamil literature of the Sangam period (1st-2nd century CE) indicate a complex ranking of landscapes and eco types and an awareness of different plants, animals and diseases. The Jain and Buddhist religious texts as well as the Jataka tales preach non-violence and compassion for all living creatures. However, references to protection given to fauna with the intention of species conservation are few. Documents like the 3rd Century BCE *Arthashastra* mention '*Haathivanas*' or 'Elephant Forests', wherein wild animals like elephants, which were of strategic importance to the state in warfare and carriage, were protected. The rulers also laid claim to forests from which timber, tusks, animal skins and other resources could be secured. The rock edicts and pillar inscriptions of Ashoka briefly mention 'protection' given to animals. Animal sacrifices were outlawed and there was a ban on burning of forests during his rule.

The Sultanates of Delhi and Central India, and later the Mughals (especially in the period from 1526 to 1707 CE) left behind a treasure trove of material in the form of written records, memoirs and portraiture. For example, the *Baburnamah* (Memoirs of Babur, the first Mughal ruler who died in 1530 CE) contrasted the animals and plants he saw in India with those of Central Asia. It records in detail the 'great masses' of rhinos between the Indus River and the city of Bhira. He was known to closely observe animals, hunting techniques of the tribals, ways of tracking tigers etc. The *Tuzuk-e-Jahangiri* (Memoirs of Jahangir, considered the greatest naturalist among the Mughal rulers) and the *Ain-e-Akbari* of Abul Fazl contain important and detailed observations in ornithology. Jahangir's court ateliers were the first to paint the Dodo and the Siberian crane (Divyabhanusinh 1995).

The Mughals developed hunting into a ritualised activity laden with political meaning. Denudation of forests and capture of animals were routine during times of war. Elephants were caught from Central India and Gujarat. They were received as tributes from the north Indian jungles and from the Northeast. Peasants and tribals who helped in clearing jungles and provided information about wildlife were rewarded. However there were also prohibitions on hunting at sacred sites and on sacred days. For example, hunting was prohibited at the Shetrunjaya hills in Saurashtra, Gujarat, a holy site for the Jains, and probably the first centre that provided care and medical help to sick and abandoned animals.

Even after the disintegration of the Mughal empire after 1707 CE, leisure sports like falconry, cheetah coursing, horsemanship and archery continued as the pastimes of landed gentry in North and Central India. Agrarian expansion was fast changing the vegetation and landscape pattern of the country, while wild animals were also being trapped on a larger scale. At the same time, local sects like the *Bishnois* (founded in the early part of the 16th century) whose followers believe in protection of all living things, spread into parts of Rajasthan, Haryana and Punjab.

Within two decades of defeating the rulers of Bengal in the battle of Palashi in 1757 CE, the British announced special cash rewards for any tiger killed. Carnivores were seen as vermin and it was considered a civilisational duty to exterminate them. In the Gangetic *doab*, a princely sum of 4 rupees was given for a tiger's head in the mid- 1820s. This reward system had the strength to break age-old religious and cultural values that forbade outright slaughter. For farmers and pastoral groups, this was an added incentive to get rid of animals that troubled them. For the rulers, hunting became a colonial sport that affirmed power and superiority among the natives. Over 80,000 tigers, more than 1,50,000 leopards and 2,00,000 wolves were slaughtered in the fifty years from 1875-1925.

On their part, the treaty-bound Indian counterparts, ruling over their respective princely states and subjugated by a superior power, found an outlet for their energies in asserting their rights over the beast of the forests. The Raj did not allow them to wage war against each other. The right to hunt certain beasts became a matter of dispute within princely states. The Nizam of Hyderabad did not allow even his own relations to shoot around the Packall Lake. The Nawabs of Junagadh in Gujarat guarded the population of Gir lions within their domain, even if it meant loss of cattle. Conversely, huge hunts or *shikars* were specially arranged in honor of colonial visitors. Certain animals of symbolic import (like the tiger) or strategic value (like the elephant) were 'reserved' for the rulers, the nobles and their kin. Such reserves also gave them the opportunity to mingle with the high officials of the Raj. Many of today's famous nature reserves, from Gir in the west to Bandipur in the south, had their origins as royal hunting reserves.

Although royal hunts continued, by the 1880s there was an awareness of the dangers of extinction of animal species, among some of the rulers. This was particularly so for animals like the tiger, whose disappearance would also mean the end of the finest hunting trophy. By this time the tiger was completely wiped out from the regions of Sindh and Punjab. In 1873 Madras Presidency had enacted a law to prevent the indiscriminate slaughter of elephant herds, and in 1879 killing of elephants was prohibited all over the country. The protection given to the lions in the Gir forests averted its extinction from Asia.

In the 18th century, British residents in India did a substantial amount of ornithological work, either individually or in conjunction with institutions like the Asiatic Society of Bengal and the Bombay Natural History Society (BNHS). By 1790 Dr. John Latham had published *India Ornithologicus*, bringing together the existing knowledge of Indian birds and giving them scientific names perhaps for the first time.

The 19th century also witnessed a great spurt in scientific and amateur research on wildlife. British and other foreign researchers pioneered many studies, and groups like the Bombay Natural History Society, Nilgiri Wildlife Association and others raised wildlife concerns to new levels. Botanists and surgeons with the East India Company were at the forefront of drawing new links between denudation, climate change and species extinction (Grove 1996). By the early 20th century there was genuine concern for vanishing species of wild creatures. Surveys and scientific studies became important, with the changing attitudes and aesthetic tastes of the British. The popularity of photographic equipments and field glasses made wildlife study much easier. A few British foresters played a major role in the emergence of conservation consciousness. For example, R.S.P. Bates photographed and documented the protection efforts of the community-run sanctuary near Madras. In Assam, A.J. Milroy was the architect of the Manas Protected Area and the protection of the rhino in Kaziranga. The Indian rulers followed suit and promoted scientific studies and survey of flora and fauna. The State of Cochin subsidised detailed bird surveys. Rao Khengarji, the ruler of Kachchh, reported the breeding of flamingoes in the Great Rann of Kachchh. In 1908, a large tract of grassland along the Brahmaputra River in Assam was set aside as a rhino reserve. During the 1930s and 40s the Thakurs of Morvi protected the rare wild ass in the western deserts. By 1931 the Mysore Maharaja had set aside small Tiger Blocks which were to be left undisturbed. He also established the Ranganathittu Bird Sanctuary, comprising of small clusters of islands in the Kaveri River in 1940 (Lal *et. al.*, 1994). In 1936, the first National Park (Hailey) was set up in the Ramganga-Dhikala forests in the United Provinces.

This period also saw the emergence of the great Indian ornithologist Salim Ali, who is known not only for his scientific work but also for popularising bird watching among the common people. Colonel Jim Corbett not only helped establish the Hailey National Park but also criticised forestry practices that destroyed multi-species forests. By the time of Independence in 1947, India had different categories of protected zones. Conversely, the 20th century saw the extinction of five large mammals from India, all but one before 1947: the Javan and Sumatran rhino, the Sikkim stag, the banteng and, finally, the cheetah.

It is no surprise that several parks and sanctuaries are comprised either of former reserved forests or of old hunting reserves of the princes. At the same time there is little doubt that the highly repressive machinery used by both the British and the princes deeply alienated people who relied on such lands.

Sources (except where otherwise mentioned): Rangarajan 2001; M. Rangarajan, personal communication 2003; Saberwal et. al., 2001; Kothari (in press).

3.3 Social, Economic and Cultural Features of India Relevant to Biodiversity

3.3.1 Demographic Features

As the second most populous country in the world with a majority of the population directly dependent on natural resources for their livelihood, India faces immense challenges in conserving its rich biodiversity while ensuring livelihood and ecological security (see *Map 3.3, Map 3.4 and Map 3.5*).

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%, from 23.9% during 1981-91 to 21.3% 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% in the decadal growth rate (from 24.2% during 1981-91 to 13.9% during 1991-2001), Kerala recorded the lowest growth rate of 9.4% followed by Tamil Nadu (11.2%). In contrast, Bihar's decadal growth rate increased from 23.4% to 28.4%. 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). Between states, however, the population density varies from only 10 per sq km in Arunachal Pradesh to 904 per sq km in West Bengal (*ibid*).

The geographical distribution of the country's tribal population more or less overlaps with the country's forest areas. These areas also have the maximum concentrations of poverty as conventionally defined in financial terms, though this characterisation is simplistic in that it hides the enormous natural wealth of the region that tribals have traditionally had access to. The density of population in such areas is in most cases well below the national average.

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 0-6 age group declined sharply from 945 in 1991 to 927 in 2001. This decline has been particularly sharp in the income-rich states and UTs of Punjab, Haryana, Gujarat, Chandigarh and Delhi, all falling in the 'Green Revolution' belt. In Punjab the child sex ratio declined by 82 points from 875 to 793 in just ten years.

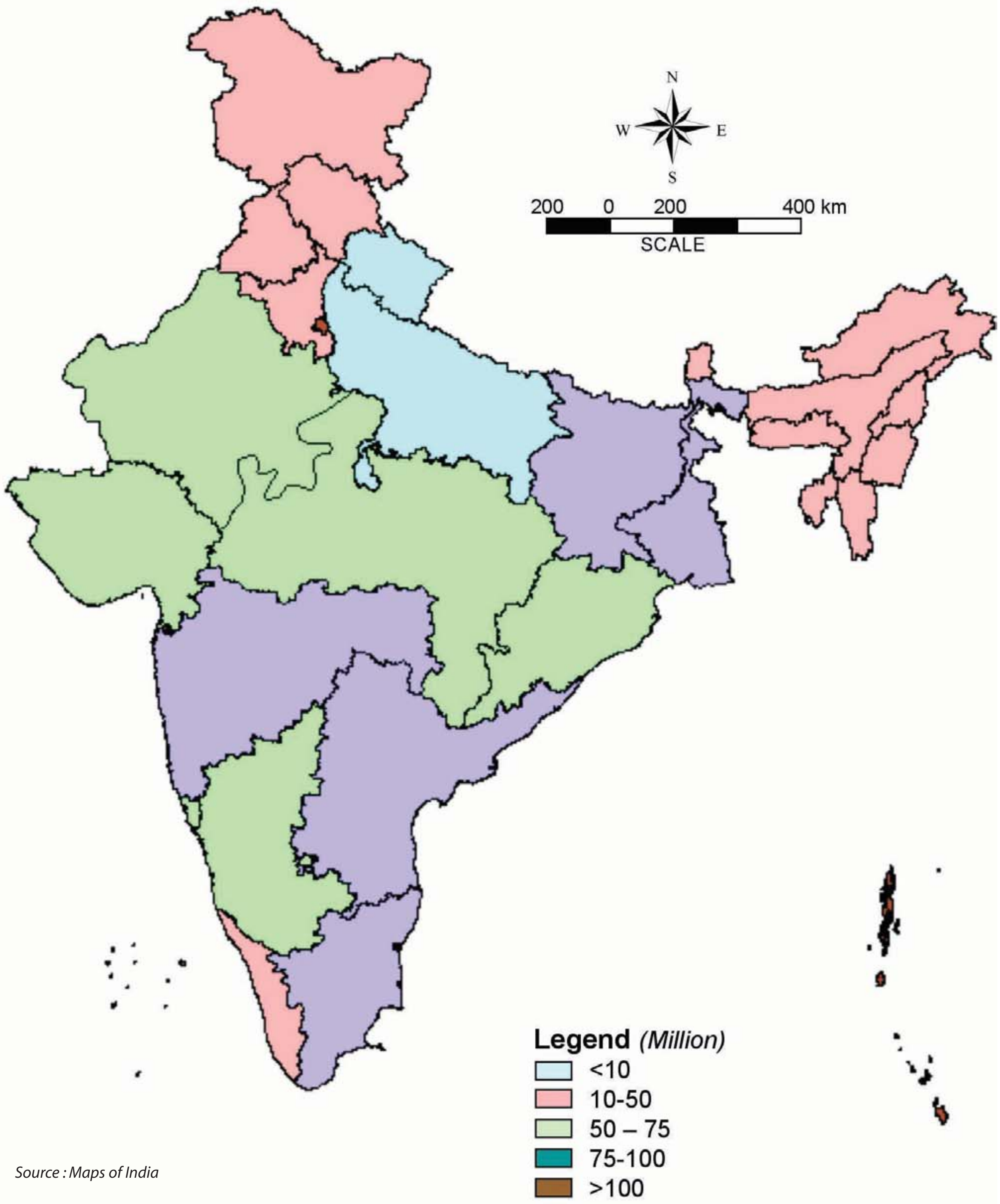
72% of the population lives in rural areas (Bose 2001) and is directly dependent on terrestrial and aquatic resources for its food, health, shelter and diverse livelihood systems. This includes forest-dwellers, tribal communities, small and marginal farmers, shifting cultivators, pastoralists, fisherfolk and artisans (these are not mutually exclusive categories). Out of 580,000 villages in India, gathering from forests and other commons remains an important source of income and subsistence in about 200,000 villages (Saxena 2001c). An estimated 170,000 villages, with a total population of 147 million, have forest land within them (FSI 2000).

Women are major gatherers of biological resources from common lands and key actors in subsistence farming as well as livestock rearing. Several studies have indicated the specific knowledge of bio-diverse plant and crop systems (including seed selection, domesticated livestock breeds, and wild food, fruit and medicinal plants) acquired by women of different communities based on their interaction with local ecosystems for ensuring household food security. The status of women, reflected also in much higher female to male sex ratios than in the non-tribal groups, continues to be high in tribal communities where women are significant contributors to household economies through gathering from forests and other common pool resources. Markets and technologies driven by the 'Green Revolution' have reduced the value of women's specific knowledge about local biodiversity and marginalised them from production processes. This has been accompanied by a declining sex ratio in such areas.

3.3.2 Cultural/Ethnic Diversity and Its Relationship to Biodiversity

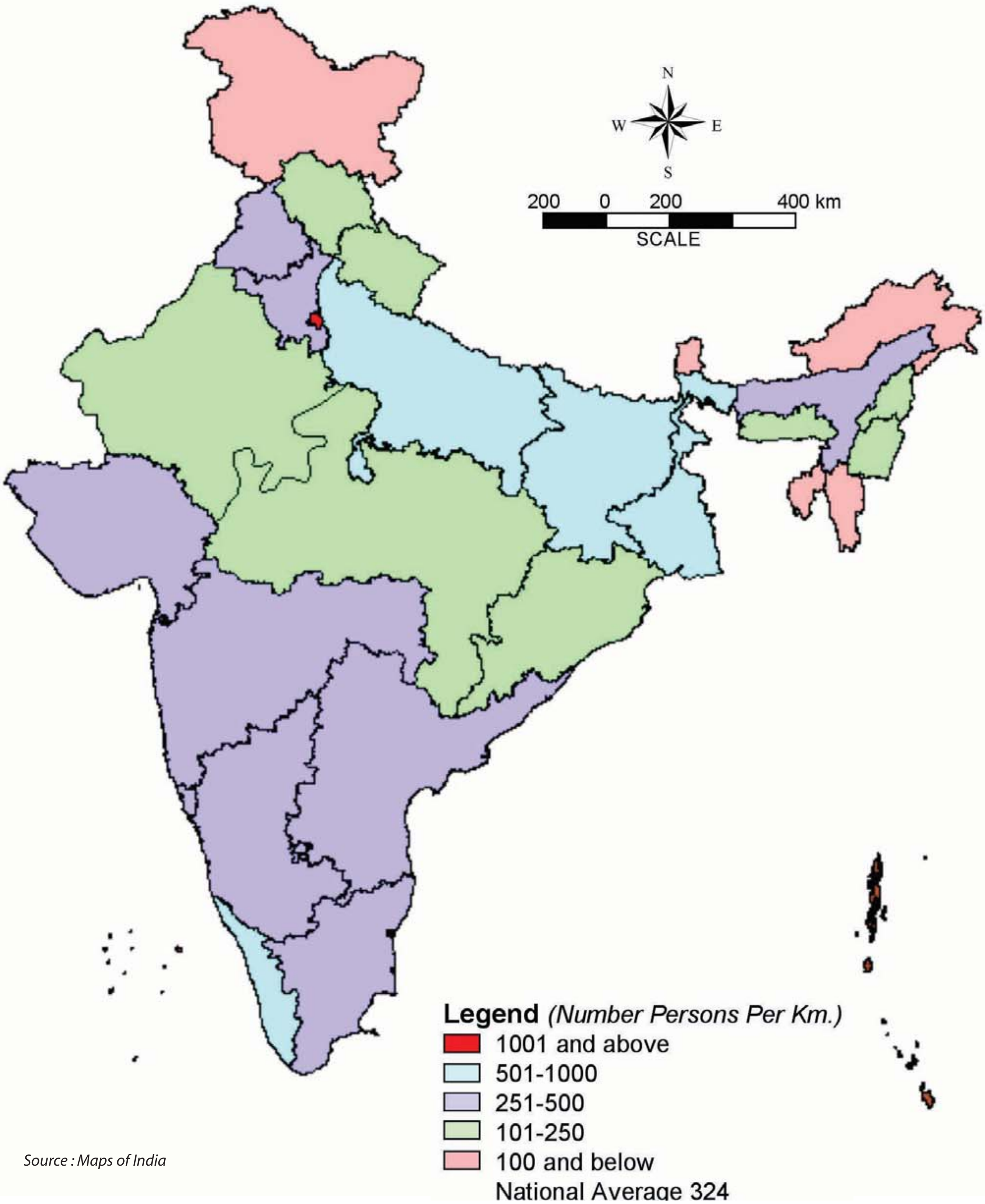
For millennia, biodiversity has supported the livelihoods and life of the people of India, shaping a diversity of cultures in which respect for nature and its myriad life forms has enjoyed a central place. Animals and plants have been revered – often worshipped – and forests, rivers, mountains and lakes have been seen as abodes of the gods. The significant tradition of protecting patches of forests, dedicated to deities and/or ancestral spirits, as sacred groves by many Indian communities is another reflection of the reverence for nature in their religious and

Map 3.3 Population of India (2001)



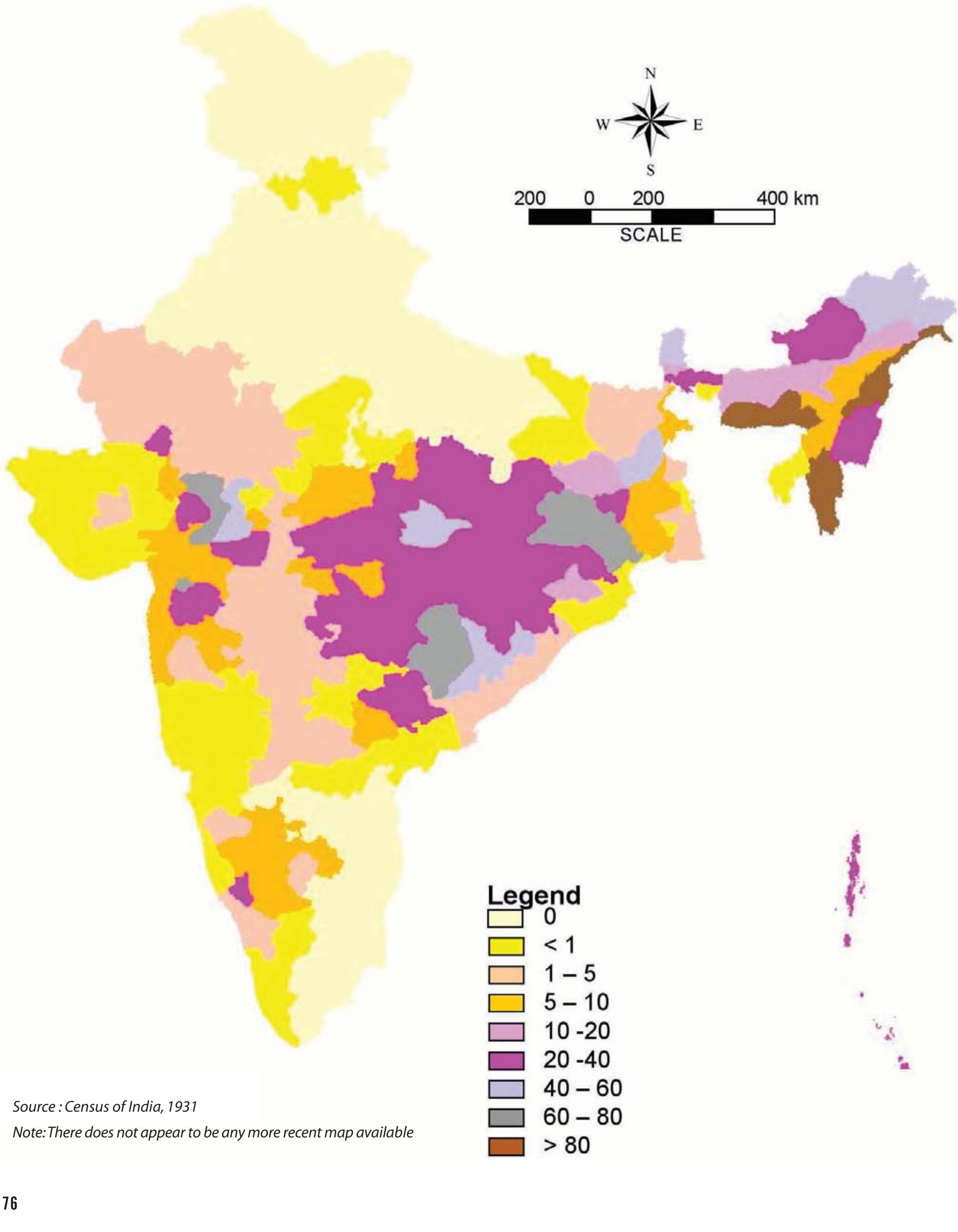
Source : Maps of India

Map 3.4 Population Density of India (2001)



Source : Maps of India

Map 3.5 Tribal Population of India



Source : Census of India, 1931

Note: There does not appear to be any more recent map available socio-cultural life. Many of the sacred groves still provide a safe refuge to several endangered and threatened species of flora and fauna (Malhotra *et. al.*, 2001).

For thousands of years, people have also modified local biodiversity for meeting their changing needs; instigating losses as natural habitats have been replaced by farmlands, and forests by fewer, but perhaps more 'useful' species and varieties. However, this process of replacing natural with managed biodiversity for human gain has resulted not only in losses and extinction, but also in enhanced biodiversity at taxa levels through the creation of thousands of new crop varieties and livestock breeds (Koziell 2001). Such interaction with the local ecosystems has also led to an intertwining of cultural diversity with local biodiversity, both shaping the other in a continuing process of adaptation and change.

The most comprehensive documentation of India's cultural and ethnic diversity has been undertaken by the Anthropological Survey of India (ASI), as part of a series titled *People of India*. The study found the Indian nation to consist of one of the most diverse people in the world, having 4635 identifiable communities with differences in biological traits, dress, language, forms of worship, occupation, food habits and kinship patterns (Singh 1991).

The lives and livelihoods, occupations, dress, songs and settlement patterns of 85% of the communities are rooted in local ecosystems and local natural resources. According to experts, 'rootedness' in the eco-cultural zone is an outstanding characteristic of Indian communities, irrespective of their religious beliefs. This rootedness is apparent in the large number (over a million) of local names of plants and animals.

An analysis of the names of 1018 communities suggests a close correlation of the nomenclature of a community with its occupation based on locally-available resources, place of origin or village or territory, and deity or religious association (Singh 1992). A majority of the communities of India (about 55%) derive their names from the traditional occupations they pursue. These occupations relate mainly to land (agriculture, forestry, fishing) or to labour (craftsmanship, transport, cottage industry). There are also occupations relating to other economic pursuits, and finally there are miscellaneous occupations related to the needs of peasants, folk communities, and urban dwellers. Next to these occupations are a series of community names (about 14%) associated with geographical locations, hills and mountains, plains and valleys, rivers and streams, deserts and forests. Lastly, there are names based on religions and sects.

Peasants derive their identity from the land. Therefore, we have such names as Bhuiyar, Bhuinhar, Bhumikara (land hold), and Bhumij (autochthoneous or indigenous people) derived from the root word '*bhu*', meaning earth. Among the communities which derive their names from occupations are Badhik (slaughterer), Bafand (cotton dresser), Bakarwal (goat herder), Bansphor (bamboo basket maker), Buna (weaver), Barui (betel leaf grower), Kakmara (crow hunter), Sapera (snake charmer), and Tulavina (cotton carder) (*ibid*).

Popular cultural expression cuts across religion. 775 traits – relating to ecology, settlement, identity, food habits, marriage patterns, social customs, social organisation, economy, occupation and impact of change and development – have been identified by experts, 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, indicating their intimate relationship with nature and the living diversity of plant and animal life. Such clans include those with the names of crocodile, corn, panther, buffalo, salt, tree, shrub, tortoise, leopard, water chestnut, chrysanthemum, jaggery, goat, vermilion, rice, flower, tiger, tiger's claw, kite, herb, horse, radish, cobra, pearl, gold, silver, bird, monkey, ape, peacock, rabbit, pepper, fish, jasmine, porcupine, food, brush, red lotus, dead tree, musk, cumin seed, broomstick, tamarind seed, horse gram, milk, cow, bell, gigantic lizard, sandal paste, areca nut, bear, leaf plate, bamboo, moon, frog, banyan tree, cart, plantain, butter onion, pipal tree, elephant, sacred rice, castor seed, etc. (Singh 1992).

Traditional knowledge and the spiritual values assigned to biodiversity are best reflected in the myriad cultural and religious festivals of India's diverse communities. For example, a significant aspect of *Ganesh Pooja* in several parts of the country is the requirement to offer the Elephant God 101 different kinds of leaves in *Patra Pooja*. The worshipper must not only find 101 different trees and shrubs, 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 preserving 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 the forest. For three days the entire town turns green with hundreds of varieties of leaves and flowers decorating the town and the temple (ibid).

An apocryphal story about the Puri Jagannath shrine has it that on each day of the year people made an offering of freshly harvested rice. People had to have knowledge about different varieties of rice, 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 (ibid).

Language, in which local cultures are embodied, is also an important source of diversity and unity. India has as many as 325 languages and 25 scripts in use, deriving from various linguistic families, apart from thousands of dialects. At least 65% of the communities are bilingual and most tribal communities are trilingual. The numerous languages are important instruments of cultural expression and preservation of diversity (Singh 1992).

Although not very well documented, the relationship between human language and biodiversity has been an important manifestation of ethnology. Besides the obvious relationship between parallel systems of language and culture (Hymes 1964), human language is also greatly influenced by the physical and biological world around them. For example, most bird names or words depicting natural resources may have evolved due to semantic justification in reference to the local habitat. A study of Telugu bird names has indicated how the birds of agriculture, gardens, orchards, towns, buildings, sea, rivers, ponds, woodlands, forests and grasslands have been named according to their specific habitat distribution (Bharat 2000).

This intrinsic relationship between languages and biodiversity gets affected with the changing environment. The loss of biodiversity leads to a corresponding loss of associated cognitive concepts and vocabulary. Many factors – environmental and economic factors; the politically motivated demands of cultural homogenization under the guise of 'national integration'; the media; the 'civilizing' and 'assimilating' influence of missionaries of various faiths and social workers – lead to the erosion of linguistic diversity. The growing relative importance of written over spoken languages (and the related issue of standardization), tends to diminish the importance of micro-environments and related subregional occupation- or community-specific linguistic variants. There has been a steady sacrifice of a rich and useful indigenous diversity in favour of convenience of communication.

3.3.3 Indigenous Traditional Knowledge and Pratices[9]

Communities who have lived in close proximity to nature and who have depended on biodiversity for their survival also have an innate knowledge about this biodiversity, a point which often tends to be overlooked.

For thousands of years communities have in many places protected places and species for their religious and cultural significance. Sacred groves are examples of the same. Many of these groves exist even today and some contain within them species that are not found anywhere else in the vicinity. There also exist sacred lakes and ponds, as also sacred landscapes, which have been responsible for the conservation of vast areas (*see Box 3.3*).

Indigenous water harvesting systems have succeeded in saving many a place from drought conditions. Pandey (2001) states, 'Simple local technology and ethic that exhorts "capture rain where it rains" have given rise to 1.5 million traditional village tanks, ponds and earthen embankments that harvest substantial rainwater in 660,000 villages in India.'

Box 3.3 Sacred Spaces

There are many forms of nature worship in our country. These include the tradition of consecrating certain forest and wetland habitats to a particular deity or ancestral spirit. The cultural restriction on interference in these sacred spaces has allowed the complex and diverse array of ecological processes to continue uninterrupted over long periods of time. This has made them important reservoirs of biological diversity, which conserve a range of rare and endemic species.

The most common type of these sacred spaces are patches of forests, designated as sacred groves (SGs). They harbour natural or near-natural vegetation, where harvesting of any living matter is generally prohibited. The sacred groves in different parts of the country are known by different names: *Deorai* (Maharashtra), *Orans* (Rajasthan), *Kavu* (Kerala), *Devar kan* and *Devarakadu* (Karnataka), *Dev van* (Himachal Pradesh), *Sarana* (Bihar), *Umanglai* (Manipur), *Kovilkadu* (Tamil Nadu), *Jaherthan* (West Bengal) etc. SGs are characteristic of most tribal villages and are believed to be a very ancient and widespread institution in the Old World cultures. For example, many of the SGs of Meghalaya are the relic type evolved through millions of years (*Meghalaya State BSAP*). Although 13,720 SGs have been reported so far in India, the total number is likely to be between 100,000 and 150,000 (Malhotra *et. al.*, 2000). The size of the existing SGs varies widely from a cluster of a few trees to several hectares. Most of the SGs harbour rich floral and faunal biodiversity. In Kerala, an SG occupying only 1.4 sq km contained 722 species of angiosperm, compared with 960 species occurring in 90 sq km of the Silent Valley forest (Pushpangadan *et. al.*, 1998).

Sacred landscapes are an elaboration of the concept of the SGs, leading into a set of interacting ecosystem types, both natural and human-made (Ramakrishnan 1998). For example, the land all along the course of the River Ganga is considered sacred. A more holistic expression of the concept of sacred landscape can be found in Buddhist philosophy. Sikkimese Buddhists consider the entire state of Sikkim to be sacred and the area below Mount Khangchendzonga in West Sikkim – a valley known as Rathong Chu, referred to as *Demojang* – the most sacred of all. Any human-induced perturbation is believed to spell disaster to the whole state.

Among wetland habitats, sacred ponds and tanks are common in our country. There are between 1.2-1.5 million ponds still in use and many of these are associated with temples and other places of worship (Pandey 2002). *Devekere*, a large sacred tank in Sirsi town in the Uttara Kannada district of Karnataka, harbours a variety of fishes and aquatic flora (Gokhale *et. al.*, 1998). In many temple ponds of Kerala, crocodiles are looked after by priests and pilgrims (Presler 1971). The tradition of *Machhiyal* in Himachal Pradesh and Uttaranchal allows fish to breed in streambeds or riverbeds.

Sacred spaces are a nursery and storehouse of *ayurvedic*, tribal and folk medicine. They help in soil conservation and in nutrient cycling. Many of the SGs harbour water resource in the form of springs, ponds etc., which act as recharge for aquifers. However, threats from commercial forestry and development projects like townships, dams, railroads, highways, plantations etc. as also cultural and economic changes in the communities themselves, have led to the weakening and destruction of these ancient practices.

Extracted from: Culture and Biodiversity BSAP; Rathong Chu Sub-state BSAP

Traditional knowledge is also important for documenting biodiversity for use value. Schools of medicine such as *Ayurveda* have from time immemorial relied on traditional knowledge. This knowledge has today become of immense value to the entire pharmaceutical industry (Pandey 2001e).

Similarly there are 15 types of resource management practices that result in biodiversity conservation and contribute to landscape heterogeneity in the arid ecosystems of Rajasthan. The environmental ethics of the Bishnoi community enjoin compassion towards wildlife, and forbid felling of *Prosopis cineraria* trees found in the region. Damage to crops by wildlife is tolerated. People in the village of Kheechan contribute about 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 2001b).

An elaborate understanding of the nuances of the aquatic milieu and the behaviour patterns of living marine organisms, is similarly a highlight of the traditional ecological knowledge system of the artisanal fisherfolk of Kerala. The technologies adopted by them to catch fish are a personification of this knowledge, which is in turn

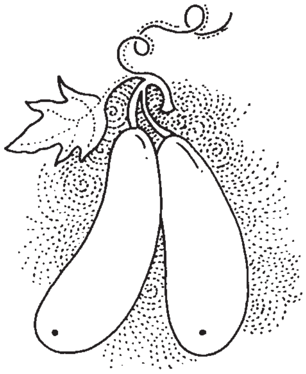
Table 3.2: Indigenous Forest Management in India that Conserves Biodiversity in a Continuum of Land Uses

Practices	Examples	Average Range of Area in Ha.
Sacred and Sanctified Landscapes	Temple forests	5-10 ha.
	Sacred Corridors	10-200 ha. (1-2 km long)
	Sacred Groves	0.1 to 70 ha.
	Sacred Trees/Taboo trees	Isolated and sanctified trees
	Ethnoforestry Refugia	1-5 ha. (modern variants)
	Keshar-chhanta (saffron-sprinkled and sanctified) forests	50-500 ha. large forests
	Panchwati (tree grove)	0.1-0.5 ha.
Family and Village Forests	*Rari* (village woodlots)	20-150 ha.
	Family Farm Groves	0.5-1 ha.
	Charnot (wooded grazing lands)	1-50 ha.
	Kankad (village boundary forests)	2-5 ha. Strips
	Rundh (closed royal woodlands)	10-500 ha.
	Baugh (silvi-horti-gardens)	5-50 ha.
	Home gardens/dooryard garden	0.01 ha. 0.5 ha.
	Inhabited village groves	5-40 ha.
	Lakheta (wooded islands amidst traditional village ponds)	A grove of 10 to 50 trees
	Beed/Bir (traditional woodlot)	5-200 ha.
Agro-forests	Several types	Extreme variation in area

Source: Pandey 2001d

handed down largely through learning-by-doing and oral traditions of songs, stories and proverbs (Kurien 1998a, 1998b). The net result is the development and use of fishing tools and techniques marked by their ecological sophistication, but with inherent limits to their levels of productivity. The 600-km coastline of Kerala was distinguished by at least 14 types of fishing crafts and at least 23 types of fishing gear (SIFFS 1992). Artisanal fishing gears are largely marked by their diversity of fabrication, passivity in use, seasonality of operation and limitation in size. In Kerala, even as recently as 1980, there were as many as 22 major craft-gear combinations used by the artisanal fishermen to sustainably harvest the resources of the coastal waters (Kurien 2000).

Over centuries, Indian communities have developed a wide range of techniques to harvest water – be it rainwater, groundwater, stream or river water, or flood water. Many of the techniques have survived the test of time and continue to be in use even today. Each region had developed its own water harvesting and management systems using indigenous knowledge of tremendous sophistication. These were usually attuned to the physical and biological attributes of the area (*see Box 3.4*).



Several nomadic and pastoral communities live in India, with their own unique cultural knowledge base attuned to a livelihood and lifestyle milieu very different from that of farmers and fisherfolk. Sophisticated knowledge of seasonal changes and of the flora and fauna available in a wide variety of habitats are a key feature of nomadic communities. These are coupled with often complex customary laws on resource use (*see Box 3.5*).

Despite political domination by mainstream cultures, the traditional ecological ethos continues to survive in many local communities, although often in attenuated forms. Traditional resource-use norms and associated cultural institutions prevailing in rural Bengal indicate that a large number of elements of local biodiversity, regardless of their use value, are still protected by local cultural practices. For example, the Santhals and the Mundas do not harvest any part of the sal (*Shorea robusta*) tree until their Salui/Sarhul festival is over in March-April (Deb

Box 3.4 Traditional Water Harvesting Systems Used in Different Ecological Zones in India

In the western and central Himalaya, diversion channels called *kuhls* or *guhls* were built to draw water from hill streams or springs. The length of these channels varied from 1-15 km, and carried a discharge of 15-100 litres per second.

In Meghalaya, a 200-year-old system of tapping stream and spring water for irrigating plants by using bamboo pipes is prevalent. About 18-20 litres of water enters the bamboo pipe system, gets transported over hundreds of metres, and finally reduces to 20-80 drops per minute at the site of the plant, like a modern drip-irrigation system.

The Apatani people of the Ziro plateau in Lower Subansiri district of Arunachal Pradesh use traditional water harvesting and irrigation practices for running rice mills, irrigation and other activities.

The *ahar-pyne* system of irrigation was used in south Bihar. *Ahars* are rectangular catchment basins, and *pynes* are channels constructed to utilise the water flowing through hilly rivers.

Kunds, found in the sandier tracts of the Thar Desert, and *Vavs* (step-wells) of Gujarat are covered underground tanks with an artificially prepared catchment area to increase run-off. They were developed to supply drinking water. *Khadins*, an example of runoff farming, were developed by the Paliwal Brahmins of Jaisalmer around the 15th century.

Karnataka has been in the forefront in managing traditional water harvesting structures, like *arakere*, *volakere*, *devikere*, *katte*, *kunte* and *kola*. Some have the same structure and purpose but still bear different names in different parts. The most numerous are tanks – 40,000 tanks still exist today.

Kasaragod district of northern Malabar has a special water harvesting structure called *surangam*, a tunnel dug through a laterite hillock, from the periphery of which water or moisture seeps out.

One-third of the irrigated area of Tamil Nadu is watered by ancient tanks called *eris*, which have played several important roles in maintaining ecological harmony – flood control, preventing soil erosion, reducing wastage of run-off and recharging groundwater.

The Shompen and Jarawa tribals of Nicobar Island make extensive use of split bamboos in their water harvesting systems. The split bamboos are placed along a slope with the lower end leading into a shallow pit. These serve as conduits for rainwater, which is collected drop by drop in pits called jackwells.

Extracted from: Agarwal and Narain 1997; Arunachal Pradesh State BSAP

and Malhotra 2001). There are many such examples and some of these may not have any conservation effect, but may yet symbolically reflect a collective appreciation of the intrinsic or existence value of life forms, and the love and respect for nature. Traditional conservation ethics may still be capable of protecting much of the country's declining biodiversity, as long as local communities have a secure share in the management of natural resources (Deb and Malhotra 2001).

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

In certain commercial sectors as well, traditional knowledge has considerable importance – the pharmaceutical industry is one example. The estimated market value of plant-based medicines sold in OECD countries in 1985

Box 3.5 The Raika of Rajasthan

The Raika are a Hindu caste whose hereditary occupation is camel breeding. They are a sub-group of the Rebari, the largest pastoral group of Western India, concentrated in Rajasthan and Gujarat and estimated to number about 500,000-800,000 people (Srivastava 1999). The Raika also dominate Rajasthan's sheep-breeding sector.

The Raika distinguish a large number of different breeds and strains but their classification system shows little overlap with the 'scientific' one (Geerlings 2001). They have developed intricate strategies for genetically manipulating their livestock populations, resulting in distinct breeds endowed with an optimal balance of production and adaptability traits. For example, the *Boti* cattle are drought- and disease-resistant and thus adapted to the extreme temperatures of the region. The *Bhagli* cattle, on the other hand, are less resistant, but have higher production potential and give better yields during good years. The Rebari have also developed the *Nari* cattle breed, which is locally famous but scientifically as yet unrecognized. For camels, the Raika keep oral records of genealogies, tracing the ancestry of their herds in female lines.

Raika society (*samaj*) is governed by many rules designed to ensure the social and ecological sustainability of their herding system, like ensuring access to grazing and preserving pastures. There are rules barring land ownership and construction of houses, the rationale being that the land will then not be available for grazing, and that permanent houses would undermine the community's mobility (Beraram 2002). Regarded as protectors of *gochars* (village grazing grounds) by villagers, the Raika have practiced rotational or sequential grazing of the different livestock species. Even today it can be observed that in villages where the Rebari have the majority in the *gram panchayat* (village council), the village grazing grounds are in excellent condition.

Unfortunately, many of these rules are in conflict with mainstream development and not attuned to remaining competitive in the current economic scenario of privatizing resources. In spite of the above-mentioned customary rules, foresters and other officials often accuse the Raika and their herds of destroying the vegetation. Although the Raika are the backbone of the livestock sector, hardly any interaction takes place between the Raika and the government officials for animal husbandry. In fact, for many decades the livestock policies and activities of the state of Rajasthan have been focusing on breed improvement by cross-breeding and artificial insemination (Koehler-Rollefson and Rathore 2001). Although the need to conserve the indigenous breeds is now being recognized and even reflected in the official breeding policy, the required linkage and collaboration with the pastoralists as the main stakeholders is yet to be established.

Extracted from: Lokhit Pashu-Palak Sansthan 2000

was US $43 billion (Principe 1989). Many of these were culled from traditional knowledge. Of the 119 plant-based compounds used in allopathic medicine worldwide, 74% had the same or related use in traditional medicinal systems (Farnsworth 1988). The interdisciplinary task force set up by Goverment of India (GoI) did an elaborate study of the USPTO's (United States Patents and Trademarks Office) database for references on 90 medicinal plants, and found that 80% of these references were to seven 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 traditional knowledge (GoI 2001, quoted in MIDS 2001).

Even prior to the recent increased interest in traditional knowledge due to a series of international agreements relating to biodiversity and trade and due to the rapid development of biotechnology, the GoI has been promoting several programmes that utilise traditional knowledge (Sengupta 1995). For example, the GoI had set up a separate department for promoting Indian systems of medicine, a technical programme on traditional cotton cultivation, and promotional measures for natural dyes (MIDS 2001).

Outside of government initiatives, development activists had also initiated studies in traditional knowledge, with the main objective of redefining progress and development. In the 1990s, the People's Patriotic Science and Technology Foundation (PPST) has organised three Congresses of Traditional Science and Technologies in India. Hundreds of papers were presented at these congresses, grouped under heads such as architecture and building materials, bamboo, fisheries, food and nutrition, forestry, health care, metals and materials, navigational technologies, pottery, agriculture, biodiversity, textiles, traditional industries, vermiculture, and water resources (MIDS 2001).

Box 3.6 Microbial Biodiversity in Traditional Fermented Foods and Beverages of the North-east Region

The application of biotechnology can be seen in the production of traditional fermented foods and beverages (TFFBs), which were developed during the early ages. Origin of such biotechnology-based food products took place independently in different parts of the world. The main advantages of the TFFBs were the development of special taste and flavour, and enhancement of shelf life, nutritional qualities and digestibility of the fermented foods. These changes were carried out by enzymes of selected and useful micro-organisms, which developed in the foods during fermentation.

A variety of foods of plant and animal origin were subjected to fermentation using traditional technologies. These include : soybeans, mustard seeds, young bamboo shoots, tubers (taro, dioscorea), fruits (guava, banana), vegetables (cabbage, radish), milk, fish and crabs. Rice, millets and jaggery were used for production of alcoholic beverages.

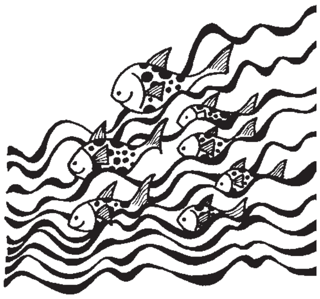
The following list gives different micro-organisms recorded in the TFFBs of the NE region:
Bacteria: *Bacillus subtilis*, *B.cereus*, *Lactobacillus plantarum*, *Lb. brevis*, *Lb. acidophilus*, *Lb. crniformis*, *Streptococcus lactis*, *S. delbruckii*, *S. faecalis*, *Enterobacter aerogenes*, *Micrococcus luteus*, *M. roseus*, *Pediococcus cerevisae*, *Pseudomonas fluorescence*.
Fungi: *Rhizopus oryzae*, *Rhizopus sp.*, *Mucor recemosus*, *Mucor sp.*, *Aspergillus oryzae*, *A. niger*, *Fusarium spp.*, *Penicillium spp*.
Yeasts: *Saccharomaces cerevisiae*, *Saccharomyces spp.*, *Rhodhotorula gracilis*, *Candida spp.*, *Scizosaccharomyces spp.*, *Hansenula spp*.

Contributed by: Dr. G.U. Ahmed

Today traditional knowledge is receiving increasing importance in many global fora. The United Nations' Convention on Biological Diversity (CBD) was the first legally binding international instrument that explicitly refers to the protection of indigenous knowledge (UNEP 1992). 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 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 indigenous knowledge (IK) from the point of view of sustainability, the World Trade Organistion's (WTO) agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS) approaches it from the angle of trade. However, several national and global fora have drawn attention to the holistic nature of IK, extending beyond the concerns of CBD or TRIPS. While trade concerns lead primarily to protection and benefit-sharing *with or without the indigenous knowledge holders*, environmental and developmental concerns lead to questions like recognition and use of modern avenues by the indigenous knowledge holders. Instead of specific aspects of IK being looked at in isolation, it needs to be recognised that IK is not 'pure' knowledge, but an integral part of diverse lifestyles and livelihood systems, including the communities' access to and control over resources, cultures and property rights regimes (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 2001e). 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 ecosystem services and management of agro-ecosystems (Janzen 1973, quoted in Pandey 2001e).



A major issue concerning traditional/indigenous knowledge is the culturally arrogant assertion that IK requires 'validation' by mainstream western science before being granted legitimacy. While the school of western ethnocentric thought considers this to be necessary, another school considers it wholly inappropriate because of the epistemological differences between the two knowledge systems. The latter school of thought feels that acceptance of the principle of *validation* creates a knowledge hierarchy which institutionalizes the superiority of formal knowledge systems over people's knowledge systems. There is no instance of formal institutions asking people to *validate* the knowledge produced by them.

The principle of validation also embeds the untenable notion that people's knowledge is a product of 'hit and miss', whereas the knowledge produced in formal scientific institutions is 'real knowledge'. Within the cosmos of people's knowledge systems there is an empirical assemblage of hypotheses, observation, experimentation and ultimate acceptance that cover periods of centuries. It has its own inbuilt peer review systems. Therefore, it is argued that instead of validation there is need for *translating* people's knowledge into formal scientific terms to enable the scientific community to understand vibrant indigenous knowledge, which it would otherwise be deprived of, and vice versa.

3.3.4 Economic and Occupational Profile

It is a cliché to say that India remains a predominantly agrarian economy, but it is worth repeating. According to the provisional figures of the 2001 Census, 58.4% of the country's total workers and 73.3% of the workers in rural areas (listed as cultivators and agricultural labourers), remain dependent on the primary sector, including agriculture, animal husbandry, forestry, fisheries, and related occupations and livelihoods. With 28% of the population now living in urban areas, significant sections of the population have also moved into the secondary and tertiary sectors, into urban and industrial settlements and livelihoods, and this number is rising, albeit slowly. The country today therefore displays the largest possible range of economic pursuits and livelihoods, ranging from ancient hunter-gatherers and nomadic pastoralists, to the modern computer professional and space scientist.

According to the 1991 census, the distribution of main workers (working for at least 183 days a year) among the primary, secondary and tertiary sectors is given in *Table 3.3*.

Table 3.3 Distribution of Main Workers Among the Primary, Secondary and Tertiary Sectors

	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), in the year 1999-2000, out of a total employed workforce of 397 million, about 28 million were in the organised sector and 369 million (93%) in the unorganised sector of the economy. An earlier 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 remaining 308 million (92%) in the unorganised sector. These estimates indicate that there has been almost no increase in employment in the organised sector, while the unorganised sector, particularly in absolute terms, expanded substantially over the 6-year period. (PC 2001b).

Expectations that planned development will increase availability of secure employment in the organized sector have been belied by experience. The recent opening-up of the economy to global forces under the programme of economic reforms has only exacerbated the problem with a clearly visible trend of contractualisation and casualisation of labour. Occupations in the vast and growing unorganised sector include 74.6 million landless agricultural labourers, small and marginal, cultivators, small traders and hawkers, artisans and other self-employed persons (PC 2001b).

The livelihood and occupational pattern of the vast majority of the country's rural population indicates their continuing direct dependence on natural resources and elements of biodiversity 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. Sustainability of such livelihoods requires a sustainable resource base, since land, water and biodiversity are their very foundation and the 'means of production for the rural people' (Kocherry 2001).

More than two-thirds of India's rural population is directly dependent on various combinations of private and common pool lands and waters for a very wide diversity of agricultural, agro-pastoral and fisheries-related (including coastal and inland) livelihood systems. These include ecosystem-based variations of settled agriculture, shifting cultivation, nomadic and non-nomadic pastoralism, and various combinations of agriculture and pastoralism. 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 2001a).

The *People of India* study of the Anthropological Survey of India also found settled cultivation to be the leading occupation pursued by 2503 communities, followed by wage labour (2483) and animal husbandry (999). Fishing is pursued by 387 communities. About 300 communities are pastoral and non-pastoral nomads. In many communities there has been a decline in occupations such as hunting and gathering, trapping of birds and other animals, pastoralism, shifting cultivation, salt making, and toddy tapping. However, communities rely on multiple occupations. The average number of occupations per community stands at 5.3, of which 1.8 are traditional and 3.5 are newly acquired (Singh 2002).

Despite this scenario, tenurial security over land for small and marginal farmers, particularly for farmers in so-called 'marginal' lands (like mountains, marshlands, coasts, arid and semi-arid areas), and access to common lands for gathering, pasture, shifting cultivation and pastoralism is declining rapidly with changing land policies in the context of nationalisation, privatisation, and globalization. All these factors are threatening agricultural livelihoods, agro-biodiversity and the indigenous knowledge systems, which sustain them (Kothari 2001).

The country's network of waterbodies, intertwined with canals and rivers leading to the sea, also harbours rich biodiversity on which about 22 million fisher-people depend. Of these about 12 million depend on marine fishing along India's 7000 km long coastline (Kocherry 1987). Another 10 million derive their livelihoods from inland fishing in the country's 52 rivers, large number of wetlands and other waterbodies. Freshwater 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 of their food and health (Kocherry 2001). Yet, be it aquatic conservation policies or economic development for the global market, the livelihoods and priorities of these fisherfolk 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 to the inadequate arable land available, or to its low productivity. Produce from forests such as fuelwood and non-timber forest products (NTFPs) and its contribution to household subsistence and income in rural areas, especially for villagers living adjacent to forests, goes largely unnoticed (Kumar *et. al.*, 2000). An estimated 147 million villagers live in and around forests (FSI 2000) and there are 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 (or very few) 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 about 300 pastoral and non-pastoral nomadic communities in the country (Singh, 2002; *Non-Pastoral Nomads Sub-thematic Review*).

Over 200 castes, about 6% of the total Indian population, are engaged in pastoral nomadism. 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. Examples include 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), and ducks (Southern India). A few castes, especially shepherds, also engage in weaving. Their other products include milk, butter, *ghee*, eggs, meat, hides, manure, and wool. These nomads depend entirely on natural vegetation and not on planted pastures (Agarwal *et. al.,* 1982). Rights over the seasonal commons have been regulated by customary law, and have evolved over centuries, reflecting their inter-dependence with settled cultivators (Chakravarti-Kaul 1996). Most of the pastoralists' traditional pasture lands have been taken over by the state, either as state owned 'forests' or as revenue 'wastelands', often without any recognition of customary common property rights over them. While the Forest Departments have often undertaken afforestation in such natural grasslands (*Prosopis juliflora* in Kutch; pine, *Acacia catechu* and eucalyptus in Himachal Pradesh and Uttaranchal; eucalyptus, pine and wattle in the Nilgiris), the Revenue Departments have allocated them for other uses (e.g., irrigated agriculture as in the case of the Indira Gandhi canal in Rajasthan). Both types of interventions have not only seriously damaged their ecosystems and wildlife habitats, but also created a crisis of survival for the nomadic communities. Even in cases where nomadic pastoralists have been able to retain access to their seasonal pastures, changes in land use or closures for afforestation on their seasonal routes (including under JFM) have created many conflicts and problems in seasonal movements.

Box 3.7 The Dying Dokpas of North Sikkim

The gentle 'Dokpas' (graziers) survive and subsist at the highest altitudes in the world, tolerating the severest of climatic conditions and one of the harshest lifestyles known to humankind. For generations these nomadic herders have used the high dry grasslands of North Sikkim to graze their yak, sheep and *pashmina*-type goats. Devout Buddhists, they are also one of the rare communities which earlier practiced eco-friendly sky burials.

Earlier when the borders were open, the Sikkim Dokpas grazed their livestock, right up to Khambazong in Tibet in the winter. The Tibet Dokpas on their part came in during the summer with their livestock, right up to Dongkung, Lungma, Kering and Lhechen areas on the Indian side. Oil, various foods, sugar, salt, fir planks, cloth, wool (large bales of which were taken directly to Kalimpong), '*Tchampa*', carpets, blankets, sheep mutton and fat were the main trading items. There would be a 3-4 day '*Haat*' (*bazaar*) on the Chho Lhamo plateau. The trans-border migrations ensured mixing of people, resulting in intermarriages in a larger region, as also good cross-breeding of the domestic livestock – yak, sheep, goats and horses – and no dearth of fodder.

Once the borders closed and the Indian army occupied the area, this lifestyle changed completely with no more border crossings for grazing or trade or marriage. The Sikkim Dokpas are now restricted to a tiny patch of the vast Tibetan Plateau, the 'Roof of the World', in the Chho Lhamo region, Lhonak and Lashar. The entire sheep population of the valley has been wiped out over the last two decades. Many have sold out their livestock and migrated to Ravongla and elsewhere. They now supplement their pastoral livelihood with odd jobs with the Indian army and husbanding some livestock belonging to the Lachenpas along with their own. Yaks have begun to show the defects of inbreeding. Gone forever are the proud Tibetan mastiffs, having got mixed with lowland mongrels brought in by the army. Parents of Dokpa children studying in Gangtok, Ravongla and elsewhere do not expect them to return to a nomadic shepherd life.

Today in North Sikkim, the apparently barren treeless cold desert of Chho Lhamo, Lhonak Valley and Lashar Valley is home to 23 Dokpa families. They are responsible for almost 90% of the yak population of the state. The elders know and acknowledge that they are the last in their line. Though they themselves have not changed – still living nomadic lives in yak-hair tents and stone shelters, wearing traditional costumes and speaking their own language – almost everything else around them has. Their cold desert land with its fabulous medicinal plants and endangered wildlife is today criss-crossed with roads, populated with non-native people, occupied for defence priorities, riddled with landmines and grazed to the ground.

This is a community that faces a reality as cruel and stark as that of biodiversity: rapid erosion and eventual extinction. Another lost culture, lost language, lost knowledge and lost ability to show the world how to live with nature.

Source: Sikkim State BSAP

Hunters, trappers, fisherfolk, artisans, entertainers, dancers, singers, fortune-tellers, puppeteers, palmists and traditional doctors are some of the non-pastoral nomads. Non-pastoral nomads constitute about 1% of the total Indian population (Agarwal *et. al.*, 1982). According to the Anthropological Survey of India there are 276 non-pastoral groups in India (Singh 1991, as quoted in *Non-Pastoral Nomads Sub-thematic Review*). In Maharashtra and Karnataka alone there are about 105 and 90 such communities respectively (*Non-Pastoral Nomads Sub-thematic Review*). The activities of the non-pastoral nomads were closely linked with the social, cultural and economic life of the sedentary people in the villages within their area of operation; but today they are an overlooked and marginalised population (*ibid*). Many are facing extinction.

3.3.5 Current Land Use Pattern and the Problems in Land Classification

India has a geographical area of 328.73 million hectares (m ha). Land is an inelastic resource and per capita availability of land is declining with the growth of population. It was 0.89 ha/capita in 1950-51, and 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. No comprehensive land use policy taking ecosystem diversity and livelihood systems based on them has been developed to date. Changes in land use have been effected 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. Simultaneously, the commons under the jurisdiction of the erstwhile princely states and *zamindars* were declared state property, either as state-owned 'forests' or revenue 'wastelands'. This period saw significant clearance of both forests and revenue 'wastelands' for conversion to agriculture on the one hand, and also declaration of natural grasslands, scrublands and other ecosystems as 'forests' bringing them under the Forest Department management for sustained yield of timber on the other. Both these resulted in major destruction of wildlife habitats and biodiversity. This was combined with a major reduction in the area of the uncultivated commons partly through their privatization and on a larger scale through their notification as state owned forests under the jurisdiction of state Forest Departments (*see Section 5.2.2*) From the early 1980s, concern over forest destruction led to a reversal of priorities. The Forest Conservation Act, 1980, made GoI permission necessary for converting forest land to other uses. The 1988 Forest Policy states that 33% of the country's total area should be brought under forest cover. Unfortunately, tree plantations on 'wastelands' continue to be equated with increased 'forest' cover, often resulting in land use changes from the already decimated natural pastures and grazing lands to locally less useful tree plantations. While displacing livelihood uses rooted in local ecosystems, such expansion of tree cover has also been responsible for significant destruction of natural biodiversity and wildlife habitats (*Haryana State BSAP*, *Uttaranchal State BSAP*, *Kachchh Sub-state BSAP*).

At present, changes in land use are not recorded for a long time, due to delays in verification and sanctioning of the changes. Consequently, there are many 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.

According to the nine-fold land classification used in official GoI records, 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 land 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 presented in Table 3.4 (Saxena 2001b).

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. Some legally designated 'forest lands', are, for example, either under shifting or settled cultivation or are natural grasslands or alpine pastures which have been classified as state-owned forests by law (*see Box 3.8*). The third category of 'fallows/culturable wastes, pastures, groves' is even more problematic, as it is well known that large areas of state-owned wastes are

Table 3.4 Area Under Culturable Lands

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

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

either under cultivation or diverted to other uses through encroachment, or function as seasonal pastures for pastoral communities. In any case, some of the sub-categories within this category do not indicate *actual* use, but only assumed potential use. For example, 'culturable wastes' are lands lying fallow for over five years. Their current use for non-agricultural purposes is not mentioned.

Box 3.8 Contradictions in Himachal Pradesh's Land Use Data

According to present Forest Department statistics, 36,986 sq kms (66.43% of Himachal Pradesh's geographic area) is 'forest' land under FD jurisdiction. Of this, only 12,501 sq km has a crown density of 10% and above, including 9,565 sq km of dense forests. As much as 20,541 sq kms (55%) is incapable of supporting tree cover due to its altitude being above 3-4 thousand meters and its being under alpine pastures, permanent snow or above the tree line. Out of the remaining 16,445 sq kms capable of supporting forest cover (i.e. 44% of the supposed forest land and 29.5% of the state's geographical area), a large part consists of 'Undemarcated Protected Forests' (UPFs) and traditional village common lands acquired by the state in the mid-1970s. These lands have not been entered in the Revenue Department's records as forest land and both departments claim disputed jurisdiction over it. On the ground, they are largely under open access, as neither village panchayats not community institutions have any management responsibility for the same.

The land records maintained by the Revenue Department show only 10,562 sq kms as forest land. The Revenue Department records, based on actual land use classification, indicate that the single largest actual land use (representing 35.4% of the measured area of the state)[10] consists of permanent pastures and grazing lands. Actual forests cover only 31.1% of the measured area (based on Sharma 2000). As noted by an innovative Forest Sector Review carried out in Himachal Pradesh, current designated forest lands neither reflect forest cover nor their livelihood uses.

Source: IIED and HPFD 2000

There is also a problem with the manner in which the Forest Survey of India assesses 'forest cover' for its 'State of Forest' reports. Forest cover for the purpose is defined 'as all lands with a tree canopy density of more than 10%, although the lands may not be statutorily notified as forests' (FSI 2000). Using this basis, lands lying fallow under shifting cultivation cycles, which have regenerated naturally, are also recorded as lands under forest cover. Such classification of land use has been instrumental in tremendous injustice to tribal shifting cultivators in the past, as large areas of their fallow lands were included among state-owned reserve forests during forest settlements (as in Andhra Pradesh during the 1960s) (GoAP 2002). Interestingly, the FAO classifies such lands as 'forest fallows' instead of 'forest cover'. Because of this, India's area under forest cover assessed by FAO was 11.5 m ha less than FSI's assessment. The issue gains greater importance in view of the proposed 'afforestation' of shifting cultivation lands during the 10th-Plan period and the persistent question raised regarding the official bias against shifting cultivation by communities practicing it in North-East India (Comments on Manipur State BSAP by the Naga Women's Union and the Naga Peoples' Movement for Human Rights, NPMHR 1999).

At the all-India level, total uncultivable land, inclusive of all categories, constituted 44% of total land in 1994-96. Of that 14% was barren and uncultivable, about 21% was forest and 9% pastures and cultivable waste. This is according to the land use statistics generated by the agriculture department (Iyengar 2001).

Overlapping with the above categorization of land use are highly variable estimates of the extent of land considered 'waste' or degraded, the improvement of which has been a central thrust of government policy. The problem starts with the definition of wastelands. Three different definitions are used, one based on land productivity, the second on ecological characteristics, and the third on both these. None of the categories refer to their existing actual uses or the biodiversity they support.

According to estimates of the Ministry of Agriculture, 175 m ha of the country's land area are wastelands. These include private lands under rainfed paddy cultivation considered prone to soil and wind erosion. According to Eswaran (2001), 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 m ha. The SPWD classification was based on soil types and on ecological qualities such as salinity, alkalinity, water erosion, wind erosion and waterlogging, 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).

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' (quoted in Eswaran 2001). This still does not refer to ecosystem integrity or biodiversity.

The March 2000 *Wastelands Atlas of India* prepared by the National Remote Sensing Agency for the Department of Land Resources used more or less the same definition (*ibid*). 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 m ha of total wasteland area (including 14.06 m ha of degraded notified forest lands), i.e., 20% of the geographical area covered in the exercise, excluding 12 m ha of Jammu and Kashmir (*ibid*).

The 1995 report of the high-level Mohan Dharia Committee on Wastelands Development (quoted in Eswaran 2001) analysed the land use statistics available for 305 m ha out of the 329 m ha 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, and 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 degraded to some extent. The Committee preferred to describe the latter 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 wastelands for diverse livelihood issues, 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 and the specific causes leading to their degradation. The definition of bio-geo-regions/ecoregions on a more rigorous scientific basis is becoming necessary from both environmental and developmental perspectives (Ghotge 2001).

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 wastelands – the land distribution policy of the 1970s and the social forestry policy of the 1980s (Saxena 2001b).

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

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 (GoI 1976). Possibly because of 'social forestry', wastelands development and the NWDB were placed under the Ministry of Environment and Forests (MoEF), and the states followed suit (Saxena 2001b). Although some effort was made to solicit the participation of local communities when social forestry was taken up on common lands, there was little effort made to understand the role of existing land uses or local biodiversity in supporting the existing diversity of livelihood systems, or indeed to understand the biodiversity of these lands per se.

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. Between 1966 and 1997-98, the different categories of revenue wastelands in Haryana, for example, declined by 43 percent from 715,000 ha to 407,000 ha, significantly reducing the area available for grazing and pasture, while also reducing biodiversity (*Haryana State BSAP*).

For the landless and small and marginal farmers, especially 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 other non-timber forest products for subsistence and income, besides providing important ecosystem services (*see Section 5.2.2*, for the recent NSS survey on common pool resources).

India today suffers the absence of 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 is also often inadequate, as there is no way to access inter-category transfer of land (Iyengar 2001). **More importantly, land use data by and large ignores the role of different land uses in sustaining the country's rich diversity of livelihood systems, particularly the non-agricultural ones such as pastoralism dependent on access to common pool land resources, and the importance of maintaining ecosystem integrity, habitats and biodiversity.** These imperatives need to underlie the development of a sound long-term land/water use policy and plan.

Notes

1. This dominance of *Glossopteris* flora has provided additional evidence to support the theory of continental drift.
2. However, this rather early date is considered controversial, the more definite date for the earliest archaeological evidence for rice being about 4500 years BP (Kajale 1988).
3. The account in this section, and generally in this chapter, is largely about inland terrestrial areas of India; several experts on marine issues were asked about a similar account for coastal and marine areas, but no information was forthcoming.
4. The site is located between two streams now known as Manhar and Mansar. Stone bunds were erected across their width and the water was then diverted inside the township where reservoirs were constructed (Bisht 1991).
5. In fact, it needs to be acknowledged that those involved in these protests, rebellions and revolts were the pioneers of the anti-colonial struggle that coalesced in the Independence movement.
6. For a detailed description of these movements, see Richard Grove, 'Colonial Conservation, Ecological Hegemony and Popular Resistance: Towards a Global Synthesis' in John Mackenzie, *Imperialism and the Natural World*, Manchester University Press, 1990.
7. For detailed studies of some of these movements, see, K.S. Singh, *Tribal Movements in India*, *Volumes 1 & 2*,

Manohar 1981, 1982, K.C. Mishra, *Tribes of India*: *The Struggle for Survival*, National Publishing House, 1987, and Smitu Kothari, 'To Be Governed or to Self-Govern', *The Hindu Folio*, July 16, 2000.

8. Gadgil and Guha have aptly described this conflict as between the political economy of profit and the moral economy of provision (Gadgil and Guha 1992).
9. The terms 'traditional knowledge' and 'indigenous knowledge' have been used interchangeably here.
10. Almost 40% of the state's area has never been measured.